Data Model of the Episode-Oriented Medical Record according to Solon in openEHR

openEHR Masterclass Thesis

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Abstract

Healthcare digitalisation has made electronic health records central to care, yet the organisation of clinical data remains a challenge that affects care quality, continuity and decision-making. Traditional source- or problem-oriented records struggle to support complex, cross-setting care pathways. This thesis investigates whether an episode-oriented medical record, as described by Solon, can be implemented within the openEHR standard and whether it offers practical benefits.

The work adopts a three-part organising scheme: care encounters provide the point-in-time chronological spine; Episodes-of-Care anchor the clinical content for each health problem; and administrative encounters define periods for operational grouping and reporting. Every clinical entry is linked to an Episode-of-Care selected by the clinician and to the contact at which it was captured. Familiar overviews such as the episode, diagnosis, problem and past medical history lists are generated as computed views from the same source data, preserving provenance and consistency.

Using a design-science approach, a comprehensive data model was developed and assessed with eight clinician-focused user stories and a realistic sample history of 132 entries. Three openEHR-conformant implementation patterns were evaluated: folder-based directory indexing, link-based referencing and a cluster-based relationship model. To compare these approaches, a structured evaluation framework was developed and applied.

The results confirm that episode-oriented records are fully realisable within existing openEHR specifications, without changes to the Reference Model. Episodes are represented as Episode-of-Care compositions that act as the single source of truth; contacts are captured explicitly; clinical statements reside in clinical compositions. Lists are treated as derived views, avoiding duplication while preserving auditability.

In practice, a pragmatic hybrid offers a balanced solution in which governed attributes are expressed in CLUSTERs, complemented by a FOLDER-based index for navigation and selective LINKs where explicit cross-document references are beneficial. The choice is context-dependent, shaped by local governance, performance expectations, operational policies, and multi-vendor or cross-repository constraints.

The thesis contributes validated design principles for episode-centred data structures in openEHR and outlines implementation guidance. These findings provide a foundation for future developments in clinical information systems and care-coordination tools.

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1 Introduction

The digitalisation of healthcare has fundamentally transformed medical practice, with electronic health records (EHRs) established as a key technology in modern medical informatics. However, organising and structuring clinical data remains a critical challenge in this field, directly affecting the quality of healthcare, the continuity of care, and clinical decision-making processes [1]. In response to the growing complexity of patient care and the requirement for thorough documentation, traditional approaches to organising medical records, such as source-oriented records (SOR) and problem-oriented medical records (POMR), have evolved [2].

As an interdisciplinary field combining healthcare, computer science and information science, medical informatics has continuously attempted to develop more sophisticated frameworks for managing clinical information [3]. The episode-oriented medical record represents a paradigm shift in this respect, focusing on discrete healthcare episodes rather than chronological or source-based organisation. This approach aligns with contemporary healthcare delivery models that focus on care coordination across multiple providers and settings while ensuring comprehensive patient medical records are maintained [4].

1.1 Theoretical Relevance and Current State of Research

The openEHR Foundation, established in 2003, has emerged as a leading international initiative developing vendor-neutral platform for electronic health records and computable clinical and research data [5]. openEHR is a non-profit organisation that publishes technical standards for an electronic health record along with domain developed clinical models to define content [6]. The openEHR architecture represents a significant advancement in health informatics by providing a multi-level modelling approach that separates a stable Reference Model from evolving clinical knowledge through archetypes and templates [7].

Current research into the organisation of medical records has identified several limitations of existing approaches. Although source-oriented records are familiar to clinicians, they often provide a fragmented view of patient care, making it difficult to track care trajectories across different providers and time periods [8]. The problem-oriented medical record (POMR), which was introduced by Lawrence Weed in the 1960s and provides structured documentation through the SOAP (subjective, objective, assessment, plan) framework, has shown limitations in complex, multi-episode care scenarios [9]. Recent studies have demonstrated the need for more sophisticated organisational paradigms that can accommodate the complexity of modern healthcare delivery while maintaining clinical workflow efficiency [10].

The concept of episode-oriented medical records addresses these challenges by organising clinical information around discrete healthcare episodes, each of which is characterised by a specific clinical context, timeframe and care objective [11]. This approach is particularly relevant in the context of value-based care models, where an understanding of care episodes is essential for measuring quality and managing costs [12]. However, the implementation of episode-oriented records within standardised electronic health record frameworks such as openEHR is an under-explored area that requires systematic investigation [13].

1.2 Research Challenge and Innovation

The central challenge addressed in this thesis lies in the translation of episode-oriented medical record concepts into the openEHR standardized framework, specifically following the Solon methodology. While openEHR provides robust technical specifications and clinical modelling capabilities, the specific implementation of episode-oriented data models within this framework has not been comprehensively addressed in the literature [14]. This gap represents a significant opportunity to enhance the clinical utility and organizational effectiveness of openEHR-based systems.

The innovative aspect of this research lies in the systematic approach to modelling episode-oriented medical records within the openEHR architecture to create reusable, interoperable episode-oriented data structures [15]. This work builds upon the foundational openEHR specifications while extending them to accommodate the specific requirements of the episode-based electronic medical record.

1.3 Context and Background

This research arises from the increasing awareness that, despite their technological sophistication, current electronic health record systems often fail to provide clinicians with intuitive, episode-centred views of patient care [16]. Healthcare organisations worldwide are increasingly adopting value-based care models that require clear delineation and documentation of care episodes for quality measurement, outcome assessment and resource allocation [17]. There is a particular need for standardised approaches to episode-oriented record keeping as healthcare systems seek to improve care coordination and clinical decision support [18].

Significant advancements have been made in standardisation efforts within the field of medical informatics, with openEHR representing one of the most comprehensive approaches to creating future-proof, interoperable health information systems [19]. However, the practical implementation of episode-oriented concepts within these standardised frameworks requires careful consideration of clinical workflows, data modelling principles and system integration requirements [20].

1.4 Research Objectives and Hypothesis

The primary objective of this thesis is to develop a comprehensive data model for episode-oriented medical records within the openEHR framework, specifically implementing the Solon methodology for episode definition and organization. This research seeks to bridge the gap between theoretical episode-oriented concepts and their practical implementation within standardized EHR architectures.

1.4.1 Research questions

This work aims to address the following research questions:

1. What are the key design principles for implementing episode-oriented data structures that ensure clinical usability and technical feasibility?
2. How can episode-oriented medical record concepts be effectively modelled within the openEHR archetype-based framework?
3. How can different approaches to modelling episode-oriented medical records be systematically evaluated and compared?
4. What are the main challenges in integrating episode-oriented concepts with existing openEHR specifications?
5. How can the various clinical sections of electronic medical records be organized in a way that healthcare professionals are accustomed to?
6. Can other documentation methodologies be expressed as derived views in an episode-oriented approach?

1.4.2 Research hypotheses

The following hypotheses are formulated based on the theoretical foundation and current state of research:

H1: Representational adequacy hypothesis
The Solon episode-oriented patient record can be comprehensively represented within the existing openEHR specification and capabilities without requiring fundamental modifications to the core framework.

H2: Multiple implementation approaches hypothesis
Multiple distinct and technically viable approaches exist for modelling episode-oriented medical records within openEHR, with each approach offering specific advantages and limitations depending on clinical context, organizational requirements, and technical constraints.

1.4.3 Expected contributions

This thesis makes a valuable contribution to the field of medical informatics. It provides a systematic methodology for implementing episode-oriented records in openEHR, establishes validated design principles for episode-oriented data structures and offers evaluation frameworks for comparing different implementation approaches. It could potentially serve as a foundation for future developments in clinical information systems and care coordination technologies.

2 Foundations and Terminology

2.1 The Solon Framework for Episode-Oriented Medical Records

The concept of episode-oriented medical records was first systematically developed by Solon et al. in 1967 in response to the limitations of traditional methods of organising medical records [21]. The authors identified that conventional measures of healthcare utilisation, such as simple counts of physician visits and hospital days, failed to capture meaningful relationships between related medical services, providing insufficient insight into the actual course and content of care received by individuals.

2.1.1 Core definition and conceptual framework

The foundational definition of an episode-oriented approach centres on the concept of a medical care episode, which is defined as follows: 'a block of one or more medical services received by an individual during a period of relatively continuous contact with one or more service providers, in relation to a particular medical problem or situation' [21]. This definition establishes episodes as unified entities that organise discrete medical services around specific health objectives, rather than arranging them chronologically or by source.

2.1.2 Distinguishing medical care episodes from illness episodes

The episode-oriented approach differs from the illness episode approach in that it focuses specifically on the delivery of medical care. This recognises that medical care episodes may not necessarily coincide with illness episodes in terms of timing or scope [21]. This perspective provides a more comprehensive understanding of healthcare utilisation patterns, serving as a bridge between clinical practice and patient care research.

2.1.3 Cost and quality implications

The Solon framework inherently supports the comparative analysis of healthcare delivery, enabling the evaluation of entire care sequences rather than individual services. This approach provides a basis for measuring achievement in patient care, establishing identifiable goals for specific episodes and relating anticipated outcomes to actual results. This enables both cost-effectiveness assessments and quality measurement within defined care episodes.

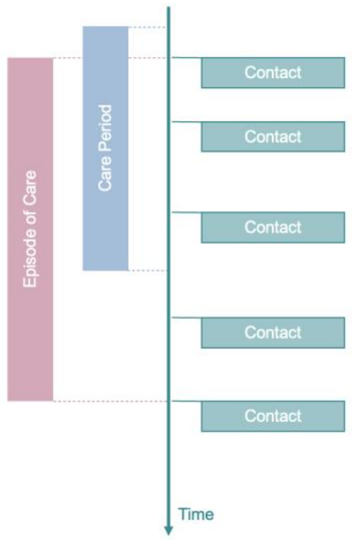
2.2 Units of Clinical Documentation

2.2.1 Overview

The delivery of patient care can be partitioned according to three distinct boundary dimensions [21]:

- Organizational dimension: A *Contact* is defined as a single interaction between a patient and a healthcare provider, characterized by a distinct beginning and end to the interaction.
- Temporal dimension: A *Care Period* is a defined as a specific time window for the aggregation of services, such as a day, a week, a month, or a year.
- Content dimension: An *Episode-of-Care* is defined as one or more contacts between a patient and one or more healthcare professionals relating to the same health problem.

The electronic medical record is organized using these organizational, temporal, and content dimensions: contacts as the fundamental documentation unit, care periods for temporal grouping, and episodes of care for clinical structuring.



Boundary	Unit	Description
Organizational	Contact	Single interaction between a patient and a healthcare provider, characterized by a distinct beginning and end to the interaction
Temporal	Period of Care	Specific time window for the aggregation of services, such as a day, a week, a month, or a year.
Content-related	Episode of Care	One or more contacts between a patient and one or more healthcare providers relating to the same health problem

Figure 1 – Units of clinical documentation

2.2.2 Contact

A *contact* is the smallest meaningful unit for documenting clinical information during patient care. It captures the documentation of an interaction between a healthcare professional and a patient, taking place at a specific time and within a defined context.

A *contact* is always based on an event, which may occur physically or virtually. Examples include outpatient consultation, home visit, ward round, telephone consultation, third-party telephone information, file review, dispensing of medication, or documentation of diagnostic and therapeutic procedures.

Contact	Remarks
Patient	Patient-centred medical record
Healthcare provider	Healthcare professional, e.g. physician, nurse, therapist
Event	Consultation, home visit, hospital stay, telephone call, surgical act
Point in time	Date, time, duration
Organization	Healthcare facility such as hospital, outpatient clinic, GP's office
Place	Clinic, department, ward, practice

Table 1 – Core attributes of a contact

The electronic medical record (EMR) can therefore be understood as the structured documentation of a chronological sequence of contacts. These contacts form the EMR's primary clinical timeline; the clinical documentation is captured and stored per contact, ordered by the contact date.

2.2.3 Distinction from the term Encounter

In clinical informatics, the terms *contact* and *encounter* are often used loosely and sometimes interchangeably. In everyday hospital parlance, 'encounter' may refer to anything from a single consultation to a full admission, while 'contact' may mean a brief interaction or simply be used as a synonym for 'encounter'. This ambiguity causes confusion between two fundamentally different concepts: the event at which care is delivered and documented, and the period over which an organisation assumes responsibility for care and aggregates work for administrative purposes.

In this thesis we adopt precise definitions:

A *contact* (care encounter) is a single point in time care event, an interaction between a patient and one or more healthcare professionals, either physical or virtual, at which clinical data are documented and stored with the contact. Examples include outpatient consultations, ward rounds, phone or video consultations, diagnostic or therapeutic procedure steps, and documented triage calls.

An *encounter* (admin encounter or service encounter) is a period during which a patient receives care from a healthcare organisation or service. It may include and aggregate several contacts. It represents the broader span of care that bundles these contacts into a clinically and administratively coherent unit. Some hospital visits may encompass several encounters if care is delivered across different organisational units. For example, an initial period in the emergency department may be followed by admission to the cardiology department.

Clearly defining the difference between a contact and an administrative/service encounter provides a clear distinction: clinical documentation belongs with the *Contact*, while organisational control resides with the *Encounter*. From an analytical perspective, clinical pathways and quality questions are based on event-level timestamps from contacts, whereas utilisation metrics rely on period-level data from encounters. Modelling and governance also benefit from this distinction, as it prevents double counting, sharpens access control and streamlines interoperability and queries. Taken together, this distinction provides a robust basis for an episode-oriented medical record that preserves event-level fidelity and supports operational needs.

2.2.4 Health problem

The relationship between patient and healthcare professional is asymmetric in knowledge and responsibility, yet collaborative in purpose. The patient presents one or more concerns that constitute health problems and seeks professional help to address them. A health problem is a clinically relevant concern, condition, symptom, sign, or risk that requires attention, monitoring, or intervention during care [46].

The first task of the healthcare professional is to recognise and structure the patient's concerns into problem statements. Drawing on clinical knowledge and the care context, they formulate working hypotheses (differential diagnoses), make diagnostic or therapeutic decisions, and implement them. The process is iterative, probabilistic, and revisable: progress is monitored, responses are interpreted, and hypotheses are updated as new information becomes available [46].

All patient information is summarized in terms of patterns into problem-oriented statements as health problems. The name and classification of the health problem may change over the course of care. A problem is first recorded based on the presenting concerns. As new information becomes available, it can be refined, renamed, or specified. During the diagnostic process, the clinician may register a provisional (suspected) diagnosis and reformulate the problem accordingly. When sufficient evidence confirms the hypothesis, it is recorded as a confirmed diagnosis. Following treatment and follow-up, the condition may be marked as resolved. Clinically significant resolved diagnoses are retained in the past medical history [46].

For example, a patient presents with abdominal pain that evolves into signs of an acute abdomen. The clinician suspects acute cholecystitis and orders laboratory tests and an ultrasound scan. When the findings confirm cholecystitis, the record is updated from a suspected to a confirmed diagnosis. Appropriate treatment is given, the condition resolves, and the diagnosis is closed as resolved. Because this is clinically significant, it is retained in the past medical history as status post cholecystitis.

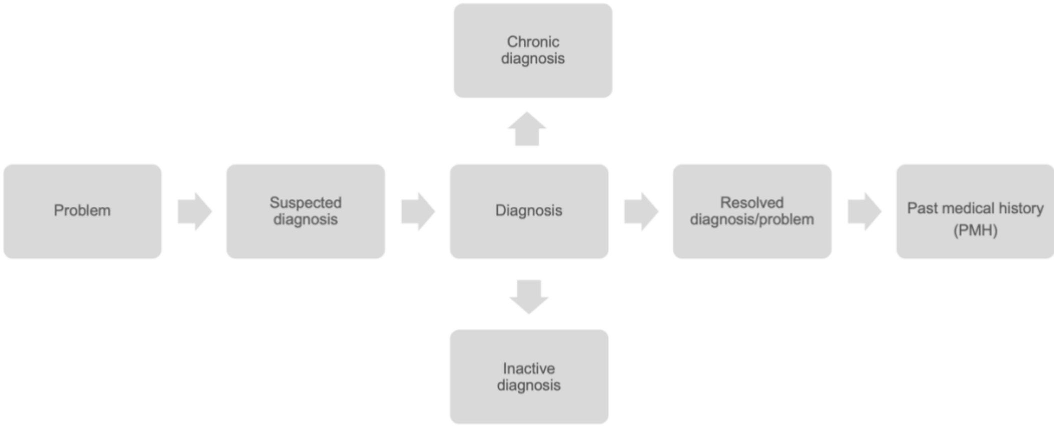


Figure 2 – Lifecycle of a health problem - changes in the same health problem over time

2.2.5 Episode of Care

In accordance with Solon's methodology, the episode of care is defined as the time span of a health problem, measured from the first to the last contact between the patient and healthcare professionals. An episode of care is composed of all information relating to a single health problem that is recorded in the medical record over this defined period for all contacts. According to the prevailing definition, it is regarded as a comprehensive collection of all medical record entries related to a specific health problem that are documented at the contact level.

A patient may have multiple concurrent health problems, with one episode of care created per health problem. In addition, a separate, linked episode is created for complications, for acute exacerbations of a chronic condition, and for recurrences after a period of resolution.

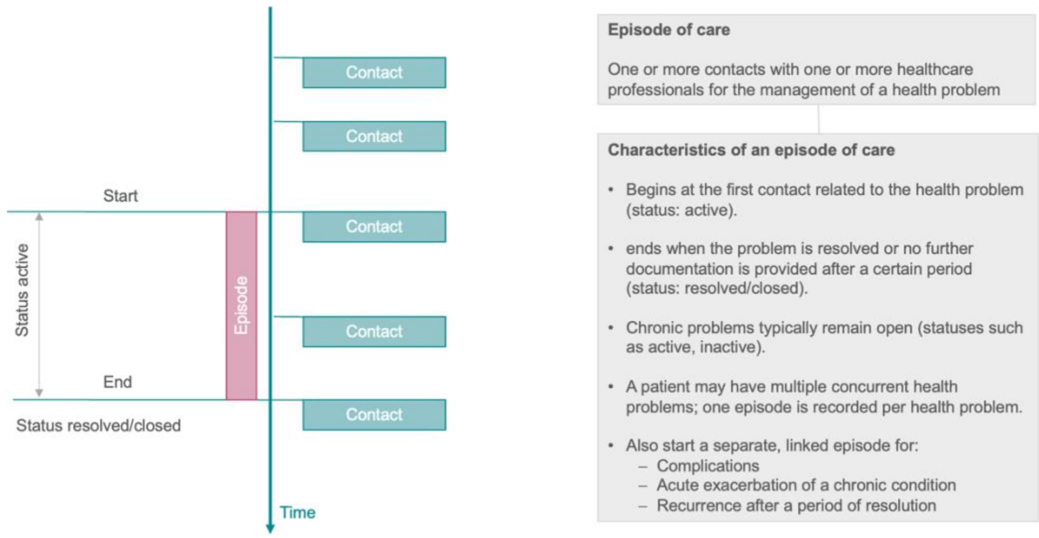


Figure 3 – Episode-of-Care – Characteristics

An episode of care is characterised by a defined beginning and end. It begins at the first contact related to the health problem, with status active, and ends when the problem is resolved or no further documentation is provided after a certain period, at which point the status is resolved/closed. A patient may have multiple concurrent health problems; one episode is recorded per health problem. Chronic problems typically remain open and are tracked using statuses such as active, inactive, on hold, or in remission.

An episode is created at the first contact where the health problem is recorded and is assigned the health problem name as its title. As diagnostic certainty and clinical understanding evolve, the health problem name may be refined, and the episode title is updated accordingly. To preserve historical fidelity, each contact retains the health problem name that was valid at the time of documentation, while the current episode title reflects the latest clinical assessment.

To illustrate this point, consider a patient who presents with abdominal pain. The episode is opened with the health problem name *Abdominal pain*, and the episode title is set to the same. Subsequent contacts provide evidence supporting a provisional diagnosis of *acute cholecystitis*; the health problem name, and thus the episode title, is updated accordingly. Ultrasound and laboratory tests confirm the diagnosis. Treatment is administered, the condition resolves, and the episode is closed as resolved; the diagnosis is recorded in the past medical history. It is important to note that each contact in the timeline continues to display the health problem name that was in effect at the time.

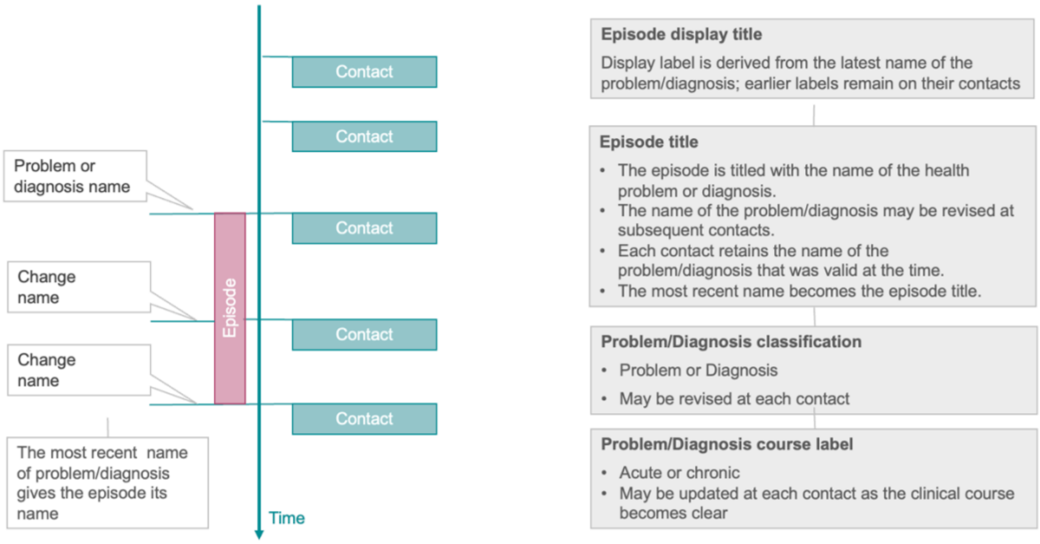


Figure 4 – Episode-of-Care – Name of health problem and episode title

Over time, new clinical insights may require the revision of existing episodes, for example when previously separate health problems are recognised as causally related, or when a single problem proves to encompass distinct underlying conditions. In such cases, the ability to merge or split episodes is essential. The associated medical record entries (e.g. observations, notes, orders, results, interventions) must also be reassigned to maintain semantic and temporal consistency.

- Merge: Two or more episodes are consolidated into a single episode when they are determined to represent the same underlying health problem.
- Split: A single episode is divided into multiple episodes when it becomes clear that the original documentation encompasses more than one condition.
- Transfer: Individual record entries are reassigned from one episode to another when they more appropriately belong to a different problem context.

2.2.6 Distinction from the term Episode

The term *Episode* is used inconsistently in healthcare and often causes confusion. In hospital operations and billing, for example, it commonly denotes an administrative period from admission to discharge used for activity reporting and costing. In primary care, an episode of care describes the period from the first to the last contact relating to the same health issue. Another nuance is the use of an episode of care to denote a period of organisational responsibility during which multiple encounters can occur. These differing uses as an administrative stay, a problem-oriented trajectory and a period of responsibility explain the ambiguity of ‘episode’.

Aligned with Solon's methodology, an episode of care is defined as a time-bounded set of interactions relating to a single health problem. It begins when the problem is first recorded at the initial contact and ends with the last contact when the problem is resolved or concluded. All contacts and their documentation are associated with that episode as event-level interactions. Administrative counting constructs remain separate and are not used as clinical aggregation units.

2.3 Medical Record Entry

2.3.1 Definition and characteristics

A *medical record entry* is a discrete unit of clinical documentation in the electronic health record that captures a single clinical concept or decision, such as an observation, measurement, assessment, order, or procedure, together with the contextual information necessary for interpretation. Each record entry is time-stamped to indicate when it occurred or was first identified. It is attributable to a specific source, such as a healthcare professional, device, or system, and is linked to the patient contact during which it was recorded.

Each medical record entry constitutes a single clinical statement. Subsequent corrections or updates are recorded as new versions or additional entries rather than silent changes. Typical examples include a blood pressure measurement, a potassium result, a focused physical finding, a diagnostic result or confirmed diagnosis, a medication order, a documented procedure, or a concise progress note.

Every clinical concept and its data elements within a medical record can be linked to standardised terminologies such as SNOMED CT, LOINC, ICD-10 and ICPC-2.

2.3.2 Clinical sections

In everyday clinical practice, medical records are organised into sections with recognisable headings that group information on the same clinical theme. Examples include *History of Present Illness*, *Past Medical History*, *Physical Examination*, *Diagnostic Studies*, *Assessment and Plan* and *SOAP Progress Notes*. The complete list of clinical sections is provided in Appendix A.

These clinical sections provide a consistent framework for related documentation, combining structured data and narrative text where appropriate. Using a consistent set of sections provides a uniform context for each entry, so the same type of information appears in the same place. This makes it easier to locate and compare information across contacts and over time.

Every medical record entry is assigned to at least one clinical section, which provides the content focus. Clinicians read and write the record in these sections. Some sections are contact-specific, such as progress notes, the examination and plan documented at a given visit, whereas others are longitudinal and persist across contacts, such as the problem and diagnoses list, medications, and allergies. This distinction enables the record to show both the chronological course of care and the enduring elements of a patient's history.

2.3.3 Progress notes

In an episode-oriented medical record, progress notes are created for each event related to a health problem and are linked to the relevant episode of care. Each note is a specific type of medical record entry: it is time-stamped, attributable to its author, and linked to both the contact as the event context and the episode as the health problem context. This dual linkage preserves the evolution of care while maintaining a coherent narrative across the episode of care.

Progress notes follow the SOAP structure according to Weed's methodology:

- Subjective: the patient's reported symptoms, concerns, and relevant context
- Objective: observable findings and measurements (examination, tests, monitoring)
- Assessment: clinical interpretation and reasoning, including working hypotheses
- Plan: intended diagnostics, treatments, counselling, follow-up, and contingencies

With the progress notes in the SOAP format, the patient's information, observations, interpretations and planned measures are recorded and presented separately. This ensures that clinical considerations and measures are transparent, comparable across individual visits and traceable within the time frame of the episode. This method supports continuity of care, verifiability and efficient recording of what has changed, why it has changed and what is planned next.

Documenting progress in SOAP form at each contact ensures that clinical reasoning and actions are transparent, comparable across contacts, as well as being traceable within the episode timeline. This method supports continuity of care, auditability, and the efficient retrieval of information about changes and plans.

Healthcare professionals often prefer to enter SOAP progress notes as free text in the four designated fields. To ensure a consistent presentation of progress notes alongside structured entries, each medical record entry should be assigned to one of the four SOAP fields. This can be done directly at the entry level or indirectly by allocating each clinical section to a SOAP field.

2.4 Clinical Lists in an Episode-Oriented Record

In everyday clinical practice, overviews in the form of lists provide quick orientation and a common working context. Within an episode-oriented medical record, lists are not separate sources of truth but derived, structured views over the underlying episodes of care (health problems) and medical record entries. They support navigation, reconciliation, and decision-making across contacts and over time.

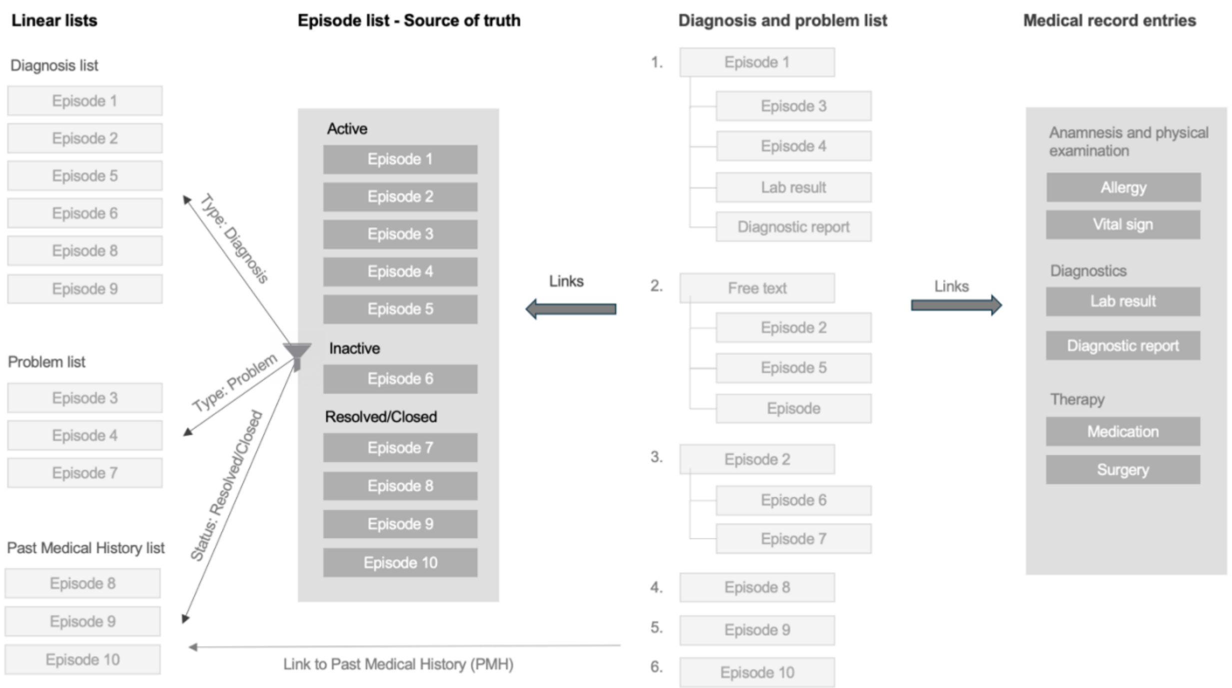


Figure 5 – Summary of all lists based on the episode list and medical record entries

2.4.1 Episode list

The totality of a patient's health problems results in a linear episode list. Episodes can be shown as a flat timeline or grouped by attributes such as status (active, inactive, resolved/closed) and clinical course (acute, chronic). In day-to-day care, the active episode list reflects the problems currently under investigation or treatment and thus serves as a natural agenda for the encounter. Filtering to active items only and sorting, for example by recency or priority, add focus without altering the underlying data.

2.4.2 Diagnosis list

A diagnosis list is a filtered view of the episode list that selects episodes currently classified as diagnosis rather than problems. It can be grouped, sorted, and filtered further according to clinical or administrative criteria. Because it is derived, consistency with the episode list is maintained automatically as the episode name or other attributes are updated.

2.4.3 Problem list

A problem list is the complementary filtered view that selects episodes currently classified as health problem rather than diagnosis. It can be grouped, sorted, and filtered further according to clinical or administrative criteria. Because it is derived, consistency with the episode list is maintained automatically as the episode name or other attributes are updated.

2.4.4 Past medical history list

All episodes whose status is resolved or closed are recorded in the past medical history list. The past medical history list may be displayed chronologically by onset or resolution date, or grouped by event type such as illnesses and injuries, providing a concise longitudinal summary. In everyday practice, only items that are clinically relevant for the patient, the specialty, or the current care context are prioritised for display, while the remainder remain available on demand. This prioritisation can be automated by an inclusion flag and were helpful, a priority level stored with the episode. The detailed clinical content remains in the source episodes and entries, the past medical history functions as a curated index back to those sources. At the start of care, relevant past medical history items may also be captured directly and created as episodes with a resolved or closed status. This ensures that the episode list, diagnosis list, problem list, and past medical history are generated consistently and automatically.

2.4.5 Diagnosis and problem list

The diagnosis and problem list is a central element of the problem-oriented medical record according to Weed and is also created and maintained in the episode-oriented medical history according to Solon.

Instead of providing a generic overview, the diagnosis and problem list can be organised as a linked hierarchy, grouping related diagnoses and problems (episodes) together and providing pointers to the most important primary data in the medical record. Rather than being a static catalogue, this system is a map curated by healthcare professionals that illustrates the landscape of a patient's condition.

Diagnoses and problems are often interdependent. The hierarchy reflects this by arranging items according to their clinical importance and their relationship to one another. A main diagnosis or overarching problem is placed at the highest level, with associated problems or specific diagnoses indented beneath it. Where useful, primary data snippets or links are attached alongside indicative keywords. These may include key history, examination findings, vital signs, lab highlights, brief imaging conclusions, medications, minor procedures and surgeries. The hierarchy thereby concentrates the most decision-relevant evidence near the statements it supports.

Example diagnosis and problem list

1. Urinary tract infection (22.03.2024)
2. Coronary heart disease with/without
   - Arterial hypertension (Dx 2009)
   - Heart failure
   - History of Myocardial infarction (2015)
3. Diabetes mellitus type 2 (Dx 2007)
   - Polyneuropathy (Dx 2014)
   - Nephropathy (Dx 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. Cholecystectomy (1988)
7. Appendectomy (1965)

Figure 6 – An example of a simple diagnosis and problem list

The list is implemented as a tree with main nodes, sub nodes, and terminal nodes. Each node primarily serves as a link back to source information in the medical record:

- a link to a health problem (episode of care)
- a link to a past medical history item
- a link to a medical record entry (e.g. anamnesis, physical examination, vital signs, allergies, laboratory values, brief diagnostic findings, medications, minor procedures, surgeries)
- a brief free-text annotation

Nodes can be rearranged; when a parent node is moved, its child nodes move with it. Main nodes are consecutively numbered to reflect clinical prioritisation, and renumbering occurs automatically upon reordering or insertion. Sub nodes and terminal nodes are visually associated without numeric prefixes, keeping the focus on the clinical structure.

Where a node links to a medical record entry (e.g. BMI), the linkage can be static, showing the value at the time, the link was created, or dynamic, always showing the current value. This distinction enables traceable snapshots and live views to be provided, depending on clinical need.

As nodes are references, any changes to the displayed content are made at the linked source (episode or record entry). Removing a node only deletes the link; the source item remains intact in the medical record. All modifications to the tree, such as insertions, moves, renaming's and removals, are logged in the audit trail, enabling the diagnosis and problem list to be reconstructed at any point in time. This provenance safeguards clinical auditability and supports longitudinal analysis.

In practice, two complementary views of the hierarchical diagnosis and problem list are useful. The *master diagnosis and problem list* is a longitudinal index of the patient that aggregates information from all episodes and contexts. The *contextual diagnosis and problem list* provides a more focused view, limited to a specific care context, such as the current episode, specialty service or encounter. This ensures that the team can see exactly what is relevant in the present moment. Both views draw on the same underlying episodes and entries, differing only in scope and presentation. This ensures consistency while meeting the needs of everyday clinical work [23].

2.5 Solution Design

Having defined the core concepts - *contact, episode of care, medical record entry*, and *clinical section* – we can outline a sophisticated architecture for an episode-oriented medical record on which to base the solution design.

2.5.1 Logical architecture

Contact is the smallest unit on the care timeline. It records an event, including the time, place, participants, and context. One contact may address more than one health problem. A partial contact divides the documentation of a single contact into parts, each of which can be associated with one episode of care [42].

An *episode of care* is the problem-oriented period that aggregates one or more contacts with one or more healthcare professionals for the management of a single health problem. The episode serves as the organising container for that health problem. As clinical understanding evolves, the health problem name and attributes may be revised at subsequent contacts. The episode title is always the most recent health problem name, whereas each contact retains the health problem name that was valid when the documentation was recorded.

Every contact is linked to at least one episode of care. When a single contact addresses multiple health problems, partial contacts partition the documentation so that each portion, along with its associated medical record entries, is attached to the correct episode. This preserves clear problem context while ensuring that event-level documentation is accurate and traceable [42].

A *medical record entry* is a discrete clinical statement, such as an observation, result, assessment, order, procedure, or progress note. Each record entry is time stamped and attributable to its author. It must be linked to the contact in which it was documented, so the event context is explicit. Each record entry must also be linked to exactly one episode of care to provide the health problem context.

In line with Solon's methodology, this episode link is strictly one to one: one record entry to one episode. In everyday practice, enforcing a strict one-to-one mapping for every entry can be challenging; therefore, recording associated links to other episodes is often pragmatic and clinically useful. These associated links do not alter the required primary association.

In everyday clinical practice, not every medical record entry can be assigned to a specific health problem. To accommodate this in practical implementations of a medical information system, a standard episode of care *General health problem* is provided as the default for such documentation.

Clinical sections provide stable headings under which record entries are organised. They create a uniform place for similar information and allow clinicians to read and write consistently across contacts and over time. Accordingly, each entry is linked to a clinical section - such as History, Examination, Diagnostic Studies, or Assessment and Plan - providing a consistent, overarching content context.

To ensure consistent *semantic referencing*, each data element in a medical record entry is given a unique and stable internal code. To achieve semantic interoperability, these elements are mapped to recognised international terminologies, such as SNOMED CT, LOINC, ICD-10 and ICPC-2, or to locally defined value sets.

2.5.2 Conceptual data model

The corresponding entity view is straightforward and simple. Patients and healthcare professionals participate in contacts, with each contact linked to a patient and to one or more healthcare professionals. Episodes of care are associated with contacts via explicit links. A single contact can contribute to more than one episode, and the partial contact construct ensures that the appropriate portion of documentation is assigned to a single episode. Each episode stores its name, status, and references to the first and last contact. Every medical record entry belongs to exactly one contact and one episode of care and has one clinical section. Each record entry carries the event time and authorship and, where appropriate, additional timestamps such as transaction or validation dates. It may also include terminology bindings for its data elements.

The diagnosis and problem list is maintained as a linked hierarchical tree in which nodes refer to episodes, past medical history items, specific record entries, or concise free-text annotations. Reordering the hierarchy changes only the links and presentation; it does not alter the underlying sources.

In this model, lists are derived views rather than independent stores of data. This means they automatically remain consistent as names, statuses or relationships evolve. The result is an architecture that preserves event-level fidelity through contacts and record entries, organises care longitudinally via episodes and clinical sections, and facilitates clear navigation and reliable analysis.

The following figure illustrates the conceptual data model derived from the basic logical architecture. It presents the fundamental tables, without including the primary and secondary key fields. Only the attributes necessary for understanding are listed per table.

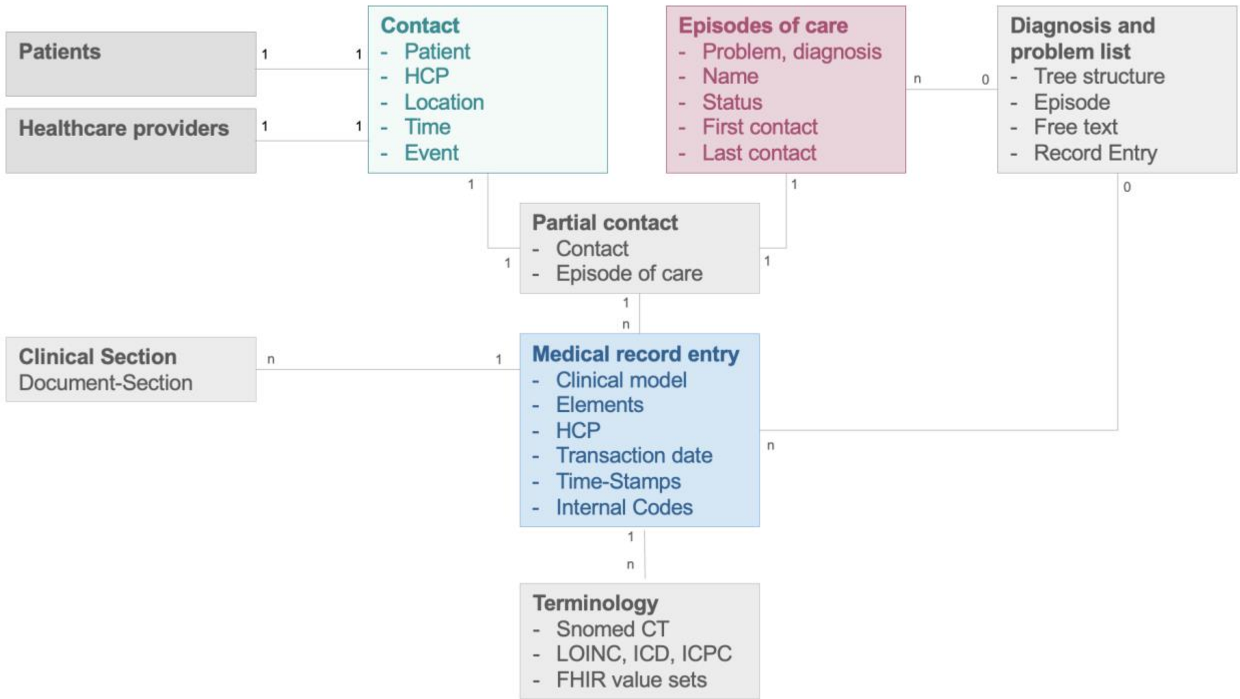


Figure 7 – Entity-relationship model of the episode-oriented medical record

2.5.3 Key Advantages of the model

Taken together, these concepts give every item of documentation three complementary anchors: the clinical section defines what kind of content it is; the contact provides the event context - when, where, and with whom it was documented; and the episode of care supplies the problem-oriented context - which health problem it belongs to. These anchors create clear, clinician-friendly guidance: medical record entries remain specific and traceable at the level of the event, while the record stays readable and navigable across the course of care. The approach is technology agnostic and suitable for multi-professional documentation across one or more organisations and health sectors.

Lists such as the episode list, diagnosis list, problem list, the hierarchical diagnosis and problem list, and the past medical history list are derived views of the same underlying information rather than separate sources of truth; they therefore remain consistent as names, statuses, or relationships evolve.

2.6 openEHR

This thesis presumes a working familiarity with general openEHR concepts and terminology. The brief recap below highlights only those aspects relevant to the research context.

2.6.1 General overview

openEHR is an open specification for electronic health record systems which addresses healthcare data interoperability thanks to its multi-level modelling approach. This architecture separates stable structural components from dynamic clinical content, enabling sustainable, vendor-independent health information management. The standard was developed in response to the issue of traditional electronic health record systems often creating data silos that impeded long-term accessibility and cross-organisational data exchange.

The foundation consists of the Reference Model, which provides the structural framework for health data storage and exchange, including demographic information, clinical data organization, and versioning mechanisms. This model defines core classes such as EHR, COMPOSITION, and ENTRY, establishing a standardized approach to representing clinical information regardless of its specific content. Clinical knowledge is captured through ARCHETYPES and TEMPLATES, which serve as reusable, standardized definitions of healthcare concepts. Archetypes define specific clinical elements such as vital signs, laboratory results, or clinical observations, while templates combine multiple archetypes to support complete clinical workflows and documentation scenarios.

The Archetype Definition Language (ADL) enables formal specification of clinical content models, allowing healthcare organizations to share and reuse validated clinical knowledge representations. This approach promotes semantic interoperability by establishing common clinical data definitions that transcend individual software implementations or organizational boundaries. The Clinical Knowledge Manager (CKM) serves as a collaborative platform where healthcare professionals and informaticians can develop, review, and publish archetypes, ensuring clinical validity and consensus-based standardization.

openEHR's design philosophy prioritizes long-term data preservation and accessibility, addressing the critical healthcare requirement for storing patient records over several decades. The separation between clinical models and technical implementation ensures that healthcare data remains interpretable and usable regardless of changes in underlying software systems or vendors. This approach directly addresses the problem of vendor lock-in that has historically plagued healthcare IT systems, where organizations become dependent on specific software providers to access their own clinical data.

The standard supports sophisticated querying capabilities via the Archetype Query Language (AQL), enabling complex clinical data retrieval across heterogeneous datasets. This functionality is particularly valuable for clinical research, population health management and quality improvement initiatives. AQL's path-based syntax allows users to navigate the hierarchical structure of openEHR data and extract specific clinical information while maintaining the semantic context of the original documentation.

Governance and standardization within the openEHR community follow established international processes. The openEHR international organization oversees specification development, while regional and national programs adapt the standard to local healthcare contexts and regulatory requirements. This distributed governance model has facilitated adoption across diverse healthcare systems, from small clinical practices to large integrated health networks.

Current developments demonstrate growing adoption and integration with other healthcare standards. Recent implementations have shown improved performance and stability, while discussions around convergence with complementary standards such as FHIR indicate openEHR's evolving role within the broader health informatics ecosystem. The relationship between openEHR and FHIR is particularly significant, as organizations increasingly recognize the complementary nature of these standards – openEHR providing robust clinical data persistence and FHIR enabling efficient data exchange and application integration.

Implementation experiences across various healthcare contexts have revealed both opportunities and challenges. Success factors include strong clinical engagement in archetype development, adequate technical infrastructure, and organizational commitment to data standardization. Challenges often involve the initial complexity of the modelling approach and the need for specialized knowledge during implementation phases. However, organizations that successfully adopt openEHR report significant benefits in terms of data quality, clinical workflow support, and long-term system sustainability.

The open-source nature and active community development continue to drive innovation while maintaining clinical validity and technical robustness. This collaborative approach ensures that the standard evolves in response to real-world healthcare needs while preserving the fundamental principles of interoperability and data longevity that define openEHR's value proposition [24].

2.6.2 Fundamental architecture of openEHR

2.6.2.1 Overview

The openEHR architecture embodies over 20 years of research from numerous projects and standards from around the world. It has been designed based on requirements captured over many years, including those developed in the EU FP3 Good European Health Record (GEHR) project (1992-1995). The architecture provides a multi-level modelling approach that separates stable information structures from domain-specific content definitions on three levels:

1. A stable Reference Model (RM) that provides generic information structures
2. Reusable definitions of clinical content in the form of *archetypes* that specify data points and groups
3. Context-specific data set definitions expressed as *templates* that combine and restrict elements from relevant archetypes for specific use cases, such as forms, documents and messages

The openEHR specifications are closely aligned with ISO 13606 – *Health informatics – Electronic health record communication* – particularly Parts 1 (Reference model) and 2 (Archetype model and archetype interchange). Parts 3–5 cover reference archetypes and term lists, security, and interface specifications. This shared lineage explains why openEHR and ISO 13606 concepts map well.

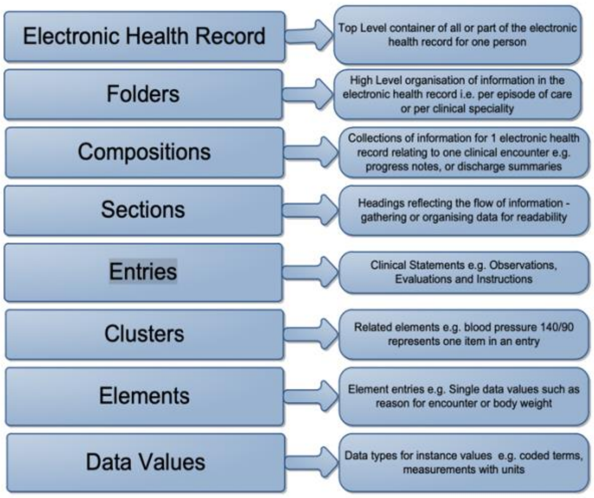


Figure 8 – ISO 13606 core components as a foundation for openEHR

2.6.2.2 Core structural components

EHR (Electronic Health Record) is the root container for a patient’s longitudinal health record. A central EHR object, identified by an EHR identifier (EHR id), maintains references to structured, versioned content and includes a list of CONTRIBUTION objects that provide the audit trail for changes to the record. The EHR provides:

- Unique identification (EHR id)
- Access control management (EHR_ACCESS)
- Status information (EHR_STATUS)
- Versioning and audit trail (CONTRIBUTION)

FOLDERs organise the record within an optional EHR Directory hierarchy. FOLDERs act like a directory by holding references (not copies) to versioned compositions, can contain subfolders, and may carry metadata describing the grouping (e.g. title, status, dates). They support navigation and indexing without altering the clinical content or its audit trail.

COMPOSITIONs are versioned containers for the clinical and administrative content of the record. They hold structured, coded data as granular clinical statements expressed as ENTRY instances (e.g. procedure, blood pressure, allergy). Each COMPOSITION represents a complete clinical document or encounter and serves as the committal unit to the EHR.

SECTION is an optional heading inside a COMPOSITION that groups related content for readability, such as History, Examination, Assessment. It provides document structure and navigation, without changing the clinical meaning or provenance of the enclosed entries.

ENTRY instances represent all clinical information in the EHR. An ENTRY expresses a single archetype-based clinical statement and may take the form of a brief narrative or encapsulate substantial structured data, such as a full laboratory panel, a coded diagnosis with status and dates, a medication order with dose, route and frequency, or a recorded procedure with timing and outcomes. There are five ENTRY subtypes:

- OBSERVATION – measurements and findings (e.g. blood pressure, laboratory results)
- EVALUATION – clinical opinions and assessments (e.g. diagnoses, risk assessments)
- INSTRUCTION – intended interventions and orders (e.g. medication prescriptions, planned procedures)
- ACTION – what was actually carried out (e.g. medication administered, procedure performed)
- ADMIN_ENTRY – administrative facts (e.g. appointments, admissions)

An ELEMENT is a leaf node within an entry's data structure. It contains one clinical value (a DV_* type), along with its units and/or coding, as well as metadata such as null semantics and, where relevant, precision. ELEMENTs represent the most granular data points that make up the record (e.g. systolic and diastolic blood pressure, cuff size, potassium level and pain score).

This openEHR architecture provides a robust foundation for interoperable electronic health records through its hierarchy from EHR to ELEMENTs, combined with archetype-driven semantic modelling. This design supports both technical interoperability and semantic consistency across healthcare settings while maintaining flexibility for diverse clinical use cases.

2.6.3 openEHR Reference Model (RM)

2.6.3.1 Overview

The openEHR Reference Model (RM) defines a stable reference information model that constitutes the first level of modelling in the multi-level architecture. While archetypes define the clinical content structures, the reference model defines the generic containers, attributes, and data types that ensure consistent capture, storage, versioning, and retrieval across implementations.

2.6.3.2 Core principle

The reference model is the computational foundation on which archetypes operate. Clinical content conforming to the reference model is *archetypable*, meaning that creation, modification, and querying of clinical content are constrained by archetypes and templates, while the reference model remains stable. This separation lets clinical models evolve without changing the underlying technical platform.

2.6.3.3 Essential reference model attributes for clinical documentation

The openEHR reference model provides a small number of universal attributes, such as authorship, subject, timing, setting, location, version and audit, which are automatically available to all archetyped content. While most clinical detail is modelled in archetypes, these RM-level attributes are carried with every entry as if native to the archetype, ensuring the essential metadata needed for clinical documentation and medico-legal compliance [25].

The basic reference model attributes are located in the COMPOSITION. Additional reference model attributes are defined for each ENTRY subclass (Observation, Evaluation, Instruction, Action), which supplement or specify the attributes of the composition. The following table shows the reference model attributes at the COMPOSITION level:

Reference Model (RM) Attribute	Remarks
Health Record (RM: ehr) EHR Occurrences: 1..1	Every Composition is associated with the Health Record of a specific patient when it is stored, and the 'patient' does not have to be modelled in an archetype.
Category (RM: category) Coded Text Occurrences: 1..1	Indicates a broad category of the Composition: persistent - of longitudinal validity, episodic, event.
Author (RM: composer) PARTY PROXY Occurrences: 1..1	The author/composer is the person who is responsible for creation of the content of the clinical document/composition.
Attestation Details (RM: version/attestations) ATTESTATION Occurrences: 0..*	Records the date, time and other details of attestations of a clinical document/composition by a person other than the author/composer e.g. a senior clinician who needs to 'sign-off' or verify a report authored by a junior member of staff
Date and Time Recorded (RM: ../contribution/audit/commit_time) Date/Time Occurrences: 1..1	The date and time that the clinical document/composition is saved to the electronic health record.
Event Start Time (RM: context/start_time) Date/Time Occurrences: 1..1	Start time of the clinical session or other kind of event.
Event End Time (RM: context/end_time) Date/Time Occurrences: 0..1	Optional end time of the clinical session or other kind of event.
Participation (RM: context/participations) Participation Occurrences: 0..*	Identification of individuals/parties involved in the event, the method by which they interacted, and the duration of the interaction. Individuals could include family members, nurses, specialists etc. Methods of interaction could include via phone call, email, face to face consultation etc.
Healthcare Facility (RM: context/health_care_facility) PARTY IDENTIFIED Occurrences: 0..1	The Healthcare Facility or Organisation in which the session/event took place. This is the most specific workgroup or delivery unit within a care delivery enterprise that has an official identifier in the health system and can be used to ensure medico-legal accountability.
Specific Location (RM: context/location) String Occurrences: 0..1	The specific location within a facility or organisation where the session/event occurred, e.g. 'microbiol lab 2', 'home', 'ward A3'.

Table 2 – Reference model attributes at the COMPOSITION level

2.6.3.4 openEHR CONTRIBUTION

A CONTRIBUTION is the change set record for a single EHR. It is the atomic unit of commit and audit and has its own identifier. Each CONTRIBUTION becomes part of the ordered history of that EHR, enabling reconstruction of its exact state at any time. Once committed, a CONTRIBUTION is immutable. Any subsequent amendment results in a new CONTRIBUTION and extends the history in a clear and traceable way.

A CONTRIBUTION links the VERSION instances that were created or updated within a given unit of work across items such as COMPOSITION, FOLDER, EHR_STATUS and EHR_ACCESS. It does not duplicate clinical content; instead it binds the affected versions into one coherent change set, separating clinical meaning from operational provenance. The audit details of the CONTRIBUTION record the identity of the committer, the identifier of the contributing system, the time committed, the type of change and an optional free text description. This intrinsic provenance provides accountability and supports safe collaboration without altering the clinical data.

2.6.3.5 Technical implementation considerations

openEHR's versioning model treats every logical change – additions, corrections, imports, deletions, or attestations – as a new committed version. This append-only approach produces a complete, tamper-evident audit trail, supports medico-legal requirements, and enables safe sharing across distributed systems without compromising data integrity.

All Composition commits are performed inside a Contribution. A Contribution can include several Compositions and is committed as one coherent change set with a single audit envelope. In typical REST interfaces, posting a single Composition causes the server to create the enclosing Contribution automatically. A dedicated Contribution resource can also be used to submit a change set that contains multiple Compositions for the same EHR in one transaction. This provides a single provenance record and consistent commit timing for the group of changes while preserving the separation of clinical content from its audit trail.

Security is addressed at multiple levels. Clinical content is separated from identifying demographics, allowing anonymity where required. Access can be configured at a fine granularity so that different users or roles see only the content they are entitled to. Where stronger guarantees are needed, digital signatures provide cryptographic verification of content integrity and authorship.

Interoperability is underpinned by the reference model's standardized metadata – authorship, subject, timing, setting, facility, provenance – which travel with the data. These invariants allow consistent clinical queries regardless of the specific archetype used and support reliable exchange while preserving clinical context and audit information.

In summary, the openEHR reference model provides invariant platform semantics, such as authorship, participation, subject, event context (time, setting, location and facility), provenance, versioning and attestation, while archetypes and templates carry variable clinical content. This separation enables systems to evolve clinically by updating content models without changing the platform. It also ensures that every persisted item includes the context and audit evidence required for safe and legally compliant documentation, reliable exchange and consistent querying across settings.

3 Research Design and Methods

3.1 Methodological Approach

This study adopts the Design Science Research (DSR) paradigm, complemented by a conceptual proof-of-concept (PoC) demonstration. Design science research is well suited to the development and rigorous evaluation of IT artefacts – in this case, an episode-oriented representation of the medical record according to Solon. In line with the scope of the study, no functional prototype or end-user application has been implemented. Instead, feasibility is demonstrated, insofar as possible, through API-level verification using curated Postman collections run against the EHRbase sandbox. The PoC demonstrates the practical applicability of the model when operationalised with openEHR archetypes/templates and relationship mechanisms, and highlights design trade-offs. The focus is on designing and verifying the information model and retrieval patterns, rather than UI/UX, performance engineering, or system integration.

3.2 Procedure

3.2.1 Development phase

The development phase established the conceptual and technical foundation. First, five openEHR masterclasses (delivered by Rosaldo) were completed to consolidate domain knowledge and best practices. Building on this, the official openEHR specifications were analysed in depth with particular attention to information model layers, archetype/template semantics, and relationship mechanisms.

In parallel, a systematic literature review was conducted to characterise episode-oriented approaches to clinical documentation, identifying requirements for computability and interoperability in the process. Three reference documents, *Basic Concepts of Electronic Medical Records* [43], *Diagnosis and Problem List: Requirements in outpatient care* [44] and *Requirements, Architecture, and Information Model for an Episode-Oriented EMR in accordance with the Solon methodology* [45], were created to make the conceptual model, assumptions and design decisions explicit. Finally, the existing relational data model was transposed to the openEHR architecture by mapping entities and relationships to compositions, entries, clusters and templates, and by defining explicit relationships between the objects.

3.2.2 Validation phase

Validation proceeded along three axes. First, a sample patient record covering the relevant use cases and including both acute and chronic trajectories was assembled to demonstrate temporal coherence. Secondly, eight user stories were formulated as functional requirements and linked to specific model features and query patterns. Thirdly, the design itself was developed by modelling the relevant objects and systematically examining alternative openEHR relationship mechanisms. The competing approaches for representing the episode-oriented methodology were then assessed using a structured evaluation template with predefined criteria. For each modelling option, the advantages and limitations were documented to enable transparent, evidence-based decision-making.

3.3 Quality Assurance

Quality assurance combines structured mentoring and standards conformance. Scientific guidance is provided through mentoring by FreshEHR, complemented by adherence to recognised best practices from three decades of experience in electronic medical record management by the author. Conformance checks are validated using openEHR tooling, internal design reviews and a traceability matrix linking requirements, user stories and model elements.

3.4 Ethical and Legal Considerations

No real patient data is used. All examples use synthetic or publicly shareable de-identified data.

3.5 Evaluation Criteria and Measures

The artifacts are evaluated based on predefined criteria: a) Correctness: the semantics of episodes and relations comply with the Solon concept and openEHR restrictions; b) Completeness: coverage of the identified use cases and user stories; c) Queryability: important AQL queries are executed and return the expected results; d) Consistency, terminology bindings are unique and reusable; and e) Usability for secondary purposes such as the ability to support longitudinal queries and analyses.

3.6 Systematic Literature Review Protocol (Summary)

A scoped literature and standards review was performed using predefined keywords as guidance, without a formal systematic protocol. Screening emphasised recency and relevance to episode-oriented documentation and openEHR. The synthesised findings were recorded and used to derive the requirements and support modelling decisions.

3.7 Reproducibility and Artefact Availability

All artefacts are versioned in a public repository unless the licence does not allow this. Tool versions and configurations are recorded to ensure repeatability.

3.8 Limitations and Threats to Validity

The study focuses on modelling and a lightweight proof of concept rather than a production-ready implementation; generalisability is limited by the number of scenarios considered. Risks to construct validity, such as mapping distortions from the relational model, are mitigated by expert review.

4 Results

4.1 Conceptual Architecture for Modelling

All requirements of Solon's episode-oriented medical record can be expressed as a small set of core components and their mandatory relationships. An administrative encounter may include multiple contacts, each a point-in-time care event. Each contact results in one or more COMPOSITIONs that contain archetyped medical record entries. Each ENTRY carries an explicit primary link to one episode of care and its associated health problem. In everyday clinical practice, additional associated links to other episodes can be recorded where appropriate. This provides the starting point for modelling in openEHR.

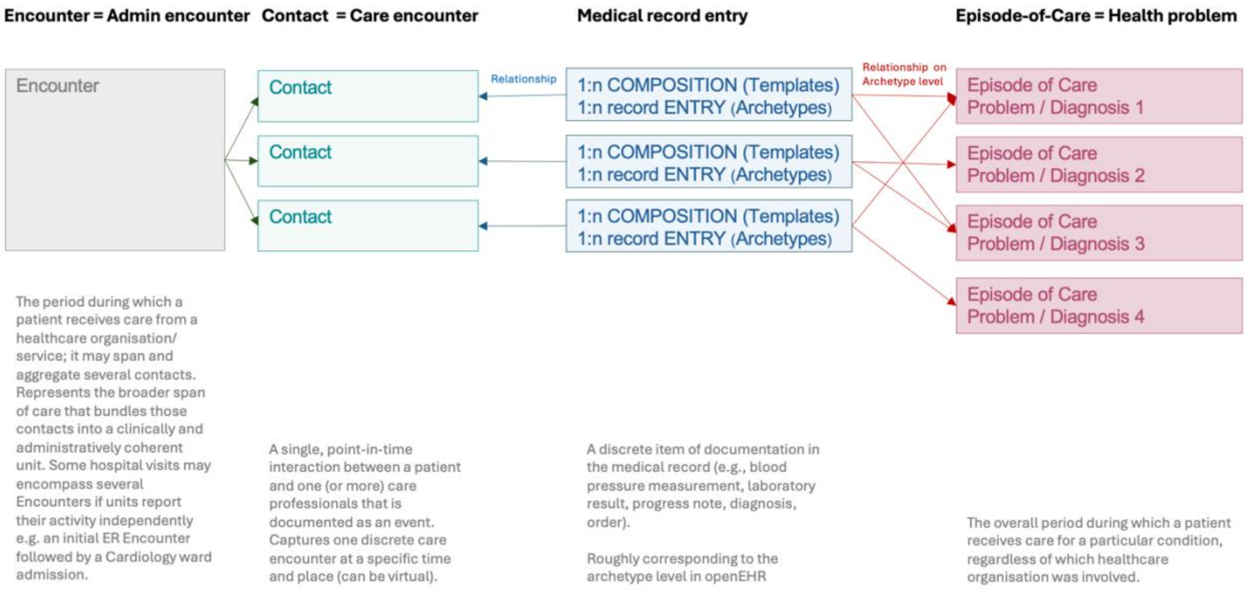


Figure 9 – Conceptual Map: Encounter, Contact, Medical record entry, Episode-of-Care

4.2 Legacy Implementations as a Design Baseline

Previous implementations of the episode-oriented medical record, as defined by Solon, have typically been delivered as proprietary solutions on relational database platforms. In this environment, the core domain objects – contact, episode of care and medical record entry – map cleanly to a normalised schema: contacts and episodes are first-class tables, mandatory relationships are enforced with foreign keys, and the required one-to-one association of each record entry with exactly one episode is represented explicitly using a partial-contact construct where a single contact spans multiple problems. Derived lists, such as the episode, diagnosis, problem, and past medical history lists, are implemented as queries or views over the same tables, thus preserving a single source of truth. This object-oriented design on a relational database has been shown to be implementable, supporting clear links between objects while maintaining both event-level detail and longitudinal problem context.

4.3 Overview of Implementation Options in openEHR

Clinical content in the openEHR architecture is represented as committed compositions originating from real-world documents or forms. These compositions are modelled using templates composed of archetypes to structure the related entries. Compositions can be organised via an optional folder directory that indexes the record by holding references to versioned objects rather than copies. In addition, explicit links can be established between compositions and between individual archetyped entries to express clinically meaningful relationships without duplicating data.

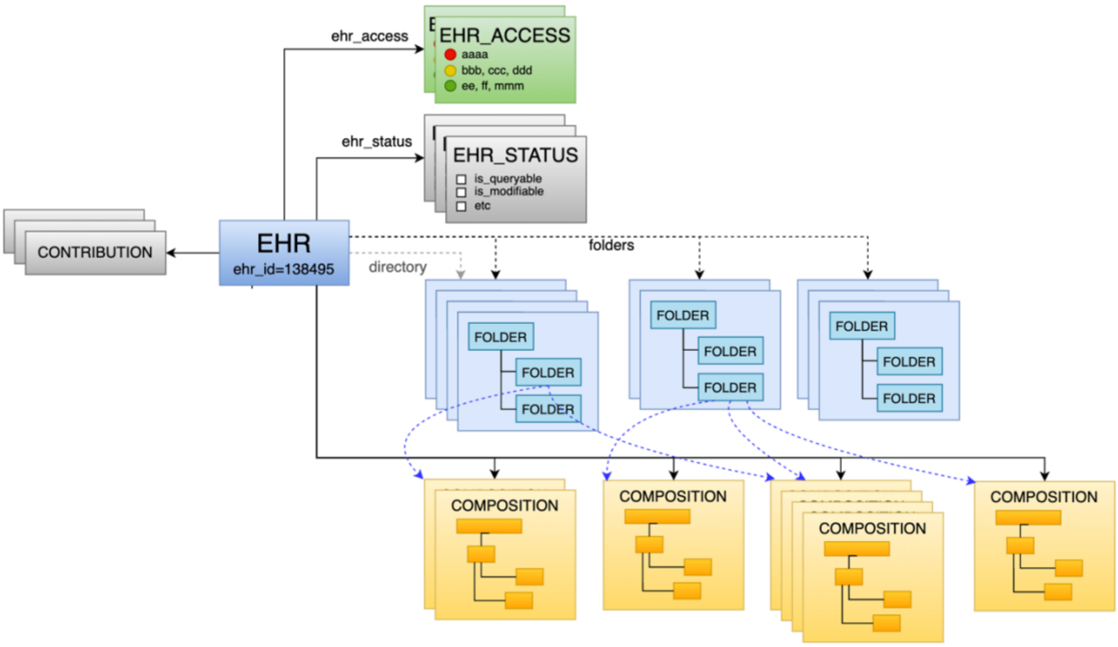


Figure 10 – Basic architecture of openEHR

The episode-oriented record proposed by Solon is organised around events and problems, whereas the base openEHR architecture is primarily content-centric and document-centred. In openEHR, clinical content is authored as archetyped ENTRY instances contained within a COMPOSITION representing a committed clinical document or note. The context of a given statement is derived mainly from the ENTRY subtype (observation, evaluation, instruction, action, or admin entry), together with the reference model attributes. SECTION is used to create headings inside a composition or template to organise content for readability. Sections provide familiar document structure, but they are not the primary carriers of clinical semantics.

In other words, the openEHR base model focuses on how clinical statements are expressed and packaged, whereas Solon's episode-oriented approach adds explicit organising constructs – contact and episode of care – to anchor those statements in event and problem contexts.

According to the openEHR specifications, *contact* and *health problem* as the clinical content of an episode of care are modelled using templates that assemble and constrain the relevant archetypes. Each *medical record entry* conforms to a specific ENTRY archetype (OBSERVATION, EVALUATION, INSTRUCTION, ACTION, or ADMIN_ENTRY) and is placed within the appropriate template for the use case being modelled.

The openEHR specification provides several mechanisms for expressing relationships between contacts, episodes of care and medical record entries:

- FOLDER (EHR.directory): Hierarchical index of references to compositions
- LINK between LOCATABLEs: Typed links connecting compositions and archetyped items at the reference model level

- Link elements within CLUSTER archetypes: EHR-internal references as DV_EHR_URI ELEMENTs inside a CLUSTER
- TAGS on compositions: Labels for indexing/filtering (outside the openEHR standard and not considered in this thesis)

As an additional, non-normative layer, this thesis applies the ContSys concepts of *health threads* and *health issues* to curate the *diagnosis and problem list* and *past medical history list* across episodes. Health Issues modelled as EVALUATIONs are organised under Health Threads and link to the underlying event COMPOSITIONs/ENTRYs, preserving provenance while enabling problem-oriented navigation and longitudinal summarisation. This conceptual layer sits above the episode-oriented openEHR structure, grouping rather than duplicating data [26, 40-41].

4.4 Templates

The architecture is operationalised by modelling openEHR templates. Each template aggregates and constrains the required archetypes, defining cardinalities, value sets and term labels, to create an implementable content model. Templates are authored in the Archetype Designer applying consistent naming, versioning, and terminology bindings, and validated using test instances. As a guiding principle, CKM-published archetypes at version 1 or higher are used wherever possible, benefiting from governance, clinical review, semantic stability, broad tool support, and predictable upgrade paths. As part of this thesis, several templates were modelled in collaboration with the mentoring team. They are available in the thesis's public GitHub repository [55].

4.4.1 Contact

The *Contact* is modelled as a point-in-time care event with predominantly organisational and administrative content. As the top-level container, the archetype openEHR-EHR-COMPOSITION.encounter.v1 is used. This COMPOSITION is intended to represent a clinical encounter and provides the required reference model context (e.g. start/end time, setting, location, health-care facility, composer, participations), while also allowing additional context items to be carried in `COMPOSITION.context.other_context` and constrained at template level. This composition-archetype has been chosen because there is no CKM-published composition with the purpose for *Contact*.

To reflect the thesis's distinction between *encounter* and *contact*, the following naming is adopted:

- Contact = Care Encounter
- Encounter = Admin Encounter (Service Encounter)

Accordingly, the template is labelled *Care Encounter*. The *Admin Encounter* can be modelled in two ways: either within the care encounter template using ADMIN_ENTRY archetypes with supporting CLUSTER nodes, or as a separate template for a COMPOSITION to which the associated care encounters are linked. In addition, when administrative encounters are managed in an external ERP, a reference to the matching FHIR encounter resource can be recorded as an external link, for example via `COMPOSITION.context.other_context` or a dedicated link element.

The table below lists archetypes commonly used to model the care encounter. In particular, openEHR-EHR-EVALUATION.`reason_for_encounter.v1` records the contact type and the presenting problem.

Archetype	Purpose, use according to CKM
COMPOSITION.encounter.v1	To record the document level details of a single interaction, contact or care event between a subject of care and healthcare provider(s) for the provision of healthcare service(s). This can be either a face-to-face or remote interaction.
EVALUATION.reason_for_encounter.v1	To record the reason, or reasons, for initiation of any type of healthcare encounter or contact by the individual who is the subject of care.
ADMIN_ENTRY.episode_institution.v0	Administrative details about a period of admitted patient care between a formal or statistical admission and a formal or statistical separation,

	characterised by only one care type of care from a healthcare institution.
ADMIN_ENTRY.admin_encounter.v1	Local Archetype - e.gov.hse, HSE Ireland, 1.0.0-alpha.1, in_development

Table 3 – Selection of archetypes for modelling the care encounter / admin encounter template

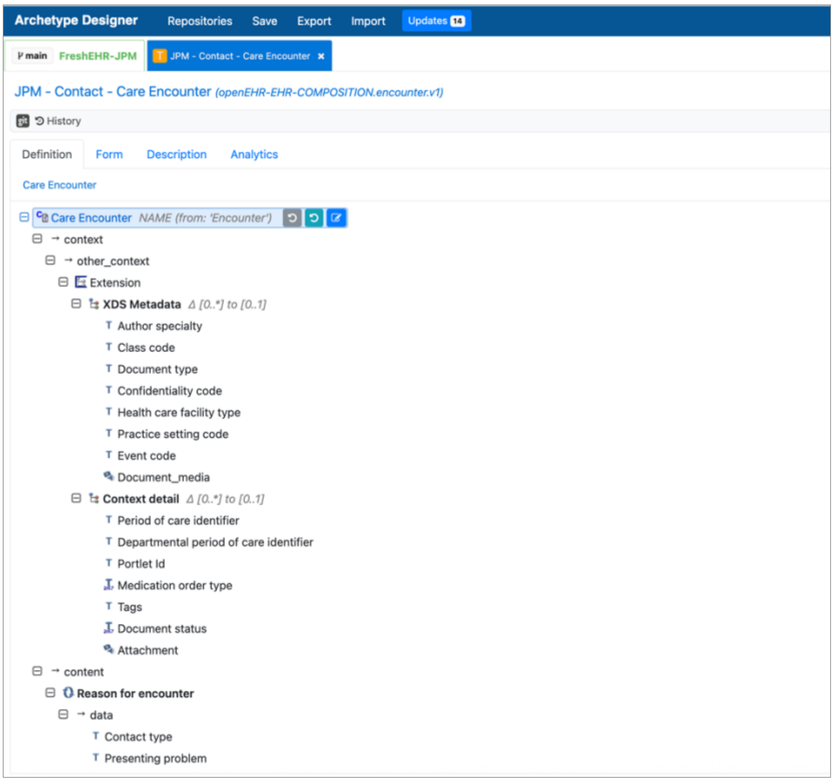


Figure 11 – Care Encounter template

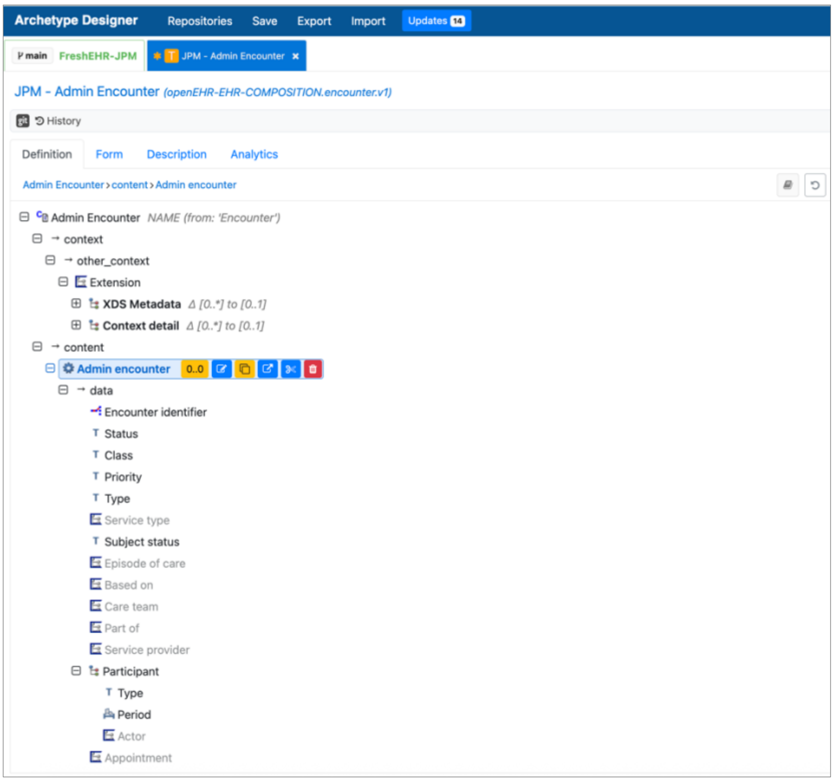


Figure 12 – Admin Encounter template

4.4.2 Episode of Care

The episode of care is modelled as the organising container for a single health problem. As the top-level container, the published composition archetype `openEHR-EHR-COMPOSITION.problem_list.v2` is used and constrained in the template with COMPOSITION.category = episodic. This uses a governed CKM archetype and aligns the temporal meaning of an episode, which spans the lifetime of the care episode, with the openEHR composition categories of event, episodic, and persistent.

This COMPOSITION supplies the required reference model context (e.g. start/end time, setting, location, health-care facility, composer, participations) and permits additional identifiers to be carried in COMPOSITION.context.other_context and constrained at template level. It is selected because there is no CKM-published composition with the purpose for Episode of Care.

The `COMPOSITION.`problem_list.v2 archetype is commonly used as a managed, persistent problem register; constraining its category to episodic in this design is a deliberate choice to make the composition instance the per-episode container, while preserving interoperability with CKM-published content.

The table below lists archetypes commonly used to model problem/diagnosis. The archetypes listed in the table can be used to model a solid skeleton for a problem/diagnosis with the important attributes. An extended comprehensive list of suitable archetypes can be found in the Appendix B.

Archetype	**Purpose, Use according to CKM**
COMPOSITION.problem_list.v2	A persistent and managed list of any combination of diagnoses, problems and/or procedures that may influence clinical decision-making and care provision for the subject of care.
EVALUATION.problem_diagnosis.v1	Details about a single identified health condition, injury, disability or any other issue which impacts on the physical, mental and/or social well-being of an individual.
CLUSTER.problem_qualifier.v2	Contextual or temporal qualifier for a specified problem or diagnosis. Use as cluster in “Status” data element in EVALUATION.problem_diagnosis.v1
CLUSTER.clinical_evidence.v1	Details about findings that support a clinical assertion.

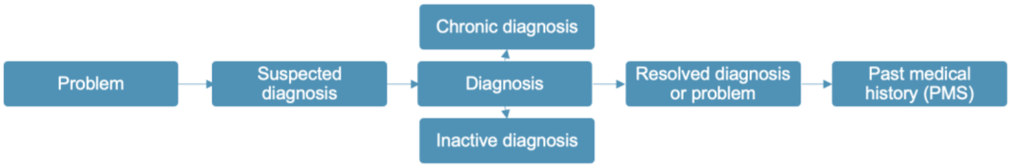
Table 4 – Selection of archetypes for modelling the Episode-of-Care template

Three aspects merit closer attention: the governance of the *episode-header attributes*, the distinction between *problem* and *diagnosis*, and the differentiation of *primary* versus *secondary diagnoses.*

Depending on requirements, the modelling of diagnosis/problem and the associated attributes and value sets may differ. Therefore, it is preferable to include the decisive episode header attributes within the episode of care template: the current name of the episode; the clinical status (active, inactive, closed); the progression status (acute or chronic); and a process status of the diagnosis for workflow control (referral, admission, pre-operative, post-operative, discharge, not applicable). These attributes can be modelled as a small, reusable CLUSTER placed in COMPOSITION.other_context, so that they are consistently available regardless of which ENTRY holds the clinical content. This normalises querying (AQL), simplifies governance across vendors and prevents implementation-specific value sets from leaking into the logical episode model.

openEHR does not differentiate between a problem and a diagnosis at the archetype level. Accordingly, EVALUATION.problem_diagnosis.v1 provides no attribute dedicated to distinguishing between the two. This distinction is necessary for tracking the lifecycle of a health problem and for supporting the automatic generation of generic lists. It can be achieved by combining attributes from `EVALUATION.problem_diagnosis.v1` and `CLUSTER.problem_qualifier.v2`. To make this distinction explicit and queryable with confidence, the CLUSTER introduces an additional coded text attribute *health problem classification* with the values *problem* and *diagnosis*.

The primary-secondary distinction is captured using the *diagnostic category* in `CLUSTER.problem_qualifier.v2`. In line with Solon's methodology, separate episodes of care are created for primary and secondary diagnoses. For secondary diagnoses, the template also offers an explicit link to the corresponding primary diagnosis, supporting automated list generation and downstream analytics.



Diagnostic certainty EVALUATION.problem_diagnosis.v1	**Suspected** Probable Confirmed	Suspected **Probable** Confirmed	Suspected Probable **Confirmed**	Suspected Probable **Confirmed**	Suspected Probable **Confirmed**
Diagnostic status CLUSTER.problem_qualifier.v2	**Preliminary** Working Established Refuted Text	Preliminary **Working** Established Refuted Text	Preliminary Working **Established** **Refuted** Text	Preliminary Working **Established** **Refuted** Text	Preliminary Working Established Refuted Text
Current/Past? CLUSTER.problem_qualifier.v2	**Current** Past	**Current** Past	**Current** Past	Current **Past**	Current **Past**
Active/Inactive? CLUSTER.problem_qualifier.v2	**Active** Inactive	**Active** Inactive	**Active** **Inactive**	Active Inactive	Active Inactive
Resolution phase CLUSTER.problem_qualifier.v2	Not resolving Resolving Resolved Indeterminate Relapsed Text	Not resolving Resolving Resolved Indeterminate Relapsed Text	Not resolving Resolving Resolved Indeterminate Relapsed Text	Not resolving Resolving **Resolved** Indeterminate Relapsed Text	Not resolving Resolving **Resolved** Indeterminate Relapsed Text
Course label CLUSTER.problem_qualifier.v2	**Acute** Acute-on-chronic Chronic	**Acute** Acute-on-chronic Chronic	**Acute** **Acute-on-chronic** **Chronic**	Acute Acute-on-chronic Chronic	Acute Acute-on-chronic Chronic
Date/time EVALUATION.problem_diagnosis.v1	- Date/time of onset - Date/time of clinically recognised			Date/time of resolution	

Figure 13 – Representation of the lifecycle of a health problem using attribute combinations

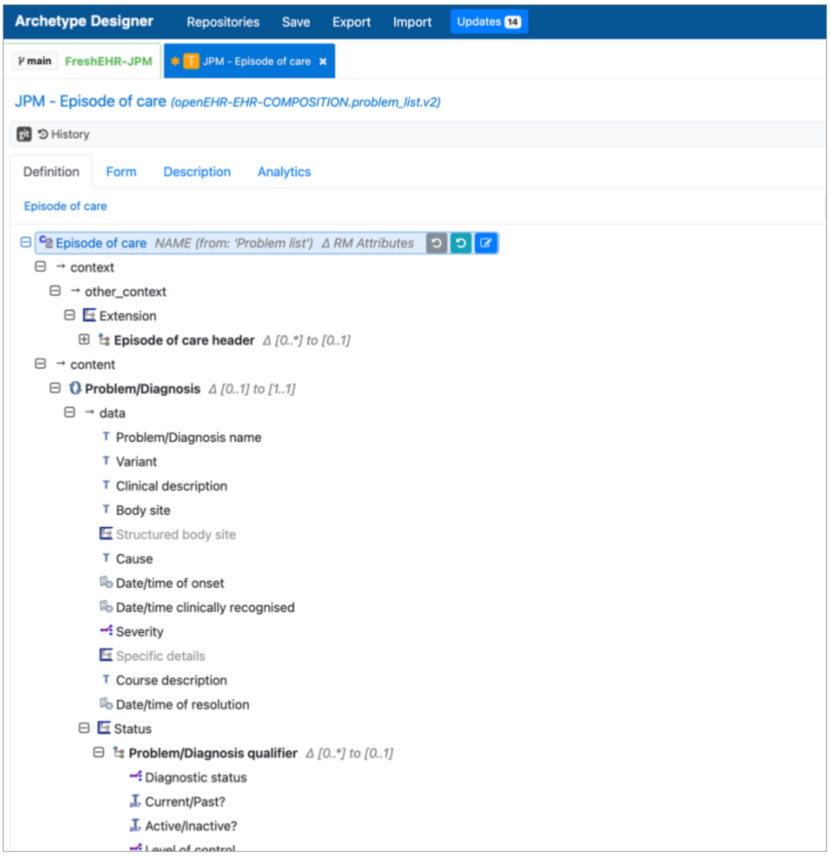


Figure 14 – Basic elements of the Episode-of-Care template

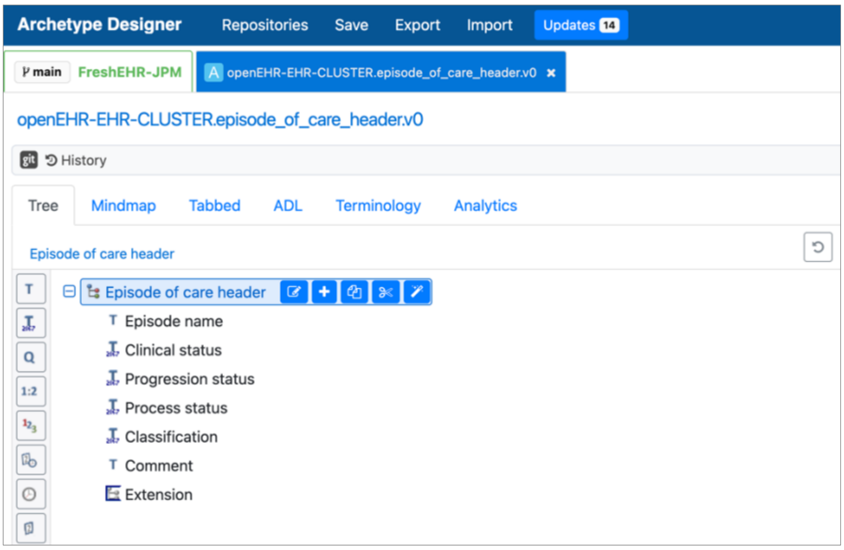


Figure 15 – Episode-of-Care header CLUSTER

4.4.3 Medical record entry

The clinical content of medical record entries is modelled using templates. The COMPOSITION archetype serves as the container and the medico legal unit of committal, and it provides contextual metadata such as author, time and care setting. Within the content of a COMPOSITION, clinical statements are modelled using ENTRY archetypes, including OBSERVATION, EVALUATION, INSTRUCTION, ACTION and ADMIN_ENTRY, which are selected according to the requirements of the use case and the underlying documents or forms. Templates bind and restrict these archetypes to define the data set required for a particular document or form, and may include terminology bindings, value sets and cardinality rules that reflect local policy and workflow.

In order to meet the requirements, three points must be considered specifically:

- Each COMPOSITION must be assigned to a *contact*; this aspect is examined in the chapter on relationships.
- Each ENTRY archetype must be assigned to one or more *episodes of care*. This aspect is examined in the chapter on relationships.
- Each ENTRY Archetype must be assigned to a *clinical section*, such as history, physical examination, laboratory results or past medical history.

Within a single COMPOSITION, different ENTRY archetypes may belong to different clinical sections. Since ENTRY archetypes do not carry a default clinical section classification, an explicit assignment to a clinical section is required at entry level for a consistent grouping and navigation across patient records. This assignment must be modelled so that each ENTRY archetype can be unambiguously associated with a clinical section, regardless of the mixture of sections within the same composition. The following table shows the various options for explicitly linking an entry to a clinical section.

Option	**Explanation**
SECTION-Archetype	Clinical sections are represented by SECTION nodes inside the COMPOSITION and each SECTION heading is bound to a LOINC document section code. Each ENTRY is placed under the appropriate SECTION so that the assignment to a clinical section is provided by structural containment while the clinical semantics remain within the ENTRY.
CLUSTER-Archetype	Each ENTRY carries a small CLUSTER that contains a single coded element named document section code and that element is bound to the LOINC document section value set. The cluster is placed in the protocol of the ENTRY so the section tag travels with the ENTRY when it is processed outside its parent composition.
EHR Directory and FOLDERS	Create one folder per clinical section and place references to versioned compositions in each folder's items. Fine-grained pointers to specific entries inside those compositions can be kept in the folder's details as a DV_EHR_URI or LOCATABLE_REF; entries may also carry a LINK back to the organising folder.
One clinical section per template	Creating templates whose entry archetypes are assigned to only one clinical section, designating the composition with the clinical section (e.g. using the XDS_metadata cluster in other_context).
Section code recorded on the ENTRY name using term mappings	The ENTRY name includes a term mapping to a LOINC document section code that acts as a secondary tag. The approach is compliant but semantically weaker because the section is a contextual classifier rather than part of the entry concept. It is suited to integration scenarios where adding an extension cluster is not desirable.
LINK from the ENTRY to the governing SECTION node	ENTRY includes a LINK with meaning is member of section and the target is the local SECTION node within the same composition. The relation makes the membership explicit at entry level while the authoritative section code remains on the SECTION.

Table 5 – Methods of assigning medical record entries to a clinical section

4.4.4 Progress Note

The progress notes within the medical record demand closer attention. In Solon's methodology, which is based on Weed's problem-oriented medical record, progress notes follow the SOAP scheme: subjective, objective, assessment, and plan. A separate progress note is created for each episode of care addressed during a contact. As previously mentioned, a progress note may also be linked to other episodes of care where this reflects routine clinical practice.

In routine practice progress notes are written in prose, which naturally maps to a four-field view in which the healthcare professional records free text in each SOAP field. When displaying progress notes for a contact it is useful to group the other medical record entries under the same SOAP headings so that the free text stands alongside the corresponding structured content.

- Subjective
    - Free text from the patient history and concerns.
    - Medical record entries aligned to subjective content.
- Objective
    - Free text for measurable facts and observations.
    - Medical record entries aligned to objective content such as physical examination findings, investigation results or vital signs.
- Assessment:
    - Free text that sets out clinical reasoning including differential diagnosis, likelihoods and the working or probable diagnosis.
    - Medical record entries such as structured differential diagnosis probability statements and the name of the episode of care.
- Plan:
    - Free text that states intended diagnostic measures and treatment.
    - Medical record entries such as orders, prescriptions and scheduled interventions.

To achieve this, each ENTRY archetype must be explicitly assigned to one of the four SOAP fields. Rather than placing this responsibility within application logic, the assignment should be persisted at the archetype level. This keeps the classification close to the data, supports validation, and enables reuse across applications. This ensures that the information is in the correct context, whether it is patient information (S), facts from the examination and diagnosis (O), the interpretation of a healthcare professional (A), or the planning of further action (P).

The COMPOSITION archetype `openEHR-EHR-COMPOSITION.encounter.v1` is used as the basis for the template, which is named *SOAP Progress Note*. To distinguish the SOAP-Entry at the first contact for a new episode of care, a corresponding template named *SOAP Initial Encounter* is provided. The four-field structure is supplied by the SECTION archetype `openEHR-EHR-SECTION.SOAP_scheme.v0` and is used for modelling, although its current draft status in the CKM. The archetype `openEHR-EHR-OBSERVATION.progress_note.v1` is used to capture free text for each of the four fields. This forms the basic framework. A key design decision is whether to persist one COMPOSITION per SOAP entry or to store all SOAP entries for a contact within a single COMPOSITION. The choice depends on the possibilities how the SOAP entries can be linked to the corresponding episode of care. Having one SOAP scheme entry per COMPOSITION seems to be clearer and simpler to implement.

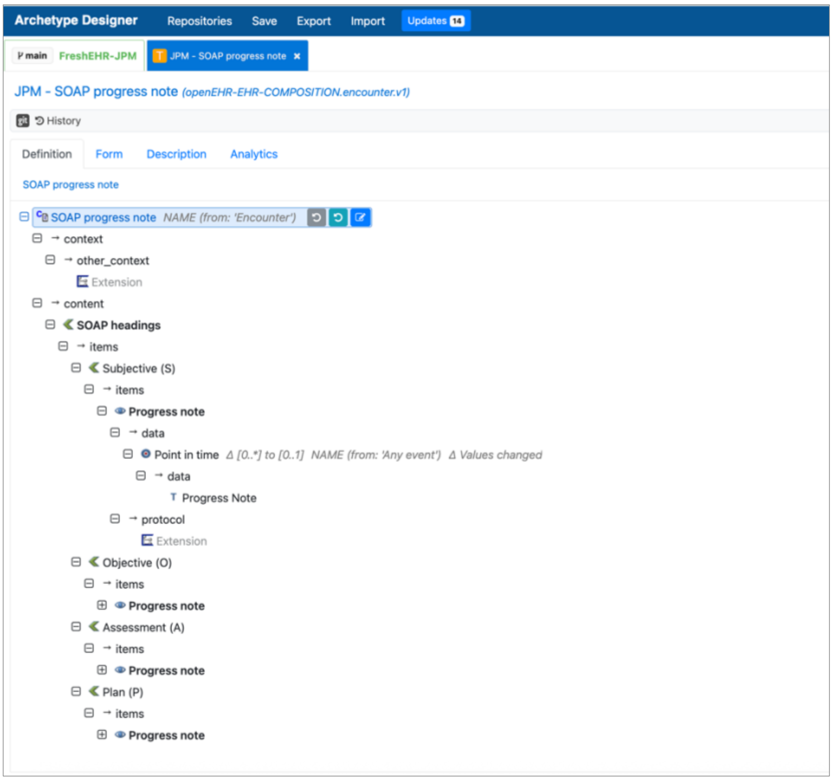


Figure 16 – Template SOAP Progress note

4.5 Relationships

Templates define the structure and constraints of clinical content, while relationship modelling specifies how template-based COMPOSITIONs and their contained ENTRY instances reference one another. In openEHR, these associations are implemented via reference semantics rather than data duplication, ensuring that identifiers, provenance and version history are preserved across links. This chapter examines three mechanisms for expressing and persisting such associations within the episode-oriented medical record:

- Folders (4.5.1)
- Links (4.5.2)
- Clusters (4.5.3)

4.5.1 Folders

In openEHR, folders provide a versioned, reference-based directory for organising EHR content without copying data. Each folder hierarchy is a tree of FOLDER nodes. A FOLDER may contain subfolders and items, where items are references to other objects, typically versioned COMPOSITIONs. Because these are references, the same COMPOSITION may appear in more than one folder, enabling multiple classifications (for example, by episode and by contact). Folder trees are persisted as VERSIONED_FOLDERs, meaning the entire hierarchy is versioned over time, independently of the compositions they index. By inheriting from LOCATABLE, FOLDERs can be specialised with archetypes to impose domain-specific structures and to carry metadata via the details attribute. Both the metadata and the folder structure themselves can be archetyped [27-28].

This design keeps the index separate from content, preserves provenance and version history on both sides (folder tree and compositions), and allows the directory to evolve over time while maintaining stable links to clinical documents.

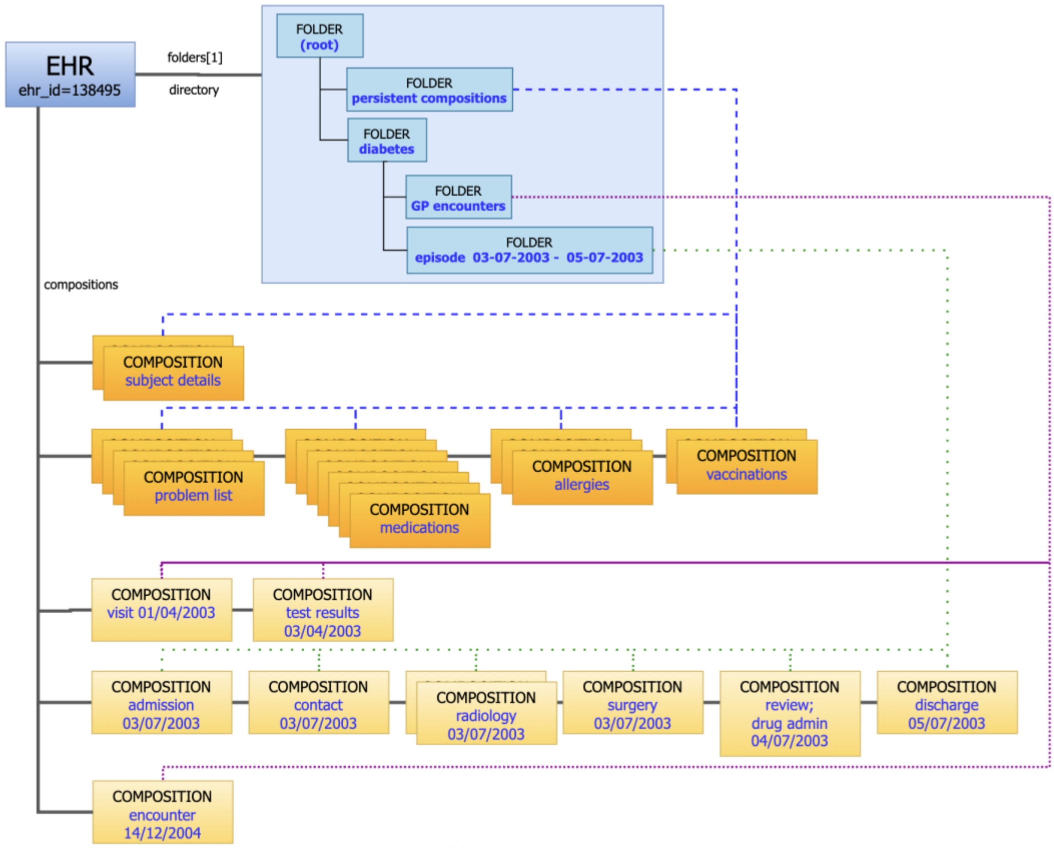


Figure 17 – Using Folders to index Compositions in the EHR [28]

4.5.1.1 Directory and folder hierarchy (fundamentals)

At the EHR level, openEHR supports attaching one or more folder trees to an EHR. A top-level directory folder can provide a shared index, with additional hierarchies for departmental or purpose-specific indexing. Using folders to represent problem-based or episode-based views is explicitly described as a valid pattern in the openEHR specifications [29].

The root directory folder serves as the entry point. Beneath it, child FOLDER nodes structure the record into logical areas. Each FOLDER may contain:

- *details* – an archetyped ITEM_STRUCTURE used to hold structured, queryable metadata under project-specific folder archetypes. It may also include explicit deep links (DV_EHR_URI) to ENTRY paths within referenced COMPOSITIONs to cross-reference fine-grained content without duplication. Where a folder has a designated COMPOSITION (for example, an episode COMPOSITION), the association can be recorded in details as an ELEMENT whose value is a DV_EHR_URI resolving to the target VERSIONED_COMPOSITION (or to a specific version).
- *items* – references to versioned target objects, typically VERSIONED_COMPOSITIONs. Because these are references, the same COMPOSITION can be indexed in multiple places within the directory without duplication. Items usually reference the version container; when a version-specific pointer is required, a DV_EHR_URI or equivalent path in details is used.
- *folders* – optional subfolders that introduce deeper levels; the entire hierarchy is versioned as a single VERSIONED_FOLDER.

Because FOLDER inherits from LOCATABLE, both the folder structure and the details payload can be governed by archetypes when metadata must be queryable and consistent. There is no CKM-published generic folder archetype; community guidance treats labels such as `openEHR-EHR-FOLDER.generic.v1` as placeholders. Projects should author their own folder archetypes if the default does not fit and may submit them to CKM for review. In most CDRs, runtime validation is performed against Operational Templates (OPT) rather than raw archetypes [30].

From an API perspective, compositions are linked to folders by placing references in the folder's items list. Updates to the directory are performed by committing a new version of the VERSIONED_FOLDER (i.e. the whole tree). This preserves provenance and version history for the indexing structure independently of the referenced compositions [31].

The same approach can be realised with EHR.folders, which allows attaching multiple versioned folder trees to the same EHR. Where EHR.folders is used, implementations may still set EHR.directory to point to the first tree for backward compatibility; the core semantics of versioned, reference-based indexing remain the same [32].

```
{
 "_type": "FOLDER",
 "name": { "_type": "DV_TEXT", "value": "Directory" },            /* Top-level 'Directory' folder (shared hierarchy) */
 "archetype_node_id": "openEHR-EHR-FOLDER.generic.v1",

 "details": {                                                       /* Root keeps only a single description element */
   "_type": "ITEM_TREE",
   "items": [
     { "_type": "ELEMENT", "name": { "value": "description" },
       "value": { "_type": "DV_TEXT",
         "value": "Root folder used by all services; domain metadata resides in child folders." } }
   ]
 },

 "folders": [

   /* ==================== Fully detailed child folder ==================== */
   {
     "_type": "FOLDER",
     "name": { "_type": "DV_TEXT", "value": "Folder 1" },
     "archetype_node_id": "openEHR-EHR-FOLDER.generic.v1",

     "details": {
       "_type": "ITEM_TREE",
       "items": [
         /* Minimal, governance-oriented metadata moved here from root */
         { "_type": "ELEMENT", "name": { "value": "purpose" },
           "value": { "_type": "DV_TEXT",
             "value": "Shared index for episode/contact/section-based navigation" } },

         { "_type": "ELEMENT", "name": { "value": "governance_owner" },
           "value": { "_type": "DV_TEXT", "value": "Clinical Records Governance Team" } },

         { "_type": "ELEMENT", "name": { "value": "classification_scheme" },
           "value": { "_type": "DV_CODED_TEXT", "value": "Episode/Contact/Section",
             "defining_code": { "_type": "CODE_PHRASE",
               "terminology_id": { "value": "local" }, "code_string": "scheme-ecs" } } },

         { "_type": "ELEMENT", "name": { "value": "status" },
           "value": { "_type": "DV_CODED_TEXT", "value": "active",
             "defining_code": { "_type": "CODE_PHRASE",
               "terminology_id": { "value": "local" }, "code_string": "active" } } },

         { "_type": "ELEMENT", "name": { "value": "description" },
           "value": { "_type": "DV_TEXT",
             "value": "Domain-specific folder; references and optional deep links below." } },

         /* Explicit pointer to the designated COMPOSITION, e.g. the contact composition within the Contact folder */
         { "_type": "ELEMENT", "name": { "value": "contact_composition_ref" },
           "value": { "_type": "DV_EHR_URI",
             "value": "ehr://{ehr_id}/composition/11111111-2222-3333-4444-555555555555" } },

         /* Optional deep link to a specific ENTRY inside a COMPOSITION */
         { "_type": "ELEMENT", "name": { "value": "entry_link_example" },
           "value": { "_type": "DV_EHR_URI",
             "value": "ehr://{ehr_id}/composition/11111111-2222-3333-4444-555555555555"
                    + "/content[openEHR-EHR-OBSERVATION.vital_signs.v1]" } }
       ]
     },

     "items": [                                                     /* References to VERSIONED_COMPOSITIONs (no copies) */
       { "id": { "_type": "HIER_OBJECT_ID", "value": "11111111-2222-3333-4444-555555555555" },
         "namespace": "ehr.example.org", "type": "VERSIONED_COMPOSITION" }, /* e.g., encounter document */
       { "id": { "_type": "HIER_OBJECT_ID", "value": "22222222-3333-4444-5555-666666666666" },
         "namespace": "ehr.example.org", "type": "VERSIONED_COMPOSITION" }  /* e.g., vital signs */
     ],

     "folders": [                                                   /* Optional subfolders for further classification */
       /* ... add subfolders here if needed ... */
     ]
   },

   /* ==================== Minimal stub of a second child folder ========== */
   {
     "_type": "FOLDER",
     "name": { "_type": "DV_TEXT", "value": "Folder 2" },
     "archetype_node_id": "openEHR-EHR-FOLDER.generic.v1"
     /* Stub: add 'details', 'items', and 'folders' analogous to 'Folder 1' as required */
   }
 ],

 "items": []  /* The top-level Directory usually does not reference COMPOSITIONs directly */
}
```

Figure 18 – Example JSON of an EHR Directory and FOLDER hierarchy

4.5.1.2 Folder-based mapping of the episode-oriented record

A practical folder-only realisation of the episode-oriented record uses three top-level folders per EHR: *Contacts*, *Episodes*, and *Sections*.

Within *Contacts*, each contact is represented by a child folder. That folder's items list holds references to all COMPOSITIONs authored during the contact, including the encounter COMPOSITION. To make the encounter COMPOSITION easy to locate when many items exist, an explicit DV_EHR_URI pointing to that COMPOSITION is recorded in the folder's details. The contact's key metadata are also captured in the folder's archetyped details ITEM_STRUCTURE so they can be queried directly – for example event, date and time, location, organisation and the authoring healthcare professional. The authoritative event context remains in the COMPOSITION, the folder mirrors selected fields for indexing. As noted above, a dedicated contact folder archetype standardizes these fields and supports consistent querying and governance.

Within *Episodes*, each episode of care is represented by a child folder. The episode's problem/diagnosis COMPOSITION is listed in the folder's items list. To make the episode COMPOSITION easy to locate when many items exist, an explicit DV_EHR_URI pointing to that COMPOSITION is recorded in the folder's details. The episode's key metadata are also captured in the folder's archetyped details ITEM_STRUCTURE so they can be queried directly – for example episode name, classification (problem, diagnosis), resolution phase, current/past, first contact date, and last contact date. Where clinically relevant, additional pointers can express relationships, for example a secondary episode linking to its primary diagnosis. A dedicated Episode folder archetype standardizes these fields and supports consistent querying and governance. When provisioning the CDR, a standard folder named *General Health Problem* is created.

The association between a *medical record entry* and the contact is established via the contact folder, whose items list includes a reference to the containing COMPOSITION. The association with the episode is captured more precisely. In the episode folder, the details include an explicit DV_EHR_URI that resolves to the ENTRY path within the source COMPOSITION. This entry level link is needed because a single COMPOSITION may contain multiple ENTRY instances that relate to different episodes. The COMPOSITION is also referenced in the episode folder's items list. The items reference maintains the canonical document index, while the entry level pointer removes ambiguity when a single COMPOSITION contains multiple entries that relate to different episodes.

Because a medical record entry can be linked to multiple episodes, it must be possible to distinguish between primary and associated links. The episode folder's details therefore record the association as a coded role (e.g. primary or associated) together with a DV_EHR_URI to the target COMPOSITION or ENTRY, while the COMPOSITION itself remains referenced in the folder's items. As an alternative, the same intent can be achieved structurally by creating two subfolders under the episode folder, such as *Primary* and *Associated*, and distributing the references accordingly. This simplifies querying but adds structural overhead.

Within *Sections*, each clinical section is represented by a child folder that carries section metadata in its details (e.g. label, LOINC code, sort order). These subfolders store ENTRY-level pointers in details (e.g. DV_EHR_URI elements) that link directly to the relevant entries across compositions. This supports navigation and list building without altering provenance or storage location.

The affiliation of each clinical section to one of the four SOAP fields (Subjective, Objective, Assessment, Plan) is captured in the section folder's metadata under details as a coded element. Using a dedicated Section Folder archetype to constrain this element standardises the representation and supports consistent querying and governance. When provisioning a CDR, it is advisable to predefine and create the complete directory skeleton with all clinical section folders and their SOAP affiliations. This upfront configuration ensures predictable routing of future content and stable query semantics from the outset.

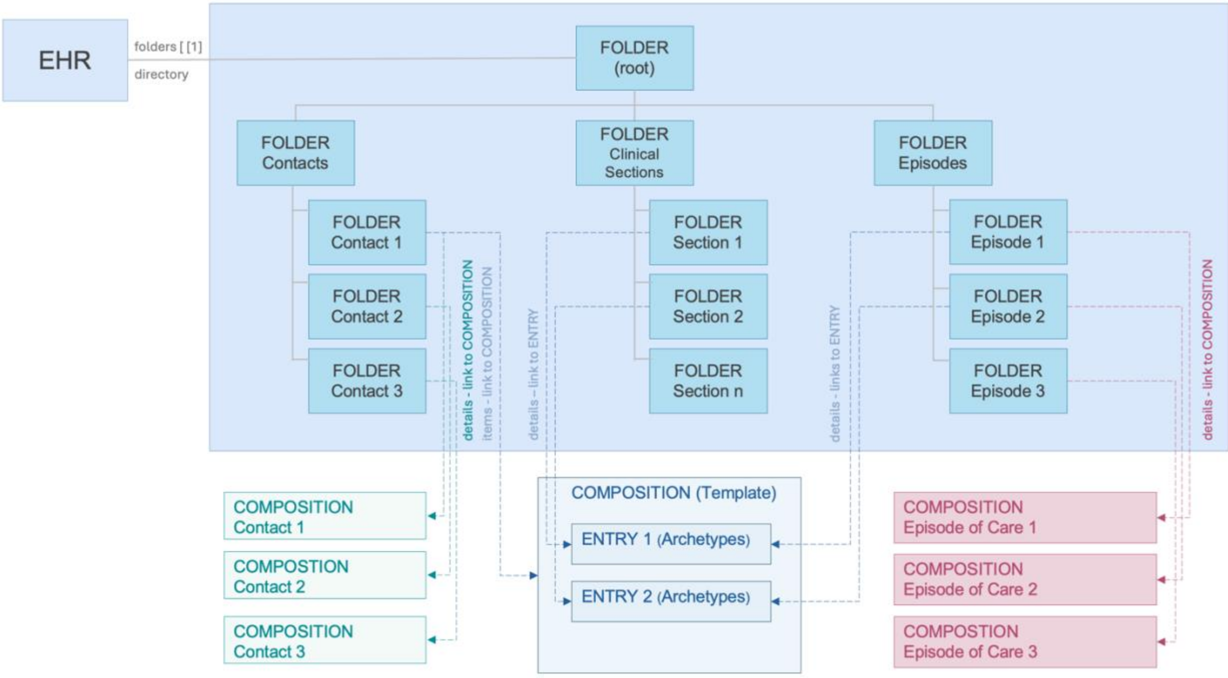


Figure 19 – Folder-based mapping of the episode-oriented record

4.5.1.3 Final Remarks on Folder-Based Indexing

This folder-based mapping is consistent with the openEHR reference model: a FOLDER is a LOCATABLE; its details attribute is an archetypable ITEM_STRUCTURE for structured metadata; and folder trees are persisted as VERSIONED_FOLDER instances, so changes to the index are versioned and auditable independently of the compositions they reference. Because folders store references (not copies), the same COMPOSITION can be indexed in multiple places, for example under contact, episode, and section. Navigation can be enhanced by adding optional DV_EHR_URI pointers in details to specific COMPOSITIONs or ENTRY paths; these pointers supplement, rather than replace, the canonical references held in items. Importantly, rules such as “each medical record entry is associated with exactly one episode” are modelling and application constraints of this work; they are not enforced by the openEHR reference model. Folders serve as an index/classification mechanism and do not alter the clinical content, provenance, or versioning of the referenced compositions.

4.5.2 Links – Reference model relationships (fundamentals)

In the openEHR reference model, LINK is the built-in mechanism for expressing explicit relationships between archetyped data structures without duplicating data. Because the links attribute is defined on LOCATABLE, any COMPOSITION, SECTION, ENTRY, CLUSTER, or ELEMENT may carry zero or more outbound links to other EHR objects or paths, providing a uniform, extensible way to attach references across the record. In practice, links should connect complete archetyped structures (e.g. an ENTRY or a CLUSTER) rather than primitive sub-elements, since sub-element relationships are seldom clinically meaningful and can be confusing. Modelling links at this level keeps associations clinically coherent and resilient to model change [33].

4.5.2.1 Link attributes – meaning, type, target

The LINK class is defined by three attributes – meaning, type, and target – which together specify the nature, purpose, and destination of a relationship.

The *meaning* attribute provides a clinical, contextual description of the relationship. It captures the semantic intent of the connection in terms that are understandable to clinicians and clinical information systems. The semantic space for meaning aligns with the categories enumerated in Annex C of ENV 13606 Part 2, including generic relationships, documentation and reporting relationships, organisational relationships, clinical relationships, circumstantial relationships, and view-management relationships. This ISO-derived value set is not codified within openEHR terminology and is not freely accessible [33,34].

LINK.meaning	Short description
in response to	Links a diagnostic result to the order/request that prompted it.
follow-up to	Links a subsequent encounter or assessment to an earlier episode or record.

Table 6 – Examples of LINK.meaning values

The *type* attribute provides a higher-level categorisation of the link, indicating its class or purpose at a clinical or domain-specific level. It supports systematic organisation and processing of links within clinical information systems. Neither openEHR nor ISO 13606 defines a normative value set for LINK.type. Representative examples used in practice are listed in the following table [33].

LINK.type	Short description
episode	Association with a clinical episode or administrative case.
administrative	Link to an administrative case (e.g. inpatient stay, case number).
encounter	Reference to a specific encounter/consultation (use when not otherwise captured in context).
problem	Grouping around a health problem (clinical issue).
diagnosis	Reference to a specific diagnosis (Evaluation).
order	Link to an order/INSTRUCTION (lab, imaging, medication).
result	Link to a result (OBSERVATION), or a back-link from a result to its originating order.
procedure	Reference to performed procedures/interventions/measures.
imaging_study	Reference to imaging (radiology, ultrasound).
lab_test	Reference to laboratory tests/results.
care_plan	Link to a care/treatment plan.
goal	Reference to therapy goals (Goal-EVALUATION).
document	General document-level relationship when no more specific type fits.
referral	Referrals/registrations (e.g. physiotherapy, consult).
consent	Link to consents/advance directives or restrictions.
medication	Association to medication order/administration (INSTRUCTION/ACTION).
medical_device	Association to a medical device (implanted or non-implantable)
allergy_intolerance	Association to allergies/adverse reactions (risk context).
episode_folder	Pointer to an episode/case folder (only if your CDR supports Folder URIs).
episode_of_care	Association with a clinical episode of care
contact	Association with contact within a episode-oriented medical record
workflow	Process-related connection within clinical workflows (e.g. predecessor/successor).
legal	Connection with medico-legal significance (e.g. attestation, legal hold).

Table 7 – Examples of LINK.type values

The *target* attribute contains the actual reference to the destination of the link, aligning with the semantic intent expressed by the meaning. It is a DV_EHR_URI that resolves to the archetyped structure serving as the link endpoint, enabling systems to traverse and use the association programmatically. In practice, the target typically points to complete archetyped structures – for example a COMPOSITION (clinical document), a SECTION, an ENTRY (clinical statement), or a CLUSTER (reusable structure). Where necessary, a path may address a specific ENTRY within a COMPOSITION [33]. Some examples of LINKS in JSON format can be found in Appendix C.

4.5.2.2 Technical considerations and constraints

LINK is typed and unidirectional. Code systems and value sets used for LINK.meaning and LINK.type are governed by the modelling program or project. When a bidirectional association is desired, it is represented by creating reciprocal links and constraining meaning and type with agreed codes, so the clinical intent remains explicit and queryable [35].

All links are part of the persisted content and therefore follow openEHR versioning rules. Adding, modifying, or removing a link, results in a new version of the owning versioned object (e.g. a VERSIONED_COMPOSITION), with the audit trail captured in the CONTRIBUTION. Provenance and medico-legal properties are preserved without special handling [36].

Implementations commonly validate that LINK.target resolves to an accessible archetyped structure and that local semantics between meaning, type, and target are coherent. The reference model does not mandate global referential-integrity enforcement across link targets, and access control may prevent dereferencing even when a target exists. Consequently, dereferencing behaviour and cross-document navigation are implementation-specific. Community discussions and vendor documentation describe patterns and limitations when following links from queries [37].

The openEHR Archetype Query Language (AQL) does not include a JOIN statement. Join-like behaviour is expressed implicitly by binding multiple variables in the FROM … CONTAINS … clause and correlating them in the WHERE clause. This pattern can address multiple COMPOSITIONs in one query and is the idiomatic way to achieve join-like behaviour in openEHR [38].

This approach does not portably extend to LINK targets. In the reference model, LINK.target is a DV_EHR_URI, whereas identifiers commonly filtered on in COMPOSITION (e.g. uid/value) are strings. The AQL specification does not define URI-parsing or conversion functions, and regex on MATCHES is not part of the formal spec. As a result, matching a DV_EHR_URI to a COMPOSITION UID in a single portable query is not supported. In practice, dereferencing a DV_EHR_URI typically requires a two-step workflow with a query to obtain targets, followed by retrieval [39].

```
SELECT
   e/ehr_id/value,
   a_b/data[at0001]/events[at0006]/data[at0003]/items[at0004]/value/magnitude,
   a_b/data[at0001]/events[at0006]/data[at0003]/items[at0005]/value/magnitude
FROM EHR e CONTAINS
   (COMPOSITION c1
      CONTAINS OBSERVATION a_a[openEHR-EHR-OBSERVATION.alcohol_use.v1]
    AND
    COMPOSITION c2
      CONTAINS OBSERVATION a_b[openEHR-EHR-OBSERVATION.blood_pressure.v1])
```

Figure 20 – Example AQL addressing multiple COMPOSITIONs to realise JOIN semantics

4.5.2.3 Link-based mapping of the episode-oriented record

In a link-only realisation of the episode-oriented record expresses all associations via the openEHR LINK construct on LOCATABLE. Contacts and episodes are represented by their own COMPOSITIONs; medical record entries are represented by COMPOSITIONs and the included ENTRY instances.

Each *contact* is represented by a care encounter COMPOSITION, while the clinical content authored during that contact is captured in one or more clinical COMPOSITIONs. The association between the care encounter document and its related clinical documents is expressed via links and can be modelled in three patterns:

1. From care encounter to medical record entries (unidirectional)

The care encounter COMPOSITION carries outbound links to all clinical COMPOSITIONs authored during the contact. Each link uses LINK.meaning = "documented by" (ISO code LINK-E1) and LINK.type = "encounter"; the LINK.target is a DV_EHR_URI resolving to the target clinical COMPOSITION. This expresses that the clinical documents provide the formal documentation of what the encounter record summarises.

2. From medical record entries to care encounter (unidirectional)

Each clinical COMPOSITION carries a single outbound link to the encounter COMPOSITION. Here the semantics are the inverse: LINK.meaning = "documents" (ISO code LINK-E1i) and LINK.type = "encounter"; the LINK.target is a DV_EHR_URI of the encounter COMPOSITION. The inverse documentation relationship is therefore captured deterministically from the clinical document to its originating encounter.

3. Bidirectional

Both above links are present, allowing traversal from either side. In all variants the link payload is a DV_EHR_URI (not a copy), and links live on LOCATABLE, so they version and audit with their owning COMPOSITION.

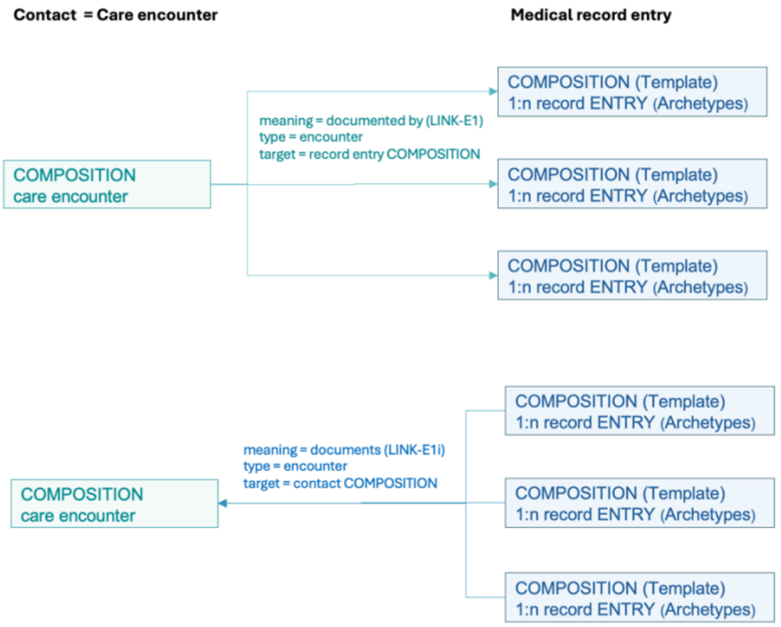


Figure 21 – Link-based association between care-encounter and clinical COMPOSITIONs

Each *episode of care* is represented by an episode COMPOSITION. To associate clinical content with an episode unambiguously, the link is created at ENTRY level: every ENTRY carries or receives a link, while document-level information remains unchanged. There are three patterns in which the association can be realised:

1. From medical record entries to episode of care (unidirectional)

Each ENTRY in a clinical COMPOSITION carries an outbound link with LINK.meaning = "is related to the same episode" (ISO code LINK-D0) and LINK.type = "episode_of_care"; the LINK.target is a DV_EHR_URI resolving to the episode COMPOSITION.

2. From episode of care to medical record entries (unidirectional)

The episode COMPOSITION exposes outbound links to each member ENTRY. Because the link is a symmetric relation, the same LINK.meaning = "is related to the same episode" (ISO code LINK-D0) and

LINK.type = “episode_of_care” are used; LINK.target points by DV_EHR_URI to the member ENTRY paths.

3. Bidirectional

Both directions are present, combining the two patterns above. In all variants, the link payload is a DV_EHR_URI and links reside on LOCATABLE, so they are versioned and audited with their owning COMPOSITIONs.

To enable a single clinical statement to contribute to more than one episode of care, associations modelled as openEHR LINKs at the ENTRY level are adapted. The LINK.meaning remains the same, while the LINK.type carries a project-specific role: episode-primary for the first (principal) association and episode-associated for any additional (associated) association. Each ENTRY contains exactly one link with type = “episode-of-care-primary” and zero or more links with type = “episode-of-care-associated”. This makes the primary – associated distinction explicit and queryable without altering the clinical content or provenance. Links reside on LOCATABLE and are versioned and audited with their owning COMPOSITIONs. The constraint “one primary episode per ENTRY” is treated as a modelling and governance rule rather than a restriction imposed by the reference model.

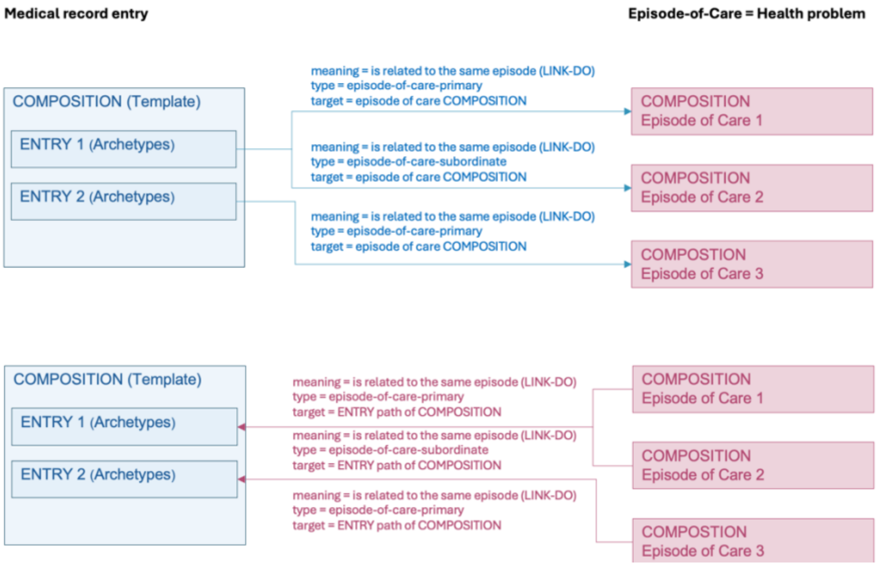


Figure 22 – Link-based association between clinical COMPOSITIONs to Episodes-of-Care

Using a link-only approach to assign each ENTRY to a *clinical section* (document section) and to a SOAP field has several constraints. Firstly, since links are part of the persisted content, any change to the section taxonomy or SOAP labelling results in new versions of clinical COMPOSITIONs. Secondly, ISO LINK term lists do not provide precise 'member-of-section' meaning, necessitating the use of generic values and reducing semantic precision. Thirdly, LINK.target is a DV_EHR_URI, but portable AQL lacks URI parsing or join functions, which makes queries such as 'all ENTRIES in section X' more complicated. Finally, distributing LOINC/SOAP semantics across many link instances fragments terminology governance and increases maintenance effort. Accordingly, links are not used as the primary carrier of section membership or SOAP association in this work.

4.5.2.4 Query and lifecycle considerations

All links are part of the persisted content and therefore versioned with their owning COMPOSITIONs; adding or changing a link creates a new version with full audit. Retrieval typically filters by links/type and/or links/meaning and resolves links/target (a DV_EHR_URI) to the intended object or ENTRY path. Because LINK is unidirectional, bidirectional associations are expressed by creating reciprocal links where needed.

4.5.3 CLUSTER – Embedded relationship structure

In the openEHR reference model, the CLUSTER is the generic container for reusable data components. Originally intended for fine-grained clinical content (e.g. measurements or examination findings), CLUSTER is also used to record relationships within clinical documents in a structured form. The CLUSTER archetypes used in this chapter are published in the public GitHub repository [55].

4.5.3.1 Essential technical aspects of a CLUSTER in openEHR

A CLUSTER is the reusable building block for structured 'sub-documents' inside openEHR content. Technically it is a LOCATABLE, so it has a name and stable archetype_node_id, is fully path-addressable for AQL, and may carry LINKs. Unlike a COMPOSITION or ENTRY, a CLUSTER has no independent clinical context (no own time, subject, setting, participation); it inherits these from its enclosing ENTRY or COMPOSITION. That makes it ideal for packaging attributes that belong together but do not constitute a clinical statement by themselves, e.g. problem qualifiers, device characteristics, anatomical site, or score breakdown.

Structurally, a CLUSTER contains an ordered list of ITEMS, which are either further CLUSTERs to nest structure or leaf ELEMENTs holding the actual DV_* values with units, terminology bindings and null flavours where needed. Because CLUSTERs can be nested arbitrarily, rich trees can be modelled while keeping each block cohesive and reusable.

CLUSTERs are archetypable in their own right. The archetype defines items, cardinalities/occurrences, value sets and constraints, and can be specialised or further constrained in templates. This enables consistent reuse of the same governed block across multiple ENTRY archetypes and templates as single source of truth for structure and terminology, while still allowing local tailoring at template level.

Being LOCATABLE, a CLUSTER can include links to express explicit relationships (e.g. a role-typed link to an Episode-of-Care anchor or a section descriptor) without duplicating content. In queries, CLUSTER data are accessed via stable archetype paths; repeated items produce predictable paths, which supports list generation, dashboards and interoperability.

With respect to versioning and provenance, CLUSTERs are persisted as part of their owning COMPOSITION. Any change to a CLUSTER's content produces a new version of that COMPOSITION; there is no separate lifecycle for the CLUSTER itself, keeping audit and medico-legal properties straightforward.

4.5.3.2 CLUSTER-based mapping of the episode-oriented record

In the CLUSTER approach, contextual relationships are captured by archetyped, reusable CLUSTERs, each tailored to its host artefact: a medical-record-entry relationship CLUSTER embedded at ENTRY level within each clinical COMPOSITION, a contact relationship CLUSTER within every care encounter COMPOSITION, and an episode relationship CLUSTER within every episode of care COMPOSITION. Across these three template families the respective CLUSTER is required and constrained as mandatory at template level, ensuring that every medical record ENTRY, each encounter document, and every episode of care anchor expose the same governed attributes.

Rather than relying on RM-level LINKs as the primary carrier, the associations are expressed as archetyped attributes: pointers to the anchors contact and episode together with classification facets for clinical section and SOAP. This keeps queries and governance (value sets, cardinalities) consistent while provenance remains with the owning COMPOSITION. Applications may still emit RM-level LINKs as optional mirrors for navigation, but these are not required for the semantics.

Each relationship CLUSTER acts as a compact 'context block' with two layers:

1. Association references – pointers to the care-encounter COMPOSITION and to the Episode-of-Care COMPOSITION; and
2. Assignment facets – the clinical section (e.g. a LOINC document-section code) and the SOAP category (Subjective/Objective/Assessment/Plan), with extension fields for other relationships as required, e.g. administrative cases

Placement on *medical record entries* (ENTRY inside a clinical COMPOSITION) – the embedded CLUSTER attached to each ENTRY captures:

- a contact reference (as DV_EHR_URI pointers) to the care-encounter COMPOSITION
- an episode association to the episode of care COMPOSITION that may repeat, each association carrying a role (DV_CODED_TEXT; primary or associated) and a target (as DV_EHR_URI pointers)
- a clinical section assignment (DV_CODED_TEXT), optionally via a small section_assignment sub-CLUSTER for label and sort order)
- a SOAP assignment (DV_CODED_TEXT; Subjective/Objective/Assessment/Plan)
- other relationships, as required, via repeating related_artifact sub-CLUSTERs (typed DV_CODED_TEXT plus DV_EHR_URI target

Placement on the *care-encounter* COMPOSITION: A compact relationship CLUSTER summarises the member clinical COMPOSITIONs authored during the encounter (as DV_EHR_URI pointers) and, where the administrative encounter is modelled separately, includes a pointer to that administrative encounter COMPOSITION.

Placement on the episode of care COMPOSITION. The episode relationship CLUSTER records:

- member ENTRY references (within their enclosing clinical COMPOSITIONs) as DV_EHR_URI targets, each association carrying a role (DV_CODED_TEXT; primary or associated)
- for secondary diagnoses, an explicit reference to the primary-diagnosis episode COMPOSITION
- for complications, a reference back to the originating episode of care that holds the precipitating diagnosis; and
- for recurrences, a reference back to the index episode of care with the same diagnosis

Some aspects warrant closer examination, in particular the placement of the relationship CLUSTER within templates and the scope of any supplementary metadata carried inside the CLUSTER.

In this design, CLUSTERs are used at both COMPOSITION and ENTRY level, as outlined above. According to the reference model and common modelling practice, CLUSTERs on a COMPOSITION are placed under COMPOSITION.context.other_context. CLUSTERs on an ENTRY are placed under ENTRY.protocol for care ENTRY types: OBSERVATION, EVALUATION, INSTRUCTION, ACTION. Where an ADMIN_ENTRY is used – which has no protocol, the CLUSTER is attached under the ENTRY’s data tree with a clearly named node to preserve a uniform path scheme across templates.

It can be useful in some projects to include selected attributes from the surrounding COMPOSITION or ENTRY inside the CLUSTER as redundant or supplementary mirrors – for example, a snapshot label of the episode name, a section code, or encounter identifiers – to stabilise indexing and simplify AQL projections. Any such mirroring must be governed to avoid semantic drift (the episode of care COMPOSITION remains the source of truth). The detailed design and governance of these optional mirrors are not pursued further in this thesis.

To remain faithful to the openEHR reference model and support resolvable navigation, LINK targets in the relationship CLUSTER should be carried as DV_EHR_URI. To enable single-statement AQL and avoid two-step dereferencing of URIs, the link can be mirrored with query-friendly fields, e.g. a stable business identifier for the episode (DV_IDENTIFIER or DV_TEXT episode_key), which is created when the episode of care is established, and is stored in both the episode header and each entry’s relationship cluster. Optionally, a DV_TEXT composition_uid can be used to correlate a specific composition version, as well as a DV_CODED_TEXT target class (COMPOSITION or ENTRY) for filtering. Queries then correlate the episode and the clinical COMPOSITION in the same AQL statement by equality on episode_key, while the DV_EHR_URI remains the authoritative pointer for runtime traversal. This dual representation remains within the reference model, avoids duplicating clinical content and provides portable, join-like AQL, without the need for URI parsing or implementation-specific regex.

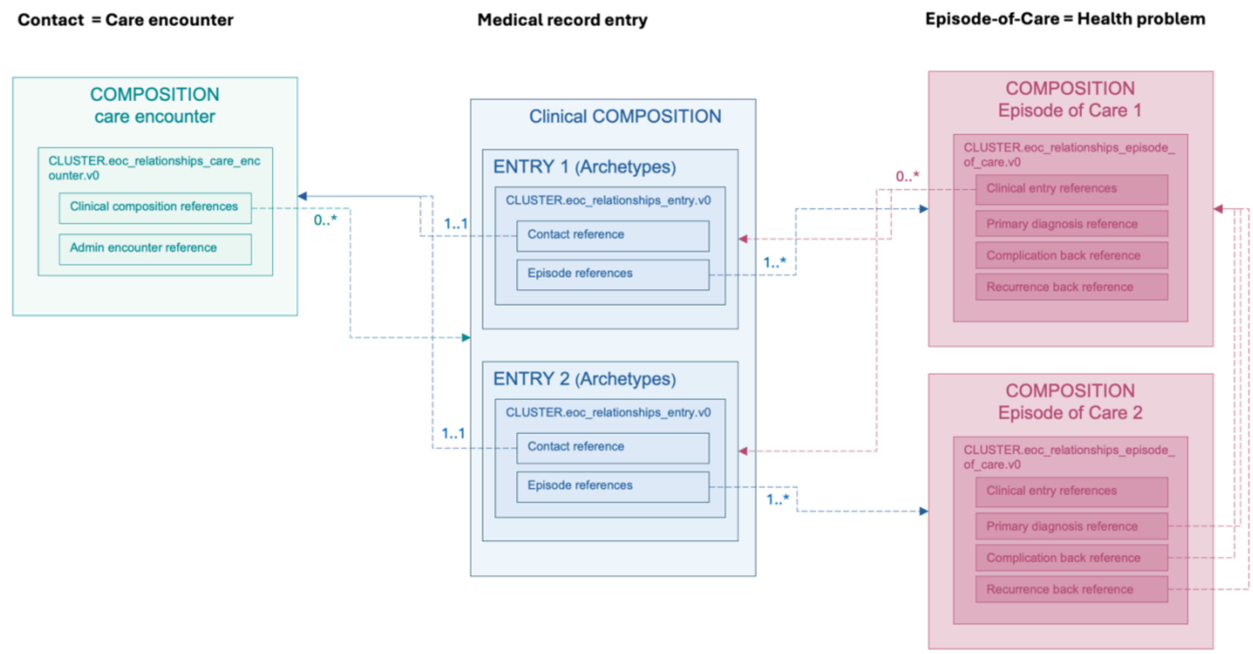


Figure 23 – CLUSTER-based associations linking care encounters, clinical entries and episodes

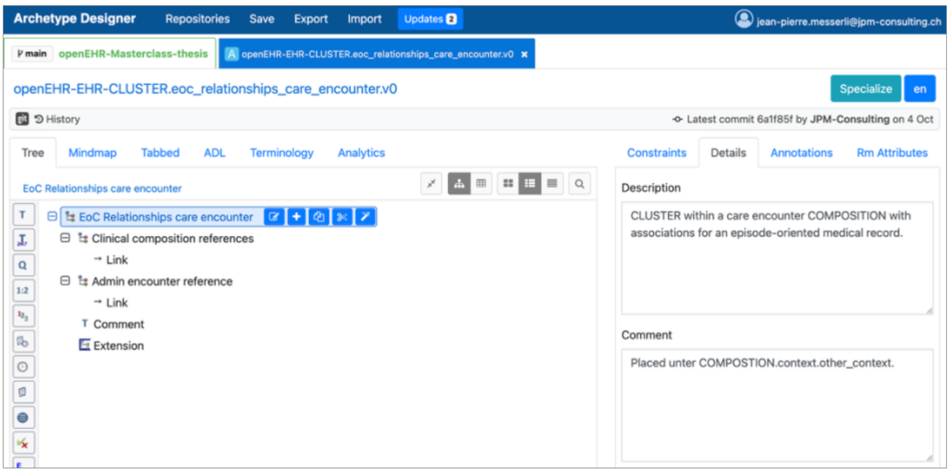


Figure 24 – CLUSTER within a care encounter COMPOSITION

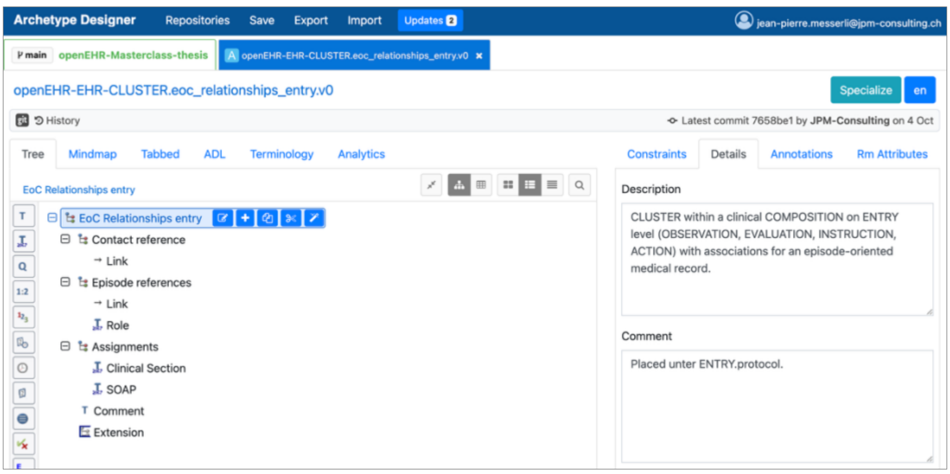


Figure 25 – CLUSTER within a clinical COMPOSITION on ENTRY level

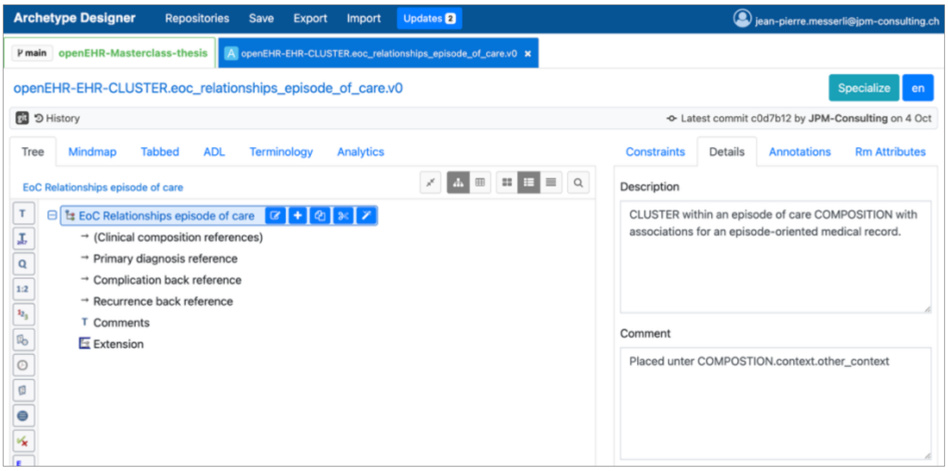


Figure 26 – CLUSTER within an episode-of-care COMPOSITION

4.5.3.3 Operational notes on CLUSTER-based indexing

Across these placements the relationship CLUSTERs provide a single governed structure that AQL can project into the required derived views such as chronological by contact, episode pivots, section based views and lists, while the episode of care COMPOSITION remains the single source of truth and no clinical content is duplicated.

Because the attributes are archetyped they benefit from governance including value sets and explicit cardinalities, for example exactly one primary per ENTRY. All CLUSTER content is persisted within the owning COMPOSITION, so versioning and audit follow the document. Where helpful applications may derive and persist reference model level LINKs, for example SAME_PLAN for episode affiliation, from the CLUSTER content to support bidirectional traversal without changing the semantics defined here.

4.6 Lists

In an episode-oriented medical record, lists are derived views rather than sources of truth. The authoritative record of a patient’s health problems is the episode of care COMPOSITION. All list presentations are computed at run time by AQL queries and filters over these episode compositions. This preserves provenance, avoids duplication, and keeps list semantics stable across contacts and over time. Where lists are persisted as COMPOSITIONs or FOLDERs, only LINKs to the episode of care COMPOSITIONs are stored.

4.6.1 Generic linear lists

Generic linear lists present episodes in a flat, sortable view independent of user-interface concerns. Ordering and grouping are applied as query filters and do not modify the underlying data. In openEHR, the list is produced by selecting episode of care COMPOSITIONs and projecting header attributes modelled in COMPOSITION.context.other_context (episode name, classification, clinical status, progression, first/last contact). Optional enrichment – such as “last activity date” or entry counts – can be derived by correlating ENTRY-level links from clinical documents to their episodes. No snapshot of the list is stored; pagination and sorting are handled by the query layer.

4.6.1.1 Episode list

In openEHR, the episode list is produced by selecting episode of care COMPOSITIONs and projecting the episode-header attributes modelled in COMPOSITION.context.other_context – namely the current episode name, clinical status (active, inactive, closed), progression (acute, chronic), and, for workflow control, the process status (referral, admission, pre-operative, post-operative, discharge, not applicable). Optional enrichment, such as a ‘last activity’ indicator, can be derived by correlating ENTRY-level links from clinical documents to their episode anchors. No snapshot of the list is stored; pagination and sorting are handled by the query layer.

4.6.1.2 Diagnosis list

The diagnosis list is a filtered view of the episode list that selects episodes whose header classification = diagnosis. Additional grouping and sorting follow the same pattern (for example by progression to distinguish acute and chronic diagnoses, or by process status such as admission or discharge diagnosis where present). Because the list is derived from episode of care COMPOSITIONs, consistency with the episode list is automatic when attributes such as the episode name or status change. Implementation in openEHR consists of an AQL query with a WHERE clause on the classification attribute, with optional filters on progression or process status.

4.6.1.3 Problem list

The problem list is the complementary filtered view that selects episodes whose header classification = problem. It supports the same ordering and grouping options as above. As with the diagnosis list, the problem list is computed by AQL over episode of care COMPOSITIONs and remains automatically consistent with the episode list because both are projections of the same source compositions.

4.6.2 Diagnosis and problem list

The diagnosis and problem list is the organising centre of the problem-oriented medical record described by Weed and is likewise used within episode-oriented records. Two complementary views are distinguished: a master diagnosis and problem list, representing a comprehensive longitudinal perspective curated collectively by healthcare professionals; and a contextual diagnosis and problem list, scoped to a specific specialty, clinical situation, or report. In the solution presented here, the episode of care COMPOSITIONs, together with the clinical COMPOSITIONs that hold the medical record entries, remain the only sources of truth. The diagnosis and problem list is a hierarchical view that assembles pointers (LINKs) to those compositions and does not duplicate clinical content.

4.6.2.1 ContSys-based structuring of the list

The openEHR specifications do not prescribe a normative modelling pattern for such lists. Community discussions and prototypes have explored a ContSys-inspired conceptual layer – health threads and health issues – to express curated, hierarchical relationships over existing clinical entries and episodes. This conceptual layer can be adapted to the desired governance model and used to shape list structure and navigation, while the authoritative data remain in episodes and clinical compositions [26, 48–50].

A lightweight ContSys-inspired layer is used to structure the diagnosis and problem list without introducing a new source of truth. Health Issue denotes any clinically relevant concern for a person, such as a condition, problem, risk, need or goal, that warrants attention. A Health Thread is the longitudinal container that organises and links information about the subject of care across time, settings and providers.

Applied to the episode-oriented record, the Health Thread serves as the list container for either a master or a contextual view. Beneath it, each Health Issue is treated as equivalent to an episode of care, anchored by a link to its episode of care COMPOSITION, and referencing zero or more links to medical record entries (ENTRY instances within clinical COMPOSITIONs) that relate to that episode, as chosen by the healthcare professional. The result is a curated hierarchy in which relationships are expressed as governed pointers rather than duplicated content. The authoritative data remain in the episode of care and clinical COMPOSITIONs, see Figures 22 and 23 [51.52].

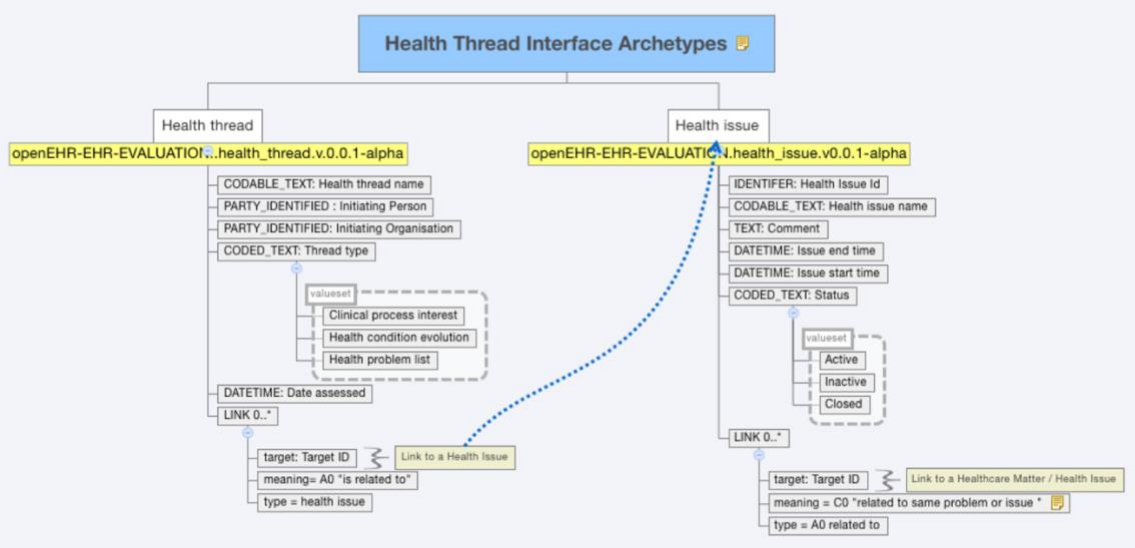


Figure 27 – ContSys interface archetypes: Health Thread and Health Issue

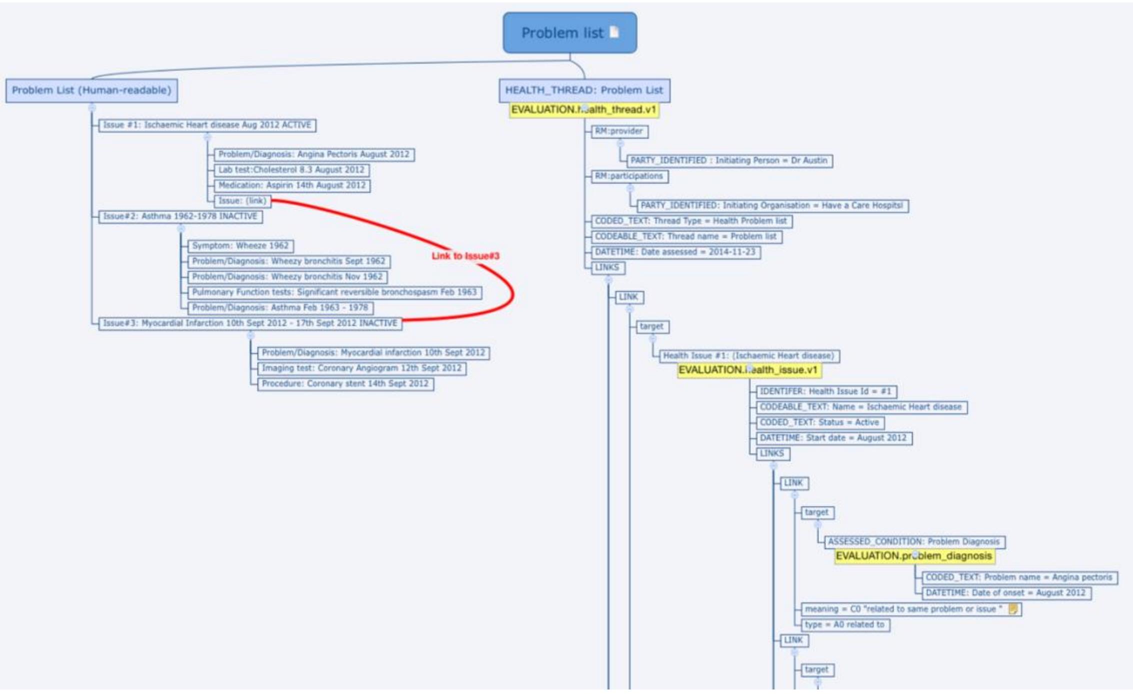


Figure 28 – Health Thread container linking Health Issues in a problem list

4.6.2.2 Archetype modelling and runtime assembly

In the Archetype Designer, modelling defines only the node types: the Health Thread EVALUATION archetype and the Health Issue EVALUATION archetype. It does not prescribe a patient-specific tree. The actual hierarchy of issues and their associated content is assembled by the application at run time and curated in the user interface. When the user saves, this curated tree is persisted in COMPOSITIONs: the Health Thread EVALUATION acts as the list container and holds pointers to the Health Issue instances. Each Health Issue is anchored by a link to its Episode-of-Care COMPOSITION, and further links (e.g. DV_EHR_URI targets) connect to the relevant clinical entries. Changes to the hierarchy therefore create new versions of the affected COMPOSITIONs, with provenance preserved, rather than creating a separate graph object outside the record. The Health Issue archetype also provides an option to record an alternative display name for the episode of care where this is needed in everyday clinical practice.

An example of a medical information system featuring a diagnosis and problem list curated jointly by healthcare professionals is provided in the Appendix D [53].

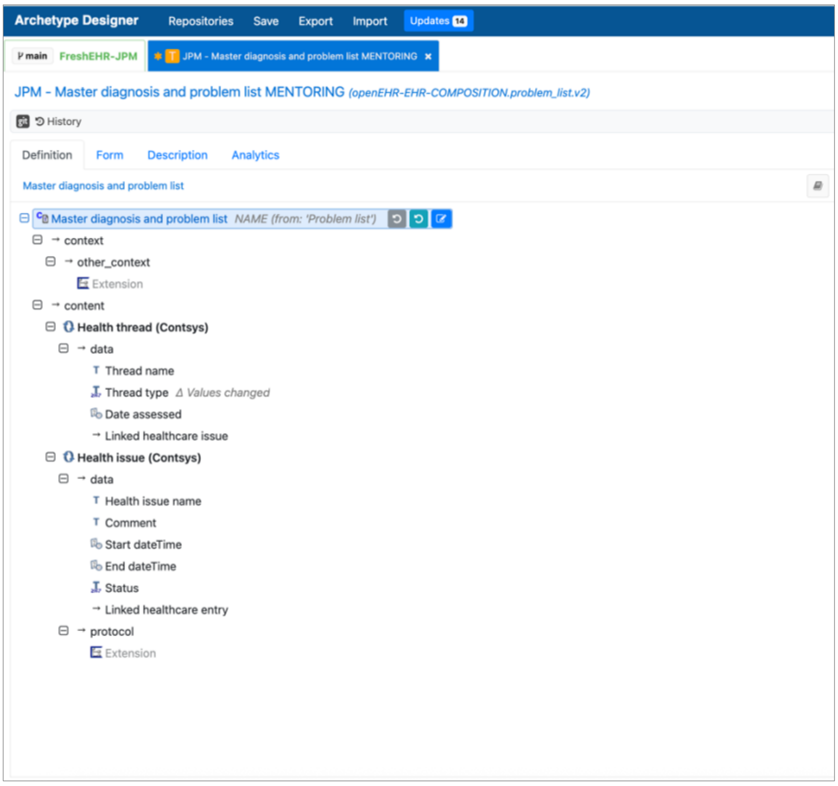


Figure 29 – Basic elements of the Master diagnosis and problem list template

4.6.2.3 Master list

The master diagnosis and problem list is the patient-wide longitudinal index spanning all episodes and care settings. Curated jointly by clinicians, it presents a comprehensive view, with episodes grouped and prioritised by clinical relevance. As a derived view, it is computed by AQL over episode of care COMPOSITIONs and their links, avoiding duplication while supporting navigation, reconciliation and longitudinal care planning.

4.6.2.4 Contextual list

A contextual diagnosis and problem list provides a focused view tailored to a specific clinical context (e.g. diabetes clinic, current episode, specialty service). It may distinguish a contextual primary diagnosis, clinically relevant comorbidities, and problems or complications arising from the primary condition, so teams can prioritise what matters now without losing sight of the wider record. Representing the contextual list as a single persistent COMPOSITION per context enables a coherent, curatable snapshot [23].

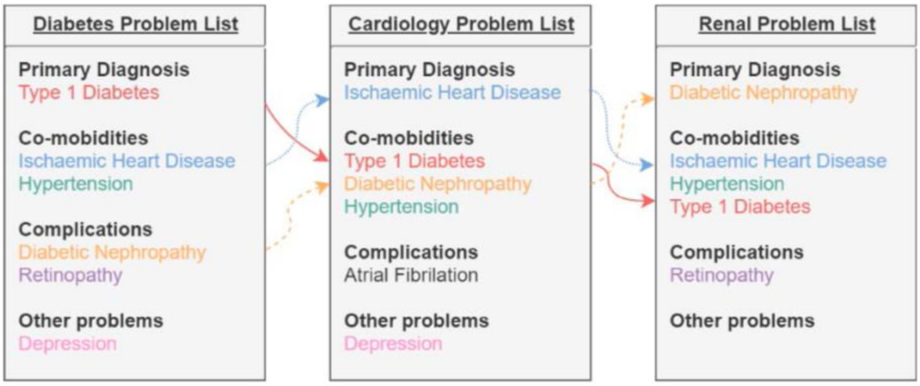


Figure 30 – Shared problem records within three contextual problem lists

Where required, dedicated templates can be defined for different contexts. If a contextual list is persisted, each context has its own COMPOSITION that stores pointers (e.g. DV_EHR_URI) to the relevant episode of care COMPOSITIONs and to ENTRY paths within clinical COMPOSITIONs, optionally organised with a Health Thread (container) and Health Issues. The contextual list remains a derived view: the episode of care and clinical COMPOSITIONs are the sources of truth; the contextual COMPOSITION holds references only and does not duplicate clinical content.

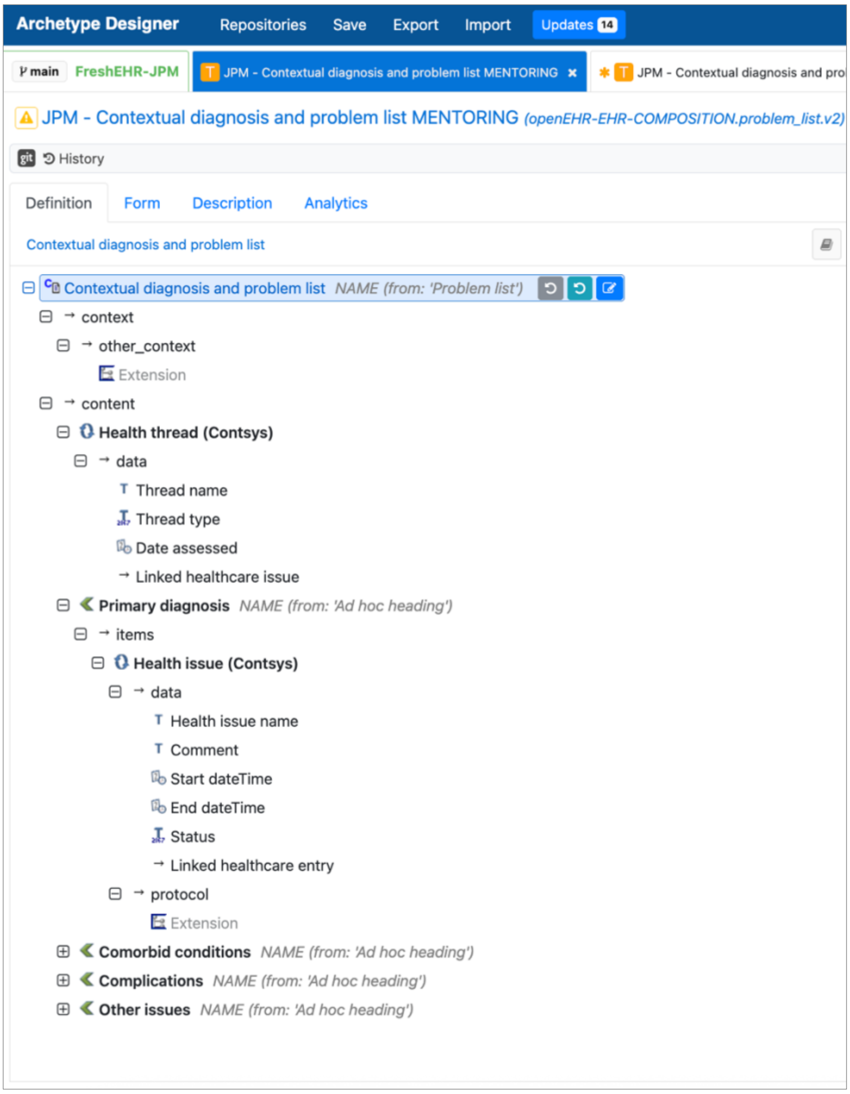


Figure 31 – Basic elements of the contextual diagnosis and problem list template

4.6.3 Past medical history list (PMH)

The past medical history list is a jointly curated, longitudinal summary restricted to episodes whose clinical status is closed. It reuses the structuring described for the diagnosis and problem list: items are episode of care COMPOSITIONs, and narrative statements captured during history taking can be linked to the relevant episodes. Because the full episode–entry linkage is preserved, users can drill down from the past medical history list to all associated clinical entries at any time.

By default, the past medical history is a derived view: an AQL query filters episode of care COMPOSITIONs by status = closed and projects header attributes (e.g. episode name, dates, classification) for display. No clinical content is duplicated; provenance remains with the episode of care and clinical COMPOSITIONs.

Where a persistent summary and sort order is helpful for day-to-day curation, a past medical history COMPOSITION may be maintained per patient that stores pointers (e.g. DV_EHR_URI) to the closed episodes, and optionally to representative ENTRY paths. In some settings a denormalised snapshot is used, copying a minimal set of episode attributes (such as name and dates) into the past medical history COMPOSITION with a back-link to the source episode; this can ease collaborative maintenance but requires governance to avoid drift. In all variants, the episode of care COMPOSITIONs and clinical COMPOSITIONs remain the single sources of truth.

4.7 Evaluation

Within openEHR, several approaches can represent the Solon episode-oriented medical record. To examine and evaluate them, three artefacts are used: (1) user stories that capture the core requirements; (2) a spreadsheet-based sample patient history providing a longitudinal, multi-episode dataset; and (3) a structured evaluation framework with defined criteria and rating scales.

4.7.1 User stories

The following user stories articulate clinician-facing functional needs, independent of any specific openEHR modelling approach. They frame the evaluation by specifying the observable outcomes and navigation patterns expected of an episode-oriented record. In this thesis, ‘health problem’ (diagnosis/problem) is treated as synonymous with an episode of care; accordingly, the stories assume the ability to pivot between chronological, section-based, and episode-centred views. Each story is instantiated using the spreadsheet-based sample patient history to demonstrate the expected behaviour.

1. As a healthcare professional, I would like to see all medical record entries for a patient in the CDR displayed chronologically and grouped by contact.
2. As a healthcare professional, I would like to be able to select an Episode of care (health problem = diagnosis/problem) and then view all medical record entries relating to that health problem in the patient's complete CDR.
3. As a healthcare professional, I would like to see all medical record entries in a patient's CDR organised according to the standard clinical sections of a medical record, for example medical history, physical examination, diagnostics, therapy, risk factors, progress notes.
4. As a healthcare professional, I would like the grouping to be according to the standard clinical sections of a medical record, with the chronological grouping by contacts or with the corresponding record entries for the selected health problem displayed.
5. As a healthcare professional, I would like to have a linear list of all patient's recorded health problems (= diagnosis/problem = episode-of-care).
6. As a healthcare professional, I would like to be able to create a hierarchical 'diagnosis and problem list' for each patient, organised in a tree structure according to Weed's problem list, which I could then adapt continuously.
7. As a healthcare professional, I would like to be able to create progress notes according to the SOAP scheme for each health problem (= diagnosis/problem = episode-of-care) or for several health problems at the same time.

8. As a healthcare professional, I would like a dashboard for each patient containing various widgets. Each widget would display medical record entries for a single section, in accordance with the standard clinical sections of a medical record.

4.7.2 Sample patient history

To support the evaluation, a spreadsheet-based sample patient history was constructed for Ms Anita Zbinden. The dataset contains 132 medical record entries spanning acute and chronic care and is purpose-built to exercise the episode-oriented model: acute episodes (e.g. urinary tract infection, cholecystitis), long-term conditions (e.g. coronary heart disease, diabetes), and routine encounters. It is used to instantiate the eight user stories, providing concrete, observable outcomes for chronological views, episode pivots, section-based views, and list generation, without introducing duplicate sources of truth.

4.7.2.1 Clinical introduction

Ms Anita Zbinden, 79-year-old woman (DOB 25 Dec 1944), new to the medical centre following relocation one months ago. General condition good, alert and fully orientated; pulse 75 bpm, regular.

Diagnosis and problem list

1. Coronary heart disease with:
    - Arterial hypertension (Dx 2009)
    - Heart failure
    - History of Myocardial infarction (2015)
2. Diabetes mellitus type 2 (Dx 2007) with:
    - Polyneuropathy (Dx 2014)
    - Nephropathy (Dx 2017)
    - HbA1c 23.02.2024: 6.4%
3. Obesity WHO grade II
    - Baseline BMI 35.9 kg/m2
    - Start therapy with liraglutide 03.04.2022
    - BMI 16 May 2024: 31.3. kg/m2
4. Husband in need of care
5. Hammer toe, left foot
6. Appendectomy (1965)

Current medication

- Acetylsalicylic acid (Aspirin Cardio) 100 mg tablet (1-0-0-0)
- Torasemide (Torasemid Spirig HC) 5 mg tablet (1-0-0-0)
- Valsartan (Valsartan Mepha) 160 mg tablet (1-0-0-0)
- Rosuvastatin (Rosuvastatin Sandoz) 20 mg tablet (1-0-0-0)
- Metformin (Metformin Sandoz) 1,000 mg tablet (1-1-1-0)
- Zolpidem (Zolpidem Mepha) 10 mg tablet (0-0-0-1) when required (PRN)

Current care

Comprehensive longitudinal management of chronic conditions within the practice; acute episodes – urinary tract infection and cholecystitis – are managed episodically within the episode-oriented record.

4.7.2.2 Extract from spreadsheet

The excerpt shown is taken from the Excel workbook that contains the sample history. The complete spreadsheet-based sample patient history is provided in Appendix E. Each row corresponds to a single medical record entry, and the columns capture narrative detail, clinical section, the linked episode-of-care, condition type (problem/diagnosis), clinical status, and both event and recording timestamps. This extract underpins the AQL examples in the evaluation and demonstrates how entries map consistently to contacts, episodes and sections to realise the expected user-story behaviour.

Date	Contact	Detail entry	Section	Health problem Episode of Care	ID	Condition	Clinical Status	Recording Timestamp	Event Timestamp	Availability Timestamp
15.11.2024	Consultation	Reason for Encounter: Initial consultation for dysuria Chief Complaint: Burning sensation with urination.	Present illness					14.11.24 16:30	15.11.24 11:00	
15.11.2024	Consultation		Problem/Diagnosis	Dysuria	10	Problem	Active	15.11.24 10:00	15.11.24 10:00	15.11.24 10:00
15.11.2024	Consultation	Blood pressure 140/90	Vital signs	General health problem	10	Problem	Active	15.11.24 10:15	15.11.24 10:10	15.11.24 11:00
15.11.2024	Consultation	Heart rate 75	Vital signs	General health problem	10	Problem	Active	15.11.24 10:15	15.11.24 10:10	15.11.24 11:00
15.11.2024	Consultation	Weight = 86 kg	Vital signs	General health problem	10	Problem	Active	15.11.24 10:15	15.11.24 10:10	15.11.24 11:00
15.11.2024	Consultation	Height = 168 cm	Vital signs	General health problem	10	Problem	Active	15.11.24 10:15	15.11.24 10:10	15.11.24 11:00
15.11.2024	Consultation	BMI = 30.5	Vital signs	General health problem	10	Problem	Active	15.11.24 10:15	15.11.24 10:10	15.11.24 11:00
15.11.2024	Consultation	Urinalysis – dipstick: Leukocyte esterase: 3+, Nitrite: positive, Blood: 1+, Protein: trace, pH: 6.0	Laboratory results	Dysuria	10	Problem	Active	15.11.24 10:30	15.11.24 10:30	15.11.24 11:00
15.11.2024	Consultation	S: Burning sensation during urination for 3 days. First episode. Denies visible blood in urine O:pyuria A: Suspected cystitis P: antibiogram, Started treatment with trimethoprim– sulfamethoxazole. Therapy adjusted per antibiogram	Progess notes	Dysuria	10	Problem	Active	15.11.24 11:10	15.11.24 11:10	15.11.24 11:10
15.11.2024	Consultation		Problem/Diagnosis	Urinary tract infection	10	Diagnosis	Active	15.11.24 11:11	15.11.24 11:11	15.11.24 11:10
15.11.2024	Consultation	Trimethoprim–sulfamethoxazole (TMP 160 mg / SMX 800 mg) PO 2x1	Medication	Urinary tract infection	10	Diagnosis	Active	15.11.24 11:12	15.11.24 11:12	15.11.24 11:12
15.11.2024	Consultation	S: Bilateral, pressure-like headaches for ~2 years, usually relieved by one paracetamol 500 mg. Over the past few weeks pain intensity has increased and tablets give only partial relief. O: Neurologic exam: alert, cranial nerves II–XII intact, motor 5/5, normal gait, no sensory deficits, Romberg negative. Fundoscopy: optic discs sharp, no papillo-œdema. Head & neck: no scalp or temporal-artery tenderness A: Chronic tension-type headache with recent exacerbation P: Start headache diary	Problem/Diagnosis	Headache	200	Problem	Active	15.11.24 11:15	15.11.24 11:15	15.11.24 11:15

Figure 32 – Extract from the spreadsheet-based sample history, consultation on 15.11.2024

4.7.3 User stories — illustrated examples

This subsection repeats each user story and, directly beneath it, presents a figure from the sample patient history that illustrates the expected output. The figures are illustrative and implementation-agnostic; they convey the required data slices and groupings (e.g. chronological by contact, episode pivots, section-based views, derived lists) rather than prescribing a user interface. All views are derived from episode of care COMPOSITIONs and introduce no additional sources of truth.

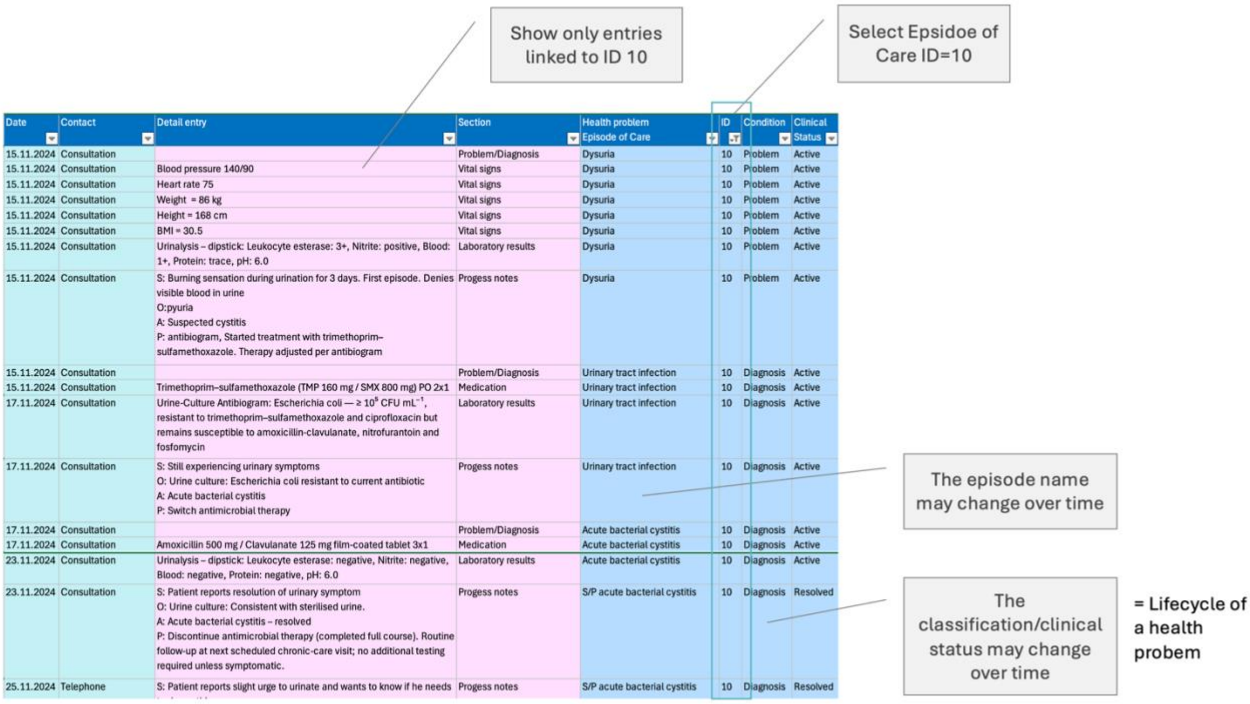
4.7.3.1 User Story 1 – Chronological by contact

As a healthcare professional, I would like to see all medical record entries for a patient in the CDR displayed chronologically and grouped by contact.

Figure 33 – Chronological by contact: Entries grouped per contact and ordered by time

4.7.3.2 User Story 2 – Episode pivot

As a healthcare professional, I would like to be able to select an episode of care (health problem = diagnosis/problem) and then view all medical record entries relating to that health problem in the patient's complete CDR.

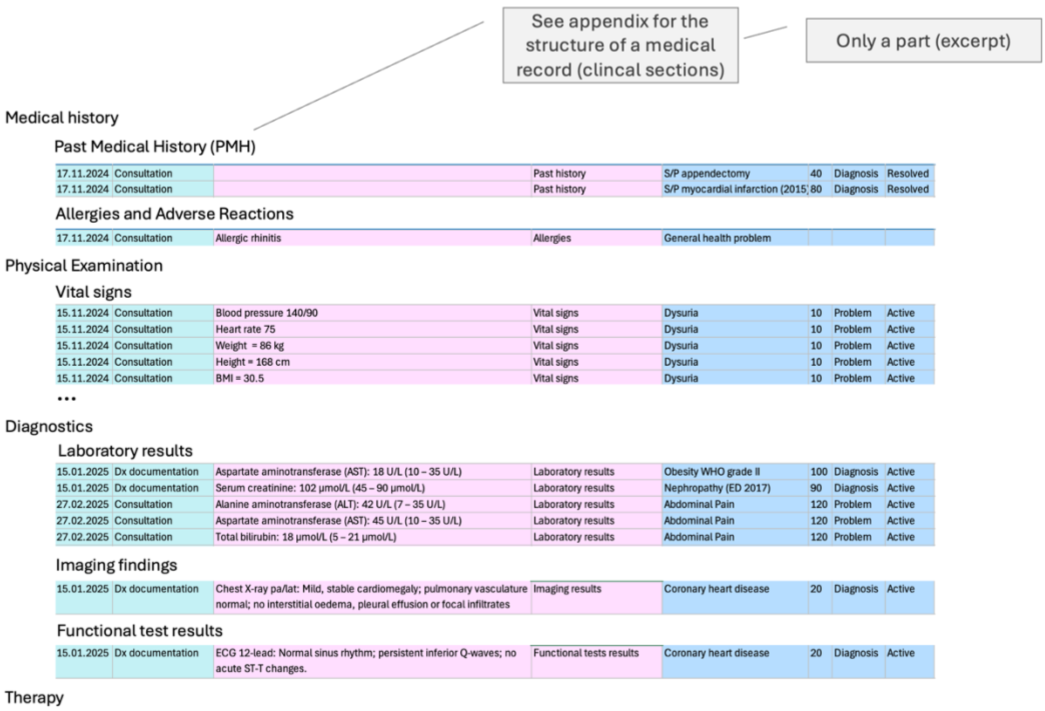


Date	Contact	Detail entry	Section	Health problem Episode of Care	ID	Condition	Clinical Status
15.11.2024	Consultation		Problem/Diagnosis	Dysuria	10	Problem	Active
15.11.2024	Consultation	Blood pressure 140/90	Vital signs	Dysuria	10	Problem	Active
15.11.2024	Consultation	Heart rate 75	Vital signs	Dysuria	10	Problem	Active
15.11.2024	Consultation	Weight = 86 kg	Vital signs	Dysuria	10	Problem	Active
15.11.2024	Consultation	Height = 168 cm	Vital signs	Dysuria	10	Problem	Active
15.11.2024	Consultation	BMI = 30.5	Vital signs	Dysuria	10	Problem	Active
15.11.2024	Consultation	Urinalysis – dipstick: Leukocyte esterase: 3+, Nitrite: positive, Blood: 1+, Protein: trace, pH: 6.0	Laboratory results	Dysuria	10	Problem	Active
15.11.2024	Consultation	S: Burning sensation during urination for 3 days. First episode. Denies visible blood in urine O:pyuria A: Suspected cystitis P: antibiogram, Started treatment with trimethoprim–sulfamethoxazole. Therapy adjusted per antibiogram	Progess notes	Dysuria	10	Problem	Active
15.11.2024	Consultation		Problem/Diagnosis	Urinary tract infection	10	Diagnosis	Active
15.11.2024	Consultation	Trimethoprim–sulfamethoxazole (TMP 160 mg / SMX 800 mg) PO 2x1	Medication	Urinary tract infection	10	Diagnosis	Active
17.11.2024	Consultation	Urine-Culture Antibiogram: Escherichia coli — ≥ 10^5 CFU mL^{-1}, resistant to trimethoprim–sulfamethoxazole and ciprofloxacin but remains susceptible to amoxicillin-clavulanate, nitrofurantoin and fosfomycin	Laboratory results	Urinary tract infection	10	Diagnosis	Active
17.11.2024	Consultation	S: Still experiencing urinary symptoms O: Urine culture: Escherichia coli resistant to current antibiotic A: Acute bacterial cystitis P: Switch antimicrobial therapy	Progess notes	Urinary tract infection	10	Diagnosis	Active
17.11.2024	Consultation		Problem/Diagnosis	Acute bacterial cystitis	10	Diagnosis	Active
17.11.2024	Consultation	Amoxicillin 500 mg / Clavulanate 125 mg film-coated tablet 3x1	Medication	Acute bacterial cystitis	10	Diagnosis	Active
23.11.2024	Consultation	Urinalysis – dipstick: Leukocyte esterase: negative, Nitrite: negative, Blood: negative, Protein: negative, pH: 6.0	Laboratory results	Acute bacterial cystitis	10	Diagnosis	Active
23.11.2024	Consultation	S: Patient reports resolution of urinary symptom O: Urine culture: Consistent with sterilised urine. A: Acute bacterial cystitis – resolved P: Discontinue antimicrobial therapy (completed full course). Routine follow-up at next scheduled chronic-care visit; no additional testing required unless symptomatic.	Progess notes	S/P acute bacterial cystitis	10	Diagnosis	Resolved
25.11.2024	Telephone	S: Patient reports slight urge to urinate and wants to know if he needs	Progess notes	S/P acute bacterial cystitis	10	Diagnosis	Resolved

Figure 34 – Episode pivot: Entries linked to a selected episode across contacts

4.7.3.3 User Story 3 – Clinical section-based view (excerpt)

As a healthcare professional, I would like to see all medical record entries in a patient's CDR organised according to the standard clinical sections of a medical record, i.e. medical history, physical examination, diagnostics, therapy, risk factors, progress notes, etc.



Medical history

Past Medical History (PMH)

17.11.2024	Consultation		Past history	S/P appendectomy	40	Diagnosis	Resolved
17.11.2024	Consultation		Past history	S/P myocardial infarction (2015)	80	Diagnosis	Resolved

Allergies and Adverse Reactions

17.11.2024	Consultation	Allergic rhinitis	Allergies	General health problem			

Physical Examination

Vital signs

15.11.2024	Consultation	Blood pressure 140/90	Vital signs	Dysuria	10	Problem	Active
15.11.2024	Consultation	Heart rate 75	Vital signs	Dysuria	10	Problem	Active
15.11.2024	Consultation	Weight = 86 kg	Vital signs	Dysuria	10	Problem	Active
15.11.2024	Consultation	Height = 168 cm	Vital signs	Dysuria	10	Problem	Active
15.11.2024	Consultation	BMI = 30.5	Vital signs	Dysuria	10	Problem	Active

...

Diagnostics

Laboratory results

15.01.2025	Dx documentation	Aspartate aminotransferase (AST): 18 U/L (10 – 35 U/L)	Laboratory results	Obesity WHO grade II	100	Diagnosis	Active
15.01.2025	Dx documentation	Serum creatinine: 102 µmol/L (45 – 90 µmol/L)	Laboratory results	Nephropathy (ED 2017)	90	Diagnosis	Active
27.02.2025	Consultation	Alanine aminotransferase (ALT): 42 U/L (7 – 35 U/L)	Laboratory results	Abdominal Pain	120	Problem	Active
27.02.2025	Consultation	Aspartate aminotransferase (AST): 45 U/L (10 – 35 U/L)	Laboratory results	Abdominal Pain	120	Problem	Active
27.02.2025	Consultation	Total bilirubin: 18 µmol/L (5 – 21 µmol/L)	Laboratory results	Abdominal Pain	120	Problem	Active

Imaging findings

15.01.2025	Dx documentation	Chest X-ray pa/lat: Mild, stable cardiomegaly; pulmonary vasculature normal; no interstitial oedema, pleural effusion or focal infiltrates	Imaging results	Coronary heart disease	20	Diagnosis	Active

Functional test results

15.01.2025	Dx documentation	ECG 12-lead: Normal sinus rhythm; persistent inferior Q-waves; no acute ST-T changes.	Functional tests results	Coronary heart disease	20	Diagnosis	Active

Therapy

Figure 35 – Section-based view (excerpt): Entries organised by clinical sections

4.7.3.4 User Story 4 – Dual grouping

As a healthcare professional, I would like the grouping to be according to the standard clinical sections of a medical record, with the chronological grouping by contacts or with the corresponding record entries for the selected health problem displayed.

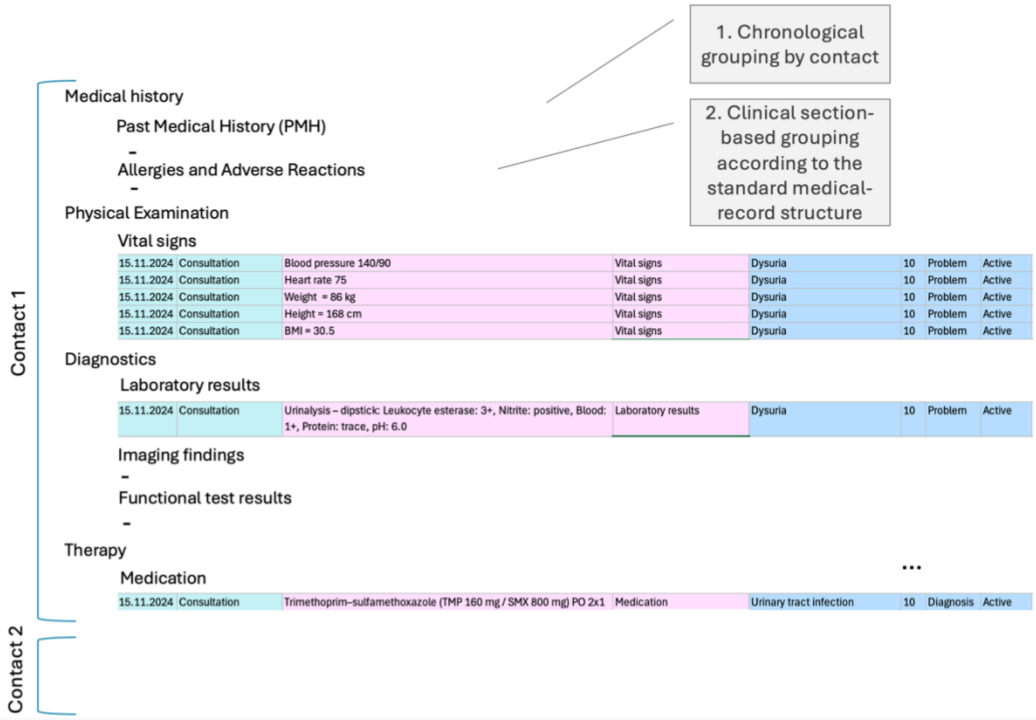


Figure 36 – Dual grouping: Chronological by contact and by clinical section

4.7.3.5 User Story 5 – Linear episode list

As a healthcare professional, I would like to have a linear list of all patient's recorded health problems (= diagnosis/problem = episode-of-care).

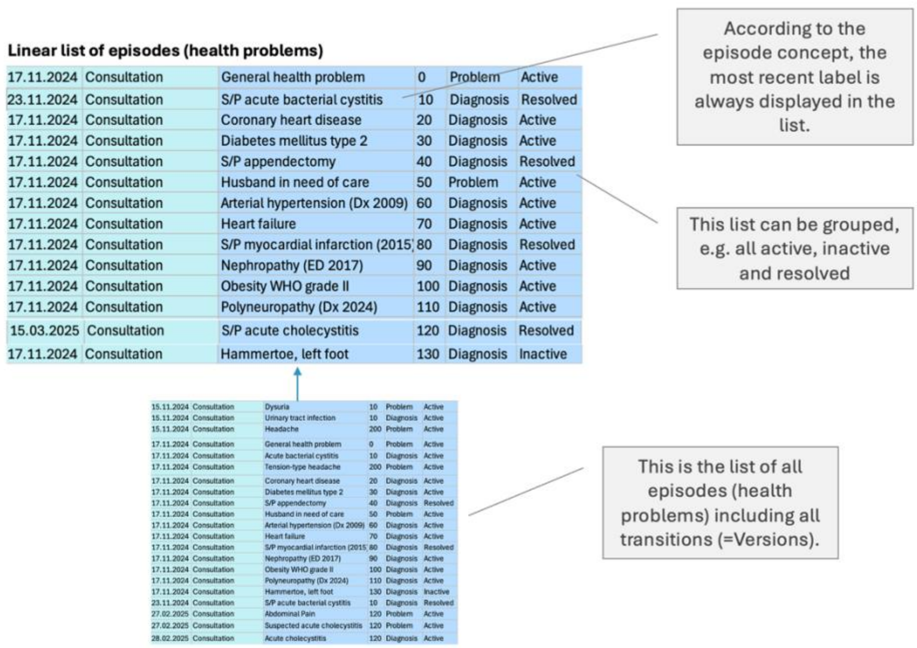


Figure 37 – Linear episode list: All episodes with key status/progression

4.7.3.6 User Story 6 – Master diagnosis & problem list

As a healthcare professional, I would like to be able to create a hierarchical 'diagnosis and problem list' for each patient, organised in a tree structure according to Weed's problem list, which I could then adapt continuously.

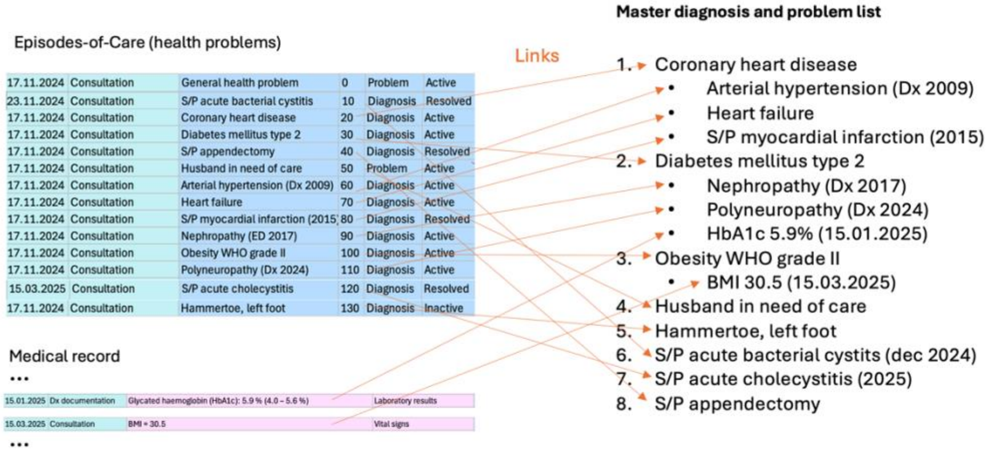


Figure 38 – Master diagnosis & problem list: Hierarchical (Weed-style) view

4.7.3.7 User Story 7 – SOAP progress notes

As a healthcare professional, I would like to be able to create progress notes according to the SOAP scheme for each health problem (= diagnosis/problem = episode-of-care) or for several health problems at the same time.

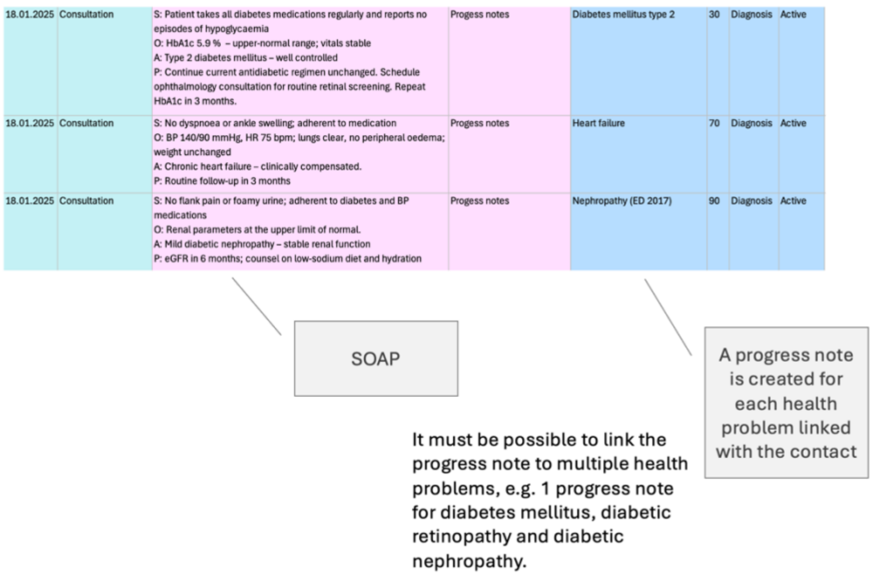


Figure 39 – SOAP progress notes: Note linked to one or multiple episodes

4.7.3.8 User Story 8 – Dashboard

As a healthcare professional, I would like a dashboard for each patient containing various widgets. Each widget would display medical record entries for a single section, in accordance with the standard clinical sections of a medical record.

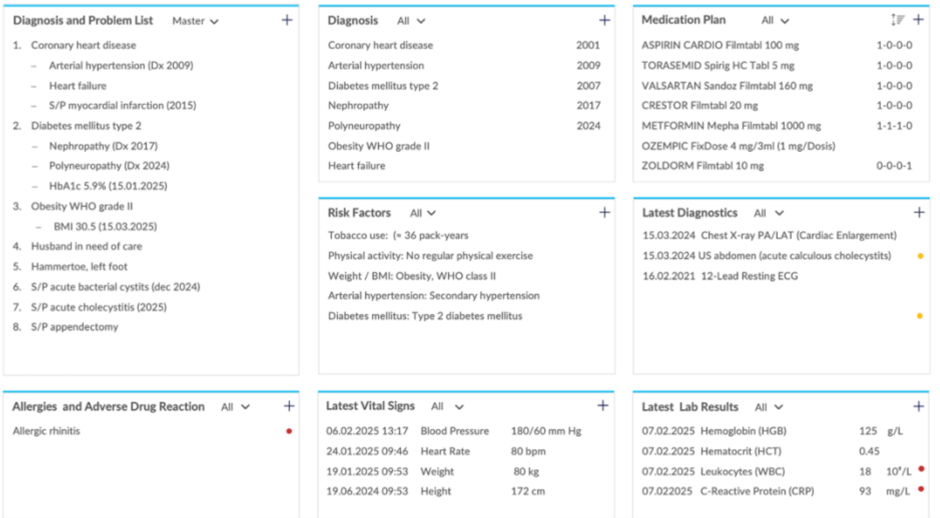


Figure 40 – Patient dashboard: Section-specific widgets as derived views

4.7.4 Evaluation framework

An evaluation framework was developed to assess the various approaches. Drawing on considerations from the openEHR Switzerland Data Modelling Exchange Group (DMEG), the framework defines criteria and value options for a systematic, vendor-neutral comparison.

The criteria encompass standard compliance, versioning behaviour, template effort, maintainability, tool and API/SDK support, terminology scope, query options (including single-statement AQL), multiple use, cross-CDR interoperability, flexibility, runtime performance impact, governance effort, multi-vendor suitability, implementation complexity, and availability of guidance. Ratings use the scales shown (Yes/No; Low–Very High) to express fitness for purpose and make trade-offs explicit [47].

Topic	Short Explanation	Values/Options
Standard compliance	Is the approach part of the official openEHR specifications?	Yes, no
CDR versioning	Does the CDR automatically create a new version on update with this approach?	Yes, no
Template effort	Effort required to author templates for this approach	High (per archetype), Medium, Low (centralized)
Maintainability	Ease of maintenance - duplicates vs single source of truth	Low, Medium (duplicates), High (single source)
Tool ecosystem	Modelling tools that support this approach out of the box	Archetype Designer, CKM, Other
Programmatic support	Can it be managed via APIs or SDKs?	Yes, no
Archetype maturity	Required archetype management level	Proprietary, CKM v0 (draft), CKM v1+ (published)
Terminology scope	Level of terminology support required	None (proprietary), National, International
Query options	Available query interfaces	AQL, REST-API only, Both

Single-statement AQL	Can all relevant data be retrieved in one AQL statement?	Yes No (multi-step/pseudo-join)
Multiple use	Supports multiple use (e.g. multiple RM LINKs per COMPOSITION; COMPOSITION referenced by multiple folders)	Yes, no
Cross-CDR interoperability	Suitability across different CDR repositories and system boundaries.	Yes, no
Flexibility	Adaptability to new requirements	Low, Medium, High, Very High
Runtime performance impact	Expected effect on system performance	Low (negligible), Medium, High, Very High
Governance effort	Governance level needed for sustainable maintenance	Archetype-level, RM-level
Suitability for multi-vendor ecosystem	Suitability for uniform implementation across different vendors	Easy, medium, difficult
Implementation complexity	Overall complexity to implement	Low, Medium, High, Very High
Implementation guide	Availability of implementation guidance	Exists, to be developed

Table 8 – Evaluation criteria for openEHR implementation approaches

4.7.5 Application of the framework and headline findings

The framework was used to conduct a brief, focused comparative analysis of the introduced approaches. This appraisal emphasises consistency and comparability against the defined user stories and the spreadsheet-based sample history, rather than exhaustiveness. Detailed performance benchmarking and vendor-specific tuning are out of scope for this section.

Findings (summary)

- All approaches can realise an episode-oriented record without duplicating clinical content when lists are treated as derived views and associations are expressed as pointers.
- Governance and maintainability: A small, reusable CLUSTER for episode header and associations provides the strongest in-template governance (value sets, cardinalities) and simplifies long-term maintenance. FOLDER indexing offers clear navigation but requires directory governance. LINK-only designs depend more heavily on project conventions and link hygiene.
- Querying: For the evaluated use cases (chronological by contact, episode pivots, section views, lists), single-statement AQL typically offers the simplest solution with CLUSTER projections. FOLDER-only and LINK-only solutions often need a two-step workflow when dereferencing DV_EHR_URI targets.
- Versioning and provenance: All patterns respect openEHR version semantics. FOLDER updates version the directory separately, while CLUSTER and LINK changes version with their owning COMPOSITIONs.
- Tooling and programmatic support: Modelling the relationship context as a CLUSTER is well supported by mainstream tooling (archetype/template level). FOLDER and LINK patterns are broadly supported programmatically via REST/AQL across vendors.
- Cross-CDR suitability: The feasibility across repositories hinges on resolvable identifiers and agreed governance for URIs and codes. None of the patterns alone guarantees cross-boundary resolution.
- Implementation complexity: CLUSTER concentrates complexity in the template but yields simpler queries. FOLDER requires directory provisioning and lifecycle policies. LINK-only keeps templates light but shifts complexity to application logic and query workflows.

These results provide a concise overview for the subsequent comparative discussion. The implications and recommended combinations are discussed in the conclusion.

5 Discussion

Digitalisation has established the electronic health record as core infrastructure. Yet how clinical data are organised within a medical information system remains a significant challenge for improving care quality, continuity, and decision-making. While traditional models such as source-oriented records and the problem-oriented medical record offer familiarity and structure, they struggle to represent care trajectories that span multiple providers and periods of care. Modern care models and value-based healthcare need views that follow the patient across time and care settings, while keeping the original context and audit trail intact.

To meet clinical, operational and analytical needs, medical documentation can be organised according to several established approaches that support care delivery, governance and consistent querying, namely:

- Document-oriented documentation
- Source-oriented documentation
- Consultation-oriented documentation
- Problem-oriented documentation according to Weed
- Episode-oriented documentation according to Solon et al.

The episode-oriented approach reflects an evolution of Weed's problem-oriented method. It preserves the discipline of problem/diagnosis-based documentation while adding explicit episodes of care with defined context and lifecycle. This approach places the strongest demands on the information model and governance, because the relationships between medical record entries, problems/diagnoses, care encounters, and lists must be expressed consistently and without duplication.

Practical experience indicates that the explicit episode concept enables other methods to be rendered seamlessly as views within a medical information system. Consequently, the problem-, consultation-, source- and document-oriented approaches can be considered simplified representations of the episode-oriented record. This is operationalised via the episode-of-care “General health problem”, which acts as a neutral episode anchor. Medical record entries can be selectively associated either with a specific episode of care or with this general episode, allowing each documentation approach to project exactly the required subset.

openEHR has become an established standard for long-term persistence of clinical data. Its multi-level modelling, with a stable Reference Model layered with archetypes and templates, provides vendor-neutral, computable semantics and a durable way to express clinical concepts as governed clinical models. The architecture is primarily document- and source-centred (COMPOSITIONs with SECTIONs and ENTRY statements) but does not enforce a specific organisational pattern for arranging content across a patient’s record.

openEHR is increasingly used to model complete clinical information systems for hospitals, ambulatory services and general practice. Such systems require a coherent, end-to-end base architecture with a patient-centred view, jointly curated clinical content, and clearly defined single sources of truth for a patient’s medical information. The episode-oriented record presented here is particularly well suited to this task: Episodes of care provide a stable organising spine that supports cross-setting continuity of care and, depending on the platform, cross-organisational workflows. This yields a governance-friendly foundation in which lists remain views, provenance is preserved, and clinical information can be navigated and analysed consistently across services.

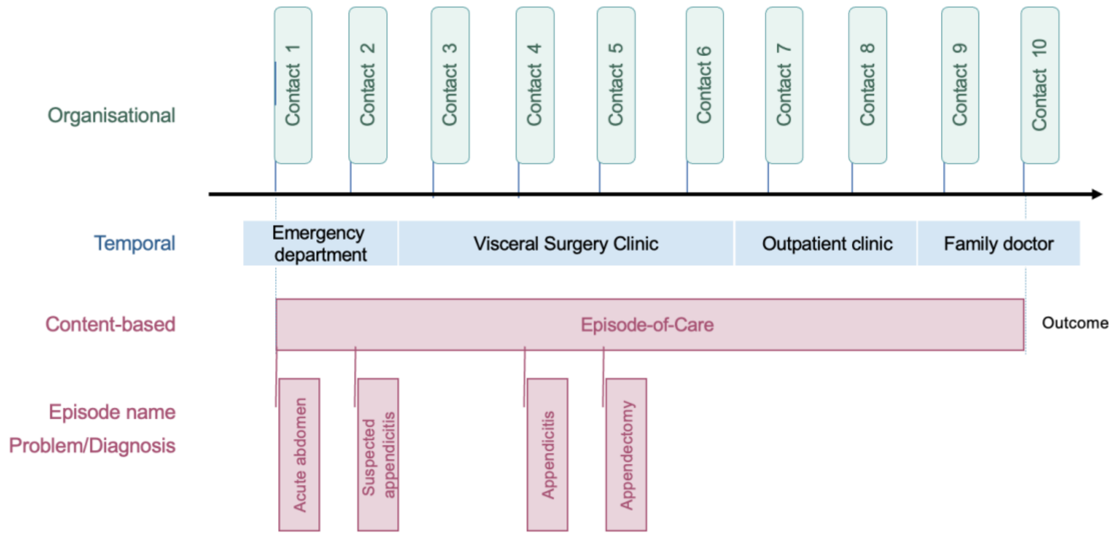


Figure 41 – A patient's Episode-of-Care across organisational units and care settings

5.1 Key Result and Status of the Hypotheses

The most important result of this study is that an episode-centred design with lists as derived views provides a coherent and practicable way to organise clinical data in openEHR. The episode-of-care COMPOSITION is the single source of truth for each health problem or diagnosis. The care-encounter COMPOSITION records the clinical contact and, where relevant, aligns with an administrative encounter for operational reporting. The clinical content itself resides in clinical COMPOSITIONs with their ENTRY instances.

Relationships between these artefacts can be realised in several standard-conformant ways within openEHR. The patterns examined were FOLDER-based directory indexing, LINK as typed references, and archetyped relationship CLUSTERs within templates, each of which can represent the required relationships.

At ENTRY level, every medical record entry is explicitly associated with an episode of care and a care encounter. Each entry is also assigned to a clinical section, using a stable section value set, and to a SOAP field. This yields a uniform, patient-centred presentation model. Chronological, episode-centric and section or SOAP views are generated consistently. The anchors and assignments needed to produce these are persisted in the patient's EHR, so no additional logic-layer specification is required.

Linear lists can be produced at run time by AQL over episode-of-care COMPOSITIONs and clinical COMPOSITIONs. They are rendered on demand, with filtering, ordering and pagination handled in the query layer. No clinical content is persisted beyond the source compositions.

Where a durable snapshot is needed for workflow or audit, a list COMPOSITION can be maintained that stores pointers (e.g. DV_EHR_URI) to the relevant episodes and, if required, to ENTRY paths. Optional metadata such as sort order, display label or grouping can be recorded to stabilise presentation. The clinical content is not copied; governance defines refresh rules so that the view remains consistent with its sources.

The diagnosis and problem list is a curated hierarchy, not a flat enumeration. In this work it is anchored on episode-of-care COMPOSITIONs and expressed using a ContSys-inspired overlay: a Health Thread acts as the container and Health Issues are aligned with episodes. A master list provides the longitudinal patient view, while contextual lists constrain scope to a specialty, a clinical situation or a single encounter. When persisted, the list COMPOSITION stores links only, supports role qualifiers such as primary and associated, and records relations such as recurrence or complication. Consistency with the source is maintained: the episode header remains authoritative, no clinical content is duplicated, and the hierarchy remains queryable and governable.

It was examined whether an explicit care encounter COMPOSITION is necessary. As an implicit alternative, the CONTRIBUTION can serve as the temporal bundle, since multiple COMPOSITIONs may be committed together as a single change set, while the encounter identity is established through uniform context attributes shared by the participating COMPOSITIONs. This implicit approach is viable and can be pursued further. Nevertheless, an explicit care encounter COMPOSITION typically improves governance, traceability and shared understanding by providing a single anchor for encounter level semantics.

5.1.1 Hypothesis H1 — Representational adequacy (confirmed)

The episode-oriented record according to Solon is fully realisable within the existing openEHR specifications. The episode of care COMPOSITION serves as the single source of truth; care-encounter COMPOSITIONs capture clinical contacts, and clinical COMPOSITIONs hold the ENTRY statements. The required behaviours – episode anchoring, encounter association, clinical section and SOAP assignment – are achieved with standard artefacts (COMPOSITION/ENTRY/CLUSTER, FOLDER, LINK, DV_EHR_URI) and governed modelling.

Linear lists are rendered at run time by AQL projections. Where persistent views are needed, list COMPOSITIONs store pointers only, not copies. Hierarchical lists, specifically the diagnosis and problem list, are persisted as a dedicated list COMPOSITION that records links to episode and entry anchors; optional structuring via a ContSys-inspired Health Thread/Health Issue overlay may be applied.

No fundamental changes to the openEHR standard are required. However, several targeted enhancements would improve query ergonomics and flexibility: adding explicit JOIN semantics in AQL for correlating records and LINK targets; extending available string functions (e.g. substring, length, concat, position) and pattern-matching capabilities (wildcards and regular expressions) for robust filtering; providing a portable function to dereference DV_EHR_URI so identifiers can be compared directly; and publishing profiles that standardise LINK.type/meaning code sets and conventions for stable, resolvable LINK targets across repositories, thereby strengthening cross-CDR interoperability. In addition, it would be beneficial for the CKM to publish a dedicated COMPOSITION archetype for the episode of care, providing a canonical anchor for encounter level semantics and promoting consistent implementation, governance and analytics across repositories.

5.1.2 Hypothesis H2 — Multiple implementation approaches (confirmed)

Applying the evaluation framework to the sample patient history confirms that several distinct mappings of the episode-oriented record are technically viable in openEHR. Three patterns are demonstrated: a FOLDER-based index for navigation, a LINK-only design that keeps templates lean, and a CLUSTER-based relationship block that concentrates governance within templates. All three satisfy the user stories. They differ mainly in where governance and workload sit.

In a CLUSTER-based mapping, governed attributes and cardinalities are expressed directly in templates, which typically simplifies AQL (single-statement projections over stable paths) and strengthens cross-vendor consistency. A FOLDER-based mapping offers intuitive navigation and independent versioning of the directory, but requires explicit provisioning and lifecycle governance of the directory tree. A LINK-only mapping minimises template complexity, yet shifts effort to application logic and may require two-step dereferencing of DV_EHR_URI for some queries.

5.1.3 Limitations (methodology, data, generalisability)

The evaluation is design- and evidence-led, not an implementation trial. It uses a single, carefully constructed sample patient history and eight user stories to exercise the approaches; it does not include multi-site deployment, usability testing, or formal change-management evaluation. Performance was reasoned from query shape rather than benchmarked on production loads. Terminology alignment (LOINC sections; local value sets in the episode header) is representative but not exhaustive, and mappings may vary by region. Consequently, generalisability is strongest for design principles and governance patterns; empirical outcomes (latency, throughput, user satisfaction) remain to be demonstrated.

5.2 Interpretation in Context of Existing Literature

The findings align with prior work on the problem-oriented medical record (POMR): they retain problem discipline while extending Solon's episode perspective by demonstrating that explicit episodes of care and curated problem lists can coexist within a single, provenance-preserving record design. This synthesis is consistent with Weed's original principles, Solon's delineation of episodes, and subsequent implementations of episode logic [9, 21, 42, 23]. It operationalises openEHR's three-level modelling with standard artefacts and applies a ContSys-inspired overlay to curate hierarchies without introducing new sources of truth [7, 26, 23].

5.3 Practical Implications

In practice, a maintainable base architecture centres on an episode of care COMPOSITION with a governed episode header so that key attributes remain stable and queryable. Each clinical COMPOSITION embeds a small relationship CLUSTER at ENTRY level. This CLUSTER records the episode associations as one or more resolvable references, each with a role qualifier (primary or associated), a contact reference to the care-encounter COMPOSITION, and the assignment to a clinical section and a SOAP field. Each care-encounter COMPOSITION likewise includes a compact relationship CLUSTER that summarises its associated clinical COMPOSITIONs and, where applicable, the administrative encounter COMPOSITION. Constraining these CLUSTERs in templates (codes and cardinalities) keeps queries predictable, avoids duplication, and strengthens maintainability across vendors.

Optionally, navigation can be supported by a FOLDER-based index with predictable top-level directories for contacts, episodes and sections, holding pointers to the relevant COMPOSITIONs without duplicating content. Where explicit cross-document references are beneficial – for example, linking a result to its originating order, expressing recurrence or complication relationships between episodes, or tying a consent to a clinical entry – selective LINKs complement the model.

Together these elements provide a pragmatic, vendor-neutral hybrid in which lists remain derived views, provenance is preserved, and queries behave consistently across time and settings. The choice is context-dependent, driven by local governance, performance expectations, operational policies, and multi-vendor or cross-repository constraints.

6 Conclusions & Outlook

This thesis shows that an episode-centred design with lists treated as derived views provides a coherent and practicable way to organise clinical data in openEHR. Episodes of care act as the single source of truth; care encounters are captured explicitly; clinical statements reside in clinical COMPOSITIONs with their ENTRY instances; and entry-level assignments to episode, encounter, clinical section and SOAP yield consistent timeline, episode and section views without duplication.

The representational adequacy hypothesis is confirmed: the episode-oriented record described by Solon is realisable within the existing openEHR specifications using standard artefacts and governed modelling. No fundamental change to the Reference Model is required. Nonetheless, targeted improvements would increase portability and ergonomics, notably clearer AQL support for correlating records (join-like operations), a minimal set of string functions and pattern-matching capabilities, and a portable way to dereference DV_EHR_URI values. Agreement on LINK.type and LINK.meaning code sets would further strengthen cross-repository interoperability.

The multiple-approaches hypothesis is also confirmed. Three viable mappings are demonstrated: FOLDER-based indexing for navigation, LINK-only designs that keep templates lean, and CLUSTER-based relationship blocks that concentrate governance in templates. They differ mainly in where governance and workload sit – within the directory, in application logic, or in templates and AQL. In practice a hybrid is attractive: CLUSTER's for governed episode header, links and section/SOAP assignments, FOLDERs for predictable navigation, and selective LINKs for explicit cross-document references. This yields predictable querying, preserves provenance, reduces duplication and supports navigation across providers and settings.

The diagnosis and problem list is best handled as a curated hierarchy anchored on episode of care COMPOSITIONs. Where persistence is required, a dedicated list COMPOSITION stores links rather than copies. A light ContSys-inspired overlay – with Health Thread as container and Health Issues aligned with episodes – supports curation without creating new sources of truth. The master list offers a longitudinal, jointly curated view; contextual lists focus on what matters in a given setting or encounter.

To make this pattern repeatable across organisations and vendors, the community should now develop implementation guidelines with concrete best practices. These should cover: the episode header CLUSTER (attributes, value sets, cardinalities); conventions for primary versus associated roles; LINK.type/meaning code sets; URI minting and resolution for compositions, folders and ENTRY paths; directory provisioning policies; clinical section value set and SOAP mappings; and rules for when and how to persist hierarchical lists. Conformance profiles, test datasets and AQL exemplars would help vendors implement the pattern consistently.

Limitations of this work – most notably the use of a single sample history and design-led evaluation – point to the next steps. A multi-vendor pilot with resolvable URIs, measured performance of AQL patterns, refinement of CKM-hosted clusters, and clinician usability studies would convert the design into operational evidence.

In sum, openEHR already provides the building blocks to realise an episode-oriented medical record that is clinically usable and technically feasible. What is needed now is a shared set of implementation guidelines and best practices so that different organisations can achieve the same semantics and behaviour in a predictable, vendor-neutral way.

7 List of figures

8 List of tables

9 Glossary, List of Abbreviations

Term	Explanation
Clinical data repository	A multi-patient repository that persists and exposes many openEHR EHR instances with versioning, audit, and query capabilities.
Clinical section	A standardized, hierarchical arrangement of document sections that organizes patient data into essential clinical domains. Typical sections include History of Present Illness (HPI), Past Medical History (PMH), Family History, Social History, Physical Examination, Allergies and Adverse Reactions, Risk Factors, Laboratory Results, Imaging Studies, and Assessment and Plan (covering Medications, Procedures, and Operations).
Contact	A single, point-in-time interaction between a patient and one (or more) care professionals that is documented as an event. Captures one discrete care encounter at a specific time and place (can be virtual).
Contextual diagnosis and problem list	A focused list of health problems as interpreted within a specific specialty or clinical context, reflecting the perspective of the treating healthcare professional.
Diagnosis and problem list	A hierarchical list in which related health problems from the various episodes are grouped and presented together. The master diagnosis and problem list represents the overall view of the patient's conditions, while the contextual diagnosis and problem list reflects the perspective of a specific medical specialty or clinical context.
Electronic Health Record	The logical, versioned health record for exactly one subject of care (patient) in openEHR.
Encounter	The overall period during which a patient receives care from a healthcare organisation; it may span and aggregate several contacts. Represents the broader span of care that bundles contacts into a clinically and administratively coherent unit.
Episode	A time-bound period of healthcare, typically defined by organizational events such as hospital admission and discharge, representing a continuous spell of care regardless of clinical content.
Episode of care	A coherent set of one or more contacts with healthcare providers related to a specific health problem, representing a clinically defined, problem-oriented unit of care in the Solon model.
Episode of disease	The course of a health condition as it unfolds in biomedical terms, from onset through progression to resolution or chronic state, independent of patient perception or healthcare contacts.
Episode of illness	The period during which a person perceives, and experiences symptoms related to a health problem, including the subjective impact and help-seeking behaviour, regardless of a biomedical diagnosis.
Health problem	A patient-specific health issue recorded as a problem or diagnosis, with a clinical status of *active*, *inactive* or *resolved/closed*. The life cycle of a health problem typically progresses from the initial problem, through a phase of suspicion, to a confirmed diagnosis, and finally into the stage of past medical history once the condition is no longer active.

Master diagnosis and problem list	A comprehensive list of a patient's health problems, providing an overarching view that integrates all episodes and specialties from the patient's perspective.
Medical record	The legally governed, organised collection of a patient's health information, created and maintained by healthcare professionals across the continuum of care.
Medical record entry (short: Record entry)	A discrete item of documentation in the medical record (e.g. blood pressure measurement, laboratory result, progress note, diagnosis, order). Roughly corresponding to the ENTRY archetype level in openEHR.
Status post	Lat. Status post - shorthand used in clinical documentation to indicate that something happened previously (a past illness, event, or procedure). It signals history, not current activity, and often includes a date or timeframe e.g. S/P myocardial infarction (2005)

Table 9 – Glossary

Abbreviation	**Explanation**
ADL	Archetype Definition Language
API	Application Programming Interface
AQL	Archetype Query Language
CC	Chief Complaint
CDR	Clinical Data Repository
CKM	Clinical Knowledge Manager
DSR	Design Science Research
Dx	Diagnosed (date of diagnosis) e.g. Arterial hypertension (Dx 2009), Arterial hypertension (diagnosed 2009)
EoC	Episode of Care
EHR	Electronic Health Record
EMR	Electronic Medical Record
FH	Family History
PMH	Past Medical History
HPI	History of Present Illness
PSH	Past Surgical History
MDT	Multidisciplinary team meeting
PE	Physical Examination
PoC	Proof-of-concept
POMR	Problem oriented medical record (Methodology according to Weed)
ROS	Review of Systems
SH	Social History
SOAP	Subjective, Objective, Assessment, Plan (Structure for progress notes according to Weed)
SOR	Source-oriented records

S/P	Status post
UI	User interface
UX	User experience
VS	Vital Signs

Table 10 – Abbreviations

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11 Appendices

The appendices provide supplementary material referenced in the main text. Each appendix is self-contained and intended for detailed definitions, examples, and implementation artefacts.

11.1 Appendix A: Clinical Sections

This appendix presents the complete set of clinical sections used throughout the medical record in this thesis. The list is technology-agnostic and serves as the canonical reference for documentation, review, and analysis; it ensures that the same type of information appears in the same place and can be compared consistently across contacts and episodes.

Each document section can be mapped to a corresponding LOINC code; most of these are also included in the HL7 FHIR value set Document section codes [54].

- Administrative / Encounter Data
- Medical History
    - Chief Complaint
    - History of Present Illness (HPI)
    - Past Medical History (PMH)
        - Past Illnesses History
        - Past Surgical History
        - Past Accidents and Injuries
        - Obstetric History (Pregnancies & Births)
        - Childhood Diseases
        - Developmental History
    - Medication history
    - Allergies and Adverse Reactions
    - Family history
    - Social history
        - Lifestyle factors, Substance Use
        - Occupational History
        - Travel History
    - Functional Status
    - Review of Systems (ROS)
- Physical Examination
    - General examination
    - Vital signs
    - System-specific Exams
- Diagnostic Studies
    - Laboratory Studies
    - Imaging Studies
    - Pathology Findings
    - Functional tests
    - Diagnostic procedures
        - Consult reports
- Assessment & Plan

    - Differential Diagnoses
    - Health Problem (Episode)
    - Diagnosis and problem list
        - Master
        - Contextual
    - Plan
- Progress notes (SOAP)
    - Subjective
    - Objective
    - Assessment
    - Plan
        - Diagnostic Work-up Plan
        - Treatment Plan
- Risk factors
- Therapy & Management
    - Medication Plan
    - Non-pharmacologic therapies
    - Device-based therapies
    - Surgical & Interventional Procedures
    - Rehabilitation / Dialysis / Radiation / Nutrition
- Immunisations
- Medical devices
    - Implanted
    - Non-implantable
- Prevention & Screening
- Certificates & Legal Documents
    - Fitness for Work
    - Exemptions
- Care plan
    - Diagnostic Work-up Plan
    - Treatment Plan
        - Therapy Goals & Outcomes
        - Follow-up & Monitoring
    - Nursing Care Plan / Clinical Pathway

Table 11 – Overview of clinical sections

11.2 Appendix B: Archetypes for Health Problem

Brief, non-exhaustive search for archetypes and clusters that could be used to model the template *health problem*. Required for the second iteration.

Archetype	Purpose, Use according to CKM
EVALUATION.problem_diagnosis.v1	Details about a single identified health condition, injury, disability or any other issue which impacts on the physical, mental and/or social well-being of an individual.
CLUSTER.problem_qualifier.v2	Contextual or temporal qualifier for a specified problem or diagnosis. Use as cluster in "Status" data element in EVALUATION.problem_diagnosis.v1
CLUSTER.clinical_evidence.v1	Details about findings that support a clinical assertion.
EVALUATION.absence.v2	Statement that specified health information is not available for inclusion in the health record or extract at the time of recording.
EVALUATION.exclusion_global.v1	An overall statement of exclusion about all Problems/diagnoses, Family history, Medications, Procedures, Adverse reactions or other clinical items that are either not currently present, or have not been present in the past.
EVALUATION.exclusion_specific.v1	A statement of exclusion of a specific Problem/diagnosis, Family history, Medication, Procedure, Adverse reaction or other clinical item that is either not currently present, or have not been present in the past.
EVALUATION.differential_diagnoses.v1	One or more possible conditions, problems or diagnoses that may be responsible for a clinical presentation, examination findings and/or test results.
EVALUATION.reason_for_encounter.v1	The reason for initiation of any healthcare encounter or contact by the individual who is the subject of care.
OBSERVATION.problem_screening.v1	Series of questions and associated answers used to screen for issues, problems or diagnoses. Use with COMPOSITION.self_reported_data.v1 as container
CLUSTER.tnm.v1	A framework for the clinical classification and stage grouping of malignancies using the TNM system. Comment: Designated as TNM or cTNM.
CLUSTER.tnm-pathological.v1	A framework for the pathological classification and stage grouping of malignancies using the TNM system. Comment: Designated as pTNM.
CLUSTER.tumour_colorectal_staging_non_tnm.v0	Non-TNM staging scores for colorectal cancer.
CLUSTER.fnclcc.v1	The histological grading of soft tissue sarcoma using the FNCLCC grading system.
OBSERVATION.nyha_heart_failure.v1	simple method of classifying the extent of heart failure, as defined by the New York Heart Association.
openEHR-EHR-EVALUATION.goal.v1	To record details about a health-related goal and any associated targets and deadlines.

Table 12 – Archetypes and clusters for modelling a Health Problem (non-exhaustive)

11.3 Appendix C: Examples for LINKS in JSON

The snippets below demonstrate correct RM-level use of LINK in openEHR JSON. They show three common targets for DV_EHR_URI: (1) the COMPOSITION container/HEAD (UUID only), (2) a specific COMPOSITION version ({uuid}::{system_id}::{version}), and (3) a path to a contained ENTRY within a COMPOSITION (openEHR path syntax). Replace placeholders such as {ehr_uuid}, {episode_object_uid}, {system_id}, and {version_number} with real values from your system.

1. Link to Container/HEAD of the COMPOSITION

```
"links": [
 {
  "_type": "LINK",
  "meaning": { "_type": "DV_TEXT", "value": "primary association to episode" },
  "type":   { "_type": "DV_TEXT", "value": "episode_of_care" },
  "target":  {
   "_type": "DV_EHR_URI",
   "value": "ehr://{ehr_uuid}/composition/{episode_object_uid}"
  }
 }
]
```

2. Link to as Specific version of the COMPOSITION:

```
"links": [
 {
  "_type": "LINK",
  "meaning": { "_type": "DV_TEXT", "value": "primary association to episode" },
  "type":   { "_type": "DV_TEXT", "value": "episode_of_care" },
  "target":  {
   "_type": "DV_EHR_URI",
   "value": "ehr://{ehr_uuid}/composition/{episode_object_uid}::{system_id}::{version_number}"
  }
 }
]
```

3. Link directly to an ENTRY inside that episode COMPOSITION (use an openEHR path):

```
"links": [
 {
  "_type": "LINK",
  "meaning": { "_type": "DV_TEXT", "value": "supports episode diagnosis" },
  "type":   { "_type": "DV_TEXT", "value": "diagnosis" },
  "target":  {
   "_type": "DV_EHR_URI",
   "value": "ehr://{ehr_uuid}/composition/{episode_object_uid}/content[openEHR-EHR-EVALUATION.problem_diagnosis.v1]"
  }
 }
]
```

Minimal full COMPOSITION skeleton (RAW) with links

```
{
 "_type": "COMPOSITION",
 "archetype_node_id": "openEHR-EHR-COMPOSITION.encounter.v1",
 "name": { "_type": "DV_TEXT", "value": "Progress note" },
 "language": { "_type": "CODE_PHRASE", "terminology_id": { "value": "ISO_639-1" }, "code_string": "en" },
 "territory": { "_type": "CODE_PHRASE", "terminology_id": { "value": "ISO_3166-1" }, "code_string": "US" },
 "category": {
  "_type": "DV_CODED_TEXT",
```

```
  "value": "event",
  "defining_code": { "_type": "CODE_PHRASE", "terminology_id": { "value": "openehr" }, "code_string": "433" }
 },
 "composer": { "_type": "PARTY_IDENTIFIED", "name": "Dr. Example" },
 "context": { "_type": "EVENT_CONTEXT", "start_time": { "_type": "DV_DATE_TIME", "value": "2025-09-01T10:30:00Z" } },

 "links": [
  {
   "_type": "LINK",
   "meaning": { "_type": "DV_TEXT", "value": "primary association to episode" },
   "type":   { "_type": "DV_TEXT", "value": "episode_of_care" },
   "target":  {
    "_type": "DV_EHR_URI",
    "value": "ehr://{ehr_uuid}/composition/{episode_object_uid}"
   }
  }
 ],

 "content": [
  /* your ENTRY instances here */
 ]
}
```

11.4 Appendix D: curaMED with curated diagnosis and problem list

Screenshot from the curaMED demo environment (Swisscom (Schweiz) AG). The left-hand navigation presents the collaboratively curated diagnosis and problem tree. Items can be positioned within the hierarchy according to configurable sort rules; existing entries can be re-assigned by drag-and-drop, and new entries created from the editing panel. Selecting a problem or diagnosis opens the linked Episode-of-Care; changes are applied to the authoritative episode record rather than to the list view. The screenshot illustrates the list-as-view principle described in this thesis; all identifiers are synthetic and for demonstration only.

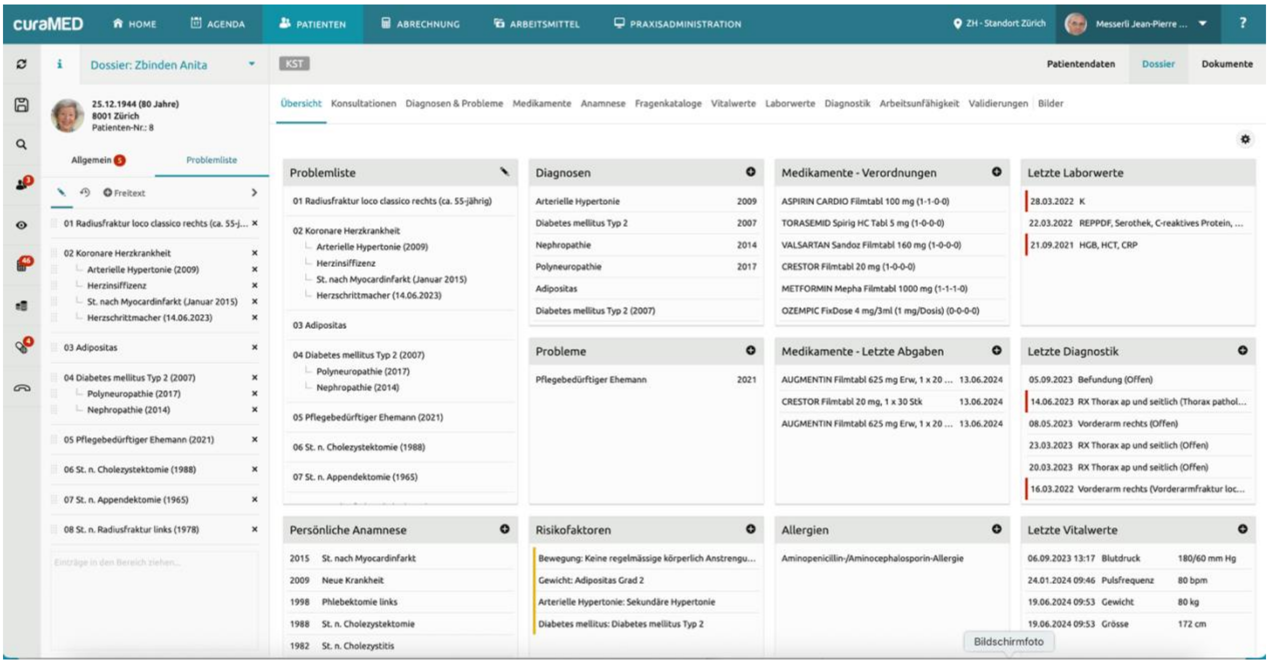

Figure 42 – Master diagnosis and problem list in curaMED (demo)

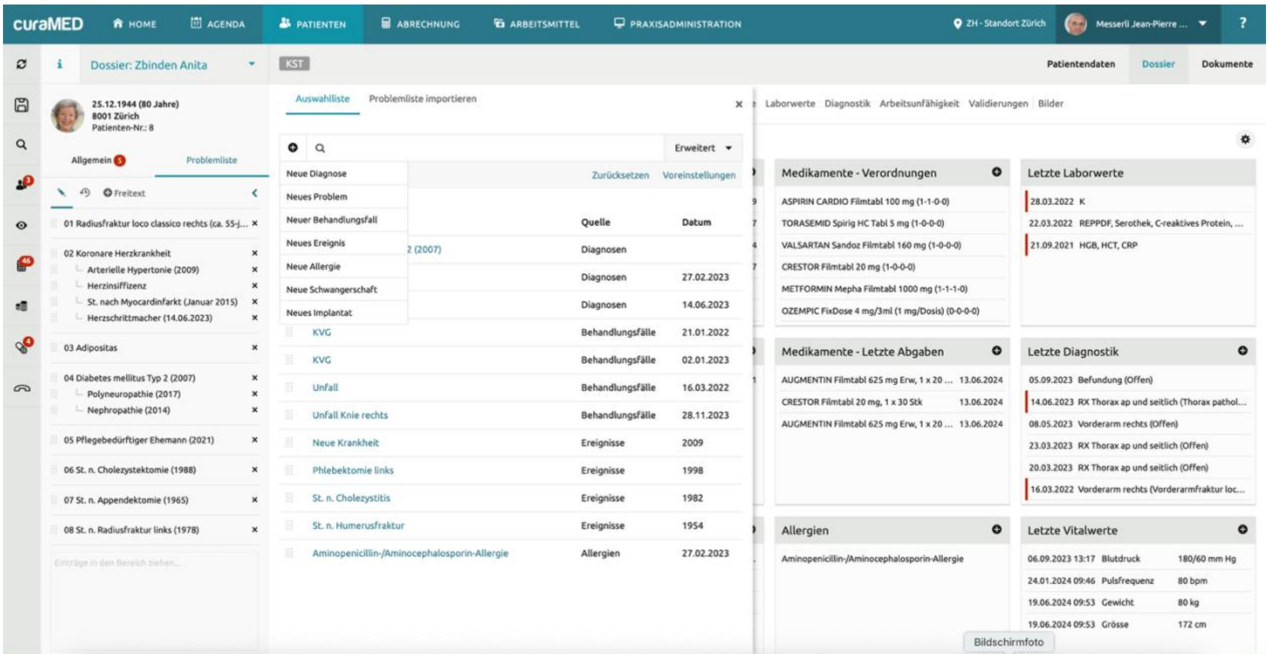

Figure 43 – Editing the diagnosis and problem list in curaMED (demo)

11.5 Appendix E: Excel workbook with sample history

Excel workbook that hosts the sample history. Each row represents one recorded medical record entry; the columns capture narrative detail, clinical section, the associated Episode-of-Care, condition type (problem/diagnosis), clinical status, and both event and recording timestamps.

Contact 15.11.2024 – Consultation

Date	Contact	Detail entry	Section	Health problem Episode of Care	ID	Condition	Clinical Status	Recording Timestamp	Event Timestamp	Availability Timestamp
15.11.2024	Consultation	Reason for Encounter: Initial consultation for dysuria Chief Complaint: Burning sensation with urination.	Present illness					14.11.24 16:30	15.11.24 11:00	
15.11.2024	Consultation		Problem/Diagnosis	Dysuria	10	Problem	Active	15.11.24 10:00	15.11.24 10:00	15.11.24 10:00
15.11.2024	Consultation	Blood pressure 140/90	Vital signs	General health problem	10	Problem	Active	15.11.24 10:15	15.11.24 10:10	15.11.24 11:00
15.11.2024	Consultation	Heart rate 75	Vital signs	General health problem	10	Problem	Active	15.11.24 10:15	15.11.24 10:10	15.11.24 11:00
15.11.2024	Consultation	Weight = 86 kg	Vital signs	General health problem	10	Problem	Active	15.11.24 10:15	15.11.24 10:10	15.11.24 11:00
15.11.2024	Consultation	Height = 168 cm	Vital signs	General health problem	10	Problem	Active	15.11.24 10:15	15.11.24 10:10	15.11.24 11:00
15.11.2024	Consultation	BMI = 30.5	Vital signs	General health problem	10	Problem	Active	15.11.24 10:15	15.11.24 10:10	15.11.24 11:00
15.11.2024	Consultation	Urinalysis – dipstick: Leukocyte esterase: 3+, Nitrite: positive, Blood: 1+, Protein: trace, pH: 6.0	Laboratory results	Dysuria	10	Problem	Active	15.11.24 10:30	15.11.24 10:30	15.11.24 11:00
15.11.2024	Consultation	S: Burning sensation during urination for 3 days. First episode. Denies visible blood in urine O:pyuria A: Suspected cystitis P: antibiogram, Started treatment with trimethoprim– sulfamethoxazole. Therapy adjusted per antibiogram	Progess notes	Dysuria	10	Problem	Active	15.11.24 11:10	15.11.24 11:10	15.11.24 11:10
15.11.2024	Consultation		Problem/Diagnosis	Urinary tract infection	10	Diagnosis	Active	15.11.24 11:11	15.11.24 11:11	15.11.24 11:10
15.11.2024	Consultation	Trimethoprim–sulfamethoxazole (TMP 160 mg / SMX 800 mg) PO 2x1	Medication	Urinary tract infection	10	Diagnosis	Active	15.11.24 11:12	15.11.24 11:12	15.11.24 11:12
15.11.2024	Consultation	S: Bilateral, pressure-like headaches for ~2 years, usually relieved by one paracetamol 500 mg. Over the past few weeks pain intensity has increased and tablets give only partial relief. O: Neurologic exam: alert, cranial nerves II–XII intact, motor 5/5, normal gait, no sensory deficits, Romberg negative. Fundoscopy: optic discs sharp, no papillo-œdema. Head & neck: no scalp or temporal-artery tenderness A: Chronic tension-type headache with recent exacerbation P: Start headache diary	Problem/Diagnosis	Headache	200	Problem	Active	15.11.24 11:15	15.11.24 11:15	15.11.24 11:15

Contact 17.11.2025 – Consultation

A	B	C	D	E	F	G	H	I	J	K
17.11.2024	Consultation	Reason for encounter: follow-up visit and chart completion								
17.11.2024	Consultation	Urine-Culture Antibiogram: Escherichia coli — ≥ 10^5 CFU mL^{-1}, resistant to trimethoprim–sulfamethoxazole and ciprofloxacin but remains susceptible to amoxicillin-clavulanate, nitrofurantoin and fosfomycin	Laboratory results	Urinary tract infection	10	Diagnosis	Active	17.11.24 08:00	15.11.24 11:30	17.11.24 08:30
17.11.2024	Consultation	Blood pressure 142/85	Vital signs	General health problem	0	Problem	Active	17.11.24 08:15	17.11.24 08:10	17.11.24 08:30
17.11.2024	Consultation	Heart rate 72	Vital signs	General health problem	0	Problem	Active	17.11.24 08:15	17.11.24 08:10	17.11.24 08:30
17.11.2024	Consultation	Weight = 85.5 kg	Vital signs	Obesity WHO grade II	100	Diagnosis	Active	17.11.24 08:15	17.11.24 08:10	17.11.24 08:30
17.11.2024	Consultation	Height = 168 cm	Vital signs	General health problem	0	Problem	Active	17.11.24 08:15	17.11.24 08:10	17.11.24 08:30
17.11.2024	Consultation	BMI = 30.5	Vital signs	Obesity WHO grade II	100	Diagnosis	Active	17.11.24 08:15	17.11.24 08:10	17.11.24 08:30
17.11.2024	Consultation	S: Still experiencing urinary symptoms O: Urine culture: Escherichia coli resistant to current antibiotic A: Acute bacterial cystitis P: Switch antimicrobial therapy	Progess notes	Urinary tract infection	10	Diagnosis	Active	17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation		Problem/Diagnosis	Acute bacterial cystitis	10	Diagnosis	Active	17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation	Amoxicillin 500 mg / Clavulanate 125 mg film-coated tablet 3x1	Medication	Acute bacterial cystitis	10	Diagnosis	Active	17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation	S: Headaches unchanged in frequency and intensity O: No new objective findings A: Chronic tension-type headache — status unchanged P: Proceed with brain MRI (CT if MRI contraindicated); await imaging results	Progess notes	Tension-type headache	200	Problem	Active	17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation		Problem/Diagnosis	Coronary heart disease	20	Diagnosis	Active	17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation		Problem/Diagnosis	Diabetes mellitus type 2	30	Diagnosis	Active	17.11.24 08:30	01.01.07 00:00	17.11.24 08:30
17.11.2024	Consultation		Past history	Appendectomy (1965)	40	Diagnosis	Resolved	17.11.24 08:30	01.01.65 00:00	17.11.24 08:30
17.11.2024	Consultation		Problem/Diagnosis	Husband in need of care	50	Problem	Active	17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation		Problem/Diagnosis	Arterial hypertension (Dx 2009)	60	Diagnosis	Active	17.11.24 08:30	01.01.09 00:00	17.11.24 08:30
17.11.2024	Consultation		Problem/Diagnosis	Heart failure	70	Diagnosis	Active	17.11.24 08:30	01.01.10 00:00	17.11.24 08:30
17.11.2024	Consultation		Past history	History of myocardial infarction (2	80	Diagnosis	Resolved	17.11.24 08:30	01.01.15 00:00	17.11.24 08:30
17.11.2024	Consultation		Problem/Diagnosis	Nephropathy (ED 2017)	90	Diagnosis	Active	17.11.24 08:30	01.01.17 00:00	17.11.24 08:30
17.11.2024	Consultation		Problem/Diagnosis	Obesity WHO grade II	100	Diagnosis	Active	17.11.24 08:30	01.01.98 00:00	17.11.24 08:30
17.11.2024	Consultation		Problem/Diagnosis	Polyneuropathy (Dx 2024)	110	Diagnosis	Active	17.11.24 08:30	01.01.24 00:00	17.11.24 08:30
17.11.2024	Consultation		Problem/Diagnosis	Hammertoe, left foot	130	Diagnosis	Inactive	17.11.24 08:30	01.01.24 00:00	17.11.24 08:30
17.11.2024	Consultation	Allergic rhinitis	Allergies	General health problem				17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation	Mother: Heart failure, diagnosed at age 67; deceased 2009	Family History	Coronary heart disease	20	Diagnosis	Active	17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation	Father: Diabetes mellitus, diagnosed at age 56; deceased 2005	Family History	Diabetes mellitus type 2	30	Diagnosis	Active	17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation	Acetylsalicylic acid (Aspirin Cardio), 100 mg film-coated tablet (1-0-0-0)	Medication	Coronary heart disease	20	Diagnosis	Active	17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation	Torsemide (Torasemid Spirig HC), 5 mg tablet (1-0-0-0)	Medication	Heart failure	70	Diagnosis	Active	17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation	Valsartan (Valsartan Sandoz), 160 mg film-coated tablet (1-0-0-0)	Medication	Arterial hypertension (Dx 2009)	60	Diagnosis	Active	17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation	Rosuvastatin (Crestor), 20 mg film-coated tablet (1-0-0-0)	Medication	Coronary heart disease	20	Diagnosis	Active	17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation	Metformin (Metformin Mepha), 1 000 mg film-coated tablet (1-1-1-0)	Medication	Diabetes mellitus type 2	30	Diagnosis	Active	17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation	Zolpidem (Zoldorm), 10 mg film-coated tablet, 1 tab at night as needed	Medication	General health problem				17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation	Tobacco use: Smoking, 12 cigarettes / day since 60 years (≈ 36 pack-years)	Risk factors	Coronary heart disease	20	Diagnosis	Active	17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation	Physical activity: No regular physical exercise	Risk factors	General health problem	0	Problem	Active	17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation	Weight / BMI: Obesity, WHO class II	Risk factors	Obesity WHO grade II	100	Diagnosis	Active	17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation	Arterial hypertension: Secondary hypertension	Risk factors	Arterial hypertension (Dx 2009)	60	Diagnosis	Active	17.11.24 08:30	17.11.24 08:30	17.11.24 08:30
17.11.2024	Consultation	Diabetes mellitus: Type 2 diabetes mellitus	Risk factors	Diabetes mellitus type 2	30	Diagnosis	Active	17.11.24 08:30	17.11.24 08:30	17.11.24 08:30

Contact 23.11.2024 – Consultation

A	B	C	D	E	F	G	H	I	J	K
23.11.2024	Consultation	Reason for encounter: follow-up visit								
23.11.2024	Consultation	Blood pressure 135/92	Vital signs	General health problem	0	Problem	Active	23.11.24 14:10	23.11.24 14:00	23.11.24 14:30
23.11.2024	Consultation	Heart rate 68	Vital signs	General health problem	0	Problem	Active	23.11.24 14:10	23.11.24 14:00	23.11.24 14:30
23.11.2024	Consultation	Weight = 85.8 kg	Vital signs	Obesity WHO grade II	100	Diagnosis	Active	23.11.24 14:10	23.11.24 14:00	23.11.24 14:30
23.11.2024	Consultation	Height = 168 cm	Vital signs	General health problem	0	Problem	Active	23.11.24 14:10	23.11.24 14:00	23.11.24 14:30
23.11.2024	Consultation	BMI = 30.5	Vital signs	Obesity WHO grade II	100	Diagnosis	Active	23.11.24 14:10	23.11.24 14:00	23.11.24 14:30
23.11.2024	Consultation	Urinalysis – dipstick: Leukocyte esterase: negative, Nitrite: negative, Blood: negative, Protein: negative, pH: 6.0	Laboratory results	Acute bacterial cystitis	10	Diagnosis	Active	23.11.24 14:15	23.11.24 14:00	23.11.24 14:30
23.11.2024	Consultation	S: Patient reports resolution of urinary symptom O: Urine culture: Consistent with sterilised urine. A: Acute bacterial cystitis – resolved P: Discontinue antimicrobial therapy (completed full course). Routine follow-up at next scheduled chronic-care visit; no additional testing required unless symptomatic.	Progess notes	History of acute bacterial cystitis	10	Diagnosis	Resolved	23.11.24 14:30	23.11.24 14:30	23.11.24 14:30

Contact 25.11.2024 – Telephone

A	B	C	D	E	F	G	H	I	J	K
25.11.2024	Telephone	Reason for encounter: Questions								
25.11.2024	Telephone	S: Patient reports slight urge to urinate and wants to know if he needs to do anything. O: - A: Irritable bladder (irritative voiding) P: The patient should drink enough fluids and should report back if the problems persist or worsen	Progess notes	History of acute bacterial cystitis	10	Diagnosis	Resolved	25.11.24 16:00	25.11.24 16:00	25.11.24 16:00

Contac 18.01.2025 – Consultation

A	B	C	D	E	F	G	H	I	J	K
18.01.2025	Consultation	Reason for encounter: Chronic-care visit								
18.01.2025	Consultation	Blood pressure 135/92	Vital signs	General health problem	0	Problem	Active	18.01.25 13:10	18.01.25 13:00	18.01.25 13:30
18.01.2025	Consultation	Heart rate 68	Vital signs	General health problem	0	Problem	Active	18.01.25 13:10	18.01.25 13:00	18.01.25 13:30
18.01.2025	Consultation	Weight = 85.8 kg	Vital signs	Obesity WHO grade II	100	Diagnosis	Active	18.01.25 13:10	18.01.25 13:00	18.01.25 13:30
18.01.2025	Consultation	Height = 168 cm	Vital signs	General health problem	0	Problem	Active	18.01.25 13:10	18.01.25 13:00	18.01.25 13:30
18.01.2025	Consultation	BMI = 30.5	Vital signs	Obesity WHO grade II	100	Diagnosis	Active	18.01.25 13:10	18.01.25 13:00	18.01.25 13:30
18.01.2025	Consultation	S: Patient takes all diabetes medications regularly and reports no episodes of hypoglycaemia O: HbA1c 5.9 % – upper-normal range; vitals stable A: Type 2 diabetes mellitus – well controlled P: Continue current antidiabetic regimen unchanged. Schedule ophthalmology consultation for routine retinal screening. Repeat HbA1c in 3 months.	Progess notes	Diabetes mellitus type 2	30	Diagnosis	Active	18.01.25 13:30	18.01.25 13:30	18.01.25 13:30
18.01.2025	Consultation	S: No dyspnoea or ankle swelling; adherent to medication O: BP 140/90 mmHg, HR 75 bpm; lungs clear, no peripheral oedema; weight unchanged A: Chronic heart failure – clinically compensated. P: Routine follow-up in 3 months	Progess notes	Heart failure	70	Diagnosis	Active	18.01.25 13:35	18.01.25 13:35	18.01.25 13:35
18.01.2025	Consultation	S: No flank pain or foamy urine; adherent to diabetes and BP medications O: Renal parameters at the upper limit of normal. A: Mild diabetic nephropathy – stable renal function P: eGFR in 6 months; counsel on low-sodium diet and hydration	Progess notes	Nephropathy (ED 2017)	90	Diagnosis	Active	18.01.25 13:40	18.01.25 13:40	18.01.25 13:40

Contact 25.02.2025 – Consultation

A	B	C	D	E	F	G	H	I	J	K
25.02.2025	Consultation	Reason for encounter: Abdominal Pain								
25.02.2025	Consultation	Blood pressure 135/92	Vital signs	General health problem	0	Problem	Active	25.02.25 17:10	25.02.25 17:00	25.02.25 17:30
25.02.2025	Consultation	Heart rate 68	Vital signs	General health problem	0	Problem	Active	25.02.25 17:10	25.02.25 17:00	25.02.25 17:30
25.02.2025	Consultation	Weight = 85.8 kg	Vital signs	Obesity WHO grade II	100	Diagnosis	Active	25.02.25 17:10	25.02.25 17:00	25.02.25 17:30
25.02.2025	Consultation	Height = 168 cm	Vital signs	General health problem	0	Problem	Active	25.02.25 17:10	25.02.25 17:00	25.02.25 17:30
25.02.2025	Consultation	BMI = 30.5	Vital signs	Obesity WHO grade II	100	Diagnosis	Active	25.02.25 17:10	25.02.25 17:00	25.02.25 17:30
25.02.2025	Consultation	S: Patient reports diffuse, mild abdominal discomfort for several hours; no nausea, vomiting, fever, or change in bowel habits. Pain not related to meals. No prior similar episodes O: Afebrile; BP and HR normal. Abdomen soft, nondistended, normal bowel sounds, no guarding or rebound; no organomegaly. Urinalysis and point-of-care glucose unremarkable A: Nonspecific abdominal pain – benign findings; etiology unclear, likely function P: Watchful waiting (expectant management). Provide advice on hydration and light diet; no medications required at this time. Educated patient on red-flag symptoms (worsening pain, fever, vomiting, GI bleeding) and instructed to return or phone immediately if any occur. Routine follow-up if symptoms persist beyond 48 h.	Progess notes	Abdominal Pain	120	Problem	Active	25.02.25 17:30	25.02.25 17:30	25.02.25 17:30

Contact 27.02.2025 – Consultation

A	B	C	D	E	F	G	H	I	J	K
27.02.2025	Consultation	Reason for encounter: Abdominal Pain								
27.02.2025	Consultation	Blood pressure 145/92	Vital signs	General health problem	0	Problem	Active	27.02.25 11:10	27.02.25 11:00	27.02.25 11:30
27.02.2025	Consultation	Heart rate 92	Vital signs	General health problem	0	Problem	Active	27.02.25 11:10	27.02.25 11:00	27.02.25 11:30
27.02.2025	Consultation	Weight = 85.8 kg	Vital signs	Obesity WHO grade II	100	Diagnosis	Active	27.02.25 11:10	27.02.25 11:00	27.02.25 11:30
27.02.2025	Consultation	Height = 168 cm	Vital signs	General health problem	0	Problem	Active	27.02.25 11:10	27.02.25 11:00	27.02.25 11:30
27.02.2025	Consultation	BMI = 30.5	Vital signs	Obesity WHO grade II	100	Diagnosis	Active	27.02.25 11:10	27.02.25 11:00	27.02.25 11:30
27.02.2025	Consultation	Temperature = 37.9 °C	Vital signs	Abdominal Pain	120	Problem	Active	27.02.25 11:10	27.02.25 11:00	27.02.25 11:30
27.02.2025	Consultation	Alanine aminotransferase (ALT): 42 U/L (7 – 35 U/L)	Laboratory results	Abdominal Pain	120	Problem	Active	27.02.25 11:30	27.02.25 11:15	27.02.25 12:00
27.02.2025	Consultation	Aspartate aminotransferase (AST): 45 U/L (10 – 35 U/L)	Laboratory results	Abdominal Pain	120	Problem	Active	27.02.25 11:30	27.02.25 11:15	27.02.25 12:00
27.02.2025	Consultation	Total bilirubin: 18 µmol/L (5 – 21 µmol/L)	Laboratory results	Abdominal Pain	120	Problem	Active	27.02.25 11:30	27.02.25 11:15	27.02.25 12:00
27.02.2025	Consultation	White blood cell count (WBC): 12.4 × 10^9/L (4.0 – 10.0 × 10^9/L)	Laboratory results	Abdominal Pain	120	Problem	Active	27.02.25 11:30	27.02.25 11:15	27.02.25 12:00
27.02.2025	Consultation	S: Pain has localized to the right upper quadrant, intensity 6/10, worsening after meals; nausea and single episode of vomiting; low-grade fever reported overnight O: Temp 37.9 °C, BP 145/92 mmHg, HR 92 bpm. RUQ tenderness with positive Murphy sign; no rebound. Mild leukocytosis (WBC 12.4 × 10^9/L); AST/ALT mildly elevated; bilirubin normal A: Suspected acute cholecystitis P: Referral to gastroenterology	Progess notes	Suspected acute cholecystitis	120	Problem	Active	27.02.25 12:00	27.02.25 12:00	27.02.25 12:00

Contact 28.02.2025 – Consultation specialist

A	B	C	D	E	F	G	H	I	J	K
28.02.2025	Consultation	Reason for encounter: Referral for suspected cholecystitis								
28.02.2025	Consultation	Alanine aminotransferase (ALT): 60 U/L (7 – 35 U/L)	Laboratory results	Suspected acute cholecystitis	120	Diagnosis	Active	28.02.25 07:45	28.02.25 07:30	28.02.25 09:00
28.02.2025	Consultation	Aspartate aminotransferase (AST): 58 U/L (10 – 35 U/L)	Laboratory results	Suspected acute cholecystitis	120	Diagnosis	Active	28.02.25 07:45	28.02.25 07:30	28.02.25 09:00
28.02.2025	Consultation	Total bilirubin: 25 µmol/L (5 – 21 µmol/L)	Laboratory results	Suspected acute cholecystitis	120	Diagnosis	Active	28.02.25 07:45	28.02.25 07:30	28.02.25 09:00
28.02.2025	Consultation	White blood cell count (WBC): 12.4 × 10^9/L (4.0 – 10.0 × 10^9/L)	Laboratory results	Suspected acute cholecystitis	120	Diagnosis	Active	28.02.25 07:45	28.02.25 07:30	28.02.25 09:00
28.02.2025	Consultation	Gallbladder: Distended (long axis ≈ 9 cm); lumen contains multiple mobile echogenic calculi with posterior acoustic shadowing. Wall circumferentially thickened (~5 mm) and hyperaemic on Doppler. Positive sonographic Murphy sign. Pericholecystic changes: Thin rim of pericholecystic fluid and mild fat stranding. Biliary tree: Common bile duct calibre normal (≤ 6 mm); no intra-hepatic ductal dilatation.Liver, pancreas, spleen, kidneys: Unremarkable for age. No ascites. Conclusion: Ultrasound features are typical for acute calculous cholecystits	Imaging results	Suspected acute cholecystitis	120	Diagnosis	Active	28.02.25 08:30	28.02.25 08:00	28.02.25 08:00
28.02.2025	Consultation	S: Persistent right-upper-quadrant pain (6/10), worse post-prandially; nausea × 2 days; no jaundice O: T 38.1 °C, positive Murphy sign. Ultrasound features are typical for acute calculous cholecystits A: Acute calculous cholecystitis P: Conservative management with antibiotic therapy and symptomatic treatment. Daily abdominal exam; repeat CBC, LFTs in 24 h. Surgical review if no clinical improvement within 48 h or sepsis develops; consider percutaneous cholecystostomy in high-risk scenario. Plan elective laparoscopic cholecystectomy after resolution of acute episode.	Progess notes	Acute cholecystitis	120	Diagnosis	Active	28.02.25 09:00	28.02.25 09:00	28.02.25 09:00
28.02.2025	Consultation	Amoxicillin 500 mg / Clavulanate 125 mg film-coated tablet 3x1	Medication	Acute cholecystitis	120	Diagnosis	Active	28.02.25 09:00	28.02.25 09:00	28.02.25 09:00

Contact 15.03.2025 – Consultation

A	B	C	D	E	F	G	H	I	J	K
15.03.2025	Consultation	Reason for encounter: Follow-up after specialist treatment for acute cholecystitis								
15.03.2025	Consultation	Blood pressure 145/92	Vital signs	General health problem	0	Problem	Active	15.03.25 15:15	15.03.25 15:00	15.03.25 16:00
15.03.2025	Consultation	Heart rate 72	Vital signs	General health problem	0	Problem	Active	15.03.25 15:15	15.03.25 15:00	15.03.25 16:00
15.03.2025	Consultation	Weight = 85.8 kg	Vital signs	Obesity WHO grade II	100	Diagnosis	Active	15.03.25 15:15	15.03.25 15:00	15.03.25 16:00
15.03.2025	Consultation	Height = 168 cm	Vital signs	General health problem	0	Problem	Active	15.03.25 15:15	15.03.25 15:00	15.03.25 16:00
15.03.2025	Consultation	BMI = 30.5	Vital signs	Obesity WHO grade II	100	Diagnosis	Active	15.03.25 15:15	15.03.25 15:00	15.03.25 16:00
15.03.2025	Consultation	Temperature = 36.7 °C	Vital signs	Abdominal Pain	120	Problem	Active	15.03.25 15:15	15.03.25 15:00	15.03.25 16:00
15.03.2025	Consultation	Haemoglobin (Hb): 130 g/L (120 – 160 g/L)	Laboratory results	General health problem	0	Problem	Active	15.03.25 15:15	15.03.25 15:00	15.03.25 16:00
15.03.2025	Consultation	Haematocrit (Hct): 0.40 (0.36 – 0.46)	Laboratory results	General health problem	0	Problem	Active	15.03.25 15:15	15.03.25 15:00	15.03.25 16:00
15.03.2025	Consultation	Fasting plasma glucose: 6.4 mmol/L (3.9 – 5.5 mmol/L)	Laboratory results	Diabetes mellitus type 2	30	Diagnosis	Active	15.03.25 15:15	15.03.25 15:00	15.03.25 16:00
15.03.2025	Consultation	Glycated haemoglobin (HbA1c): 5.9 % (4.0 – 5.6 %)	Laboratory results	Diabetes mellitus type 2	30	Diagnosis	Active	15.03.25 15:15	15.03.25 15:00	15.03.25 16:00
15.03.2025	Consultation	Alanine aminotransferase (ALT): 20 U/L (7 – 35 U/L)	Laboratory results	Acute cholecystitis	120	Diagnosis	Active	15.03.25 15:15	15.03.25 15:00	15.03.25 16:00
15.03.2025	Consultation	Aspartate aminotransferase (AST): 18 U/L (10 – 35 U/L)	Laboratory results	Acute cholecystitis	120	Diagnosis	Active	15.03.25 15:15	15.03.25 15:00	15.03.25 16:00
15.03.2025	Consultation	Serum creatinine: 102 µmol/L (45 – 90 µmol/L)	Laboratory results	Nephropathy (ED 2017)	90	Diagnosis	Active	15.03.25 15:15	15.03.25 15:00	15.03.25 16:00
15.03.2025	Consultation	Total bilirubin: 25 µmol/L (5 – 21 µmol/L)	Laboratory results	Acute cholecystitis	120	Diagnosis	Active	15.03.25 15:15	15.03.25 15:00	15.03.25 16:00
15.03.2025	Consultation	White blood cell count (WBC): 12.4 × 10^9/L (4.0 – 10.0 × 10^9/L)	Laboratory results	Acute cholecystitis	120	Diagnosis	Active	15.03.25 15:15	15.03.25 15:00	15.03.25 16:00
		S: Patient feels well; no right-upper-quadrant pain, nausea, vomiting, or fever since completing oral antibiotic course. Normal appetite and bowel habits. No medication side-effects O: Temp 36.7 °C, Abdomen soft, non-distended, non-tender; negative Murphy sign. No jaundice or hepatomegaly. No laboratory tests indicated today A: Acute calculous cholecystitis — resolved after conservative antibiotic therapy P: No further antibiotics required; continue low-fat diet until elective laparoscopic cholecystectomy. Routine follow-up at next chronic-care visit (3 months) or sooner if needed.	Progess notes	History of acute cholecystitis (202	120	Diagnosis	Resolved	15.03.25 16:00	15.03.25 16:00	15.03.25 16:00

12 Declaration of Authorship

I hereby declare that I wrote this thesis independently, using only the indicated sources and aids. Generative AI systems (Claude and ChatGPT) were used solely as auxiliary tools to help with ideas, suggest wording, and clarify the subject matter occasionally. DeepL was used for the initial translation into English. I have reviewed and adapted all content and take full responsibility for it; any verbatim passages are explicitly marked. All applicable policies governing the use of AI tools have been observed.

Place, Date

Spiez, 10 October 2025

Signature

Heading and language conventions. This thesis employs Title Case for level 1 and level 2 headings, and sentence case from level 3 onwards. Figure and table captions use sentence case. Proper names retain standard capitalisation (e.g., openEHR, SNOMED CT). British English spelling is used. Key terms are defined at first mention and summarised in the glossary. If an abbreviation is introduced but not reused, the term is written out in full thereafter for clarity; abbreviations are otherwise confined to captions or the List of Abbreviations where appropriate.