# INTERNATIONAL STANDARD

**ISO**

**12381**

First edition
2019-07

# Health informatics — Explicit time-related expressions for healthcare-specific problems

*Informatique de santé — Expressions relatives au temps explicites utilisées dans le domaine de la santé*

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# Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 215, *Health informatics*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

# Introduction

Time is an important variable in healthcare, and standards are needed about how to represent information with explicit references to time. This document is a first contribution to this harmonization process, focusing on "representation" and "explicit reference".

Indeed, a system for time-standards should have as a minimum requirement the capacity to order temporal facts (situations, events, episodes) in three major ways, independent of any specific ontology of time itself:

— by relating situations to a calendar;

— by relating situations to "reference" situations;

— by relating events together in "before- and after-" chains.

The main reason for this threefold organization is that our everyday temporal discourse contains a variety of expressions that can only be regimented into a uniform style of analysis with a certain artificiality.

The purpose of this document is to enhance, in a perspective of machine-machine and person-machine communication, the generation of statements that are guaranteed to be understood unambiguously with respect to the time-related expressions that are embedded within them.

The purpose of this document is not to develop a full-blown temporal logic, but a standardized way of representing time-related expressions, such that all kinds of questions about the temporal organization of situations can be answered on the basis of the information available. Nor is it the intention of the framework presented here to provide a means to interpret the information in its original format. Interpretation of the source information is the task of the provider of information itself. The framework presented in this document allows information providers to express their time-related information in such a way that the intended meaning can be unambiguously understood by a receiver.

This of course requires the use of a "restricted", regimented model or language, allowing the disambiguation of many time-related expressions uttered in natural language. The model (language) presented in this document is restricted enough to allow such disambiguation for time-related expressions in "traditional" medical language but is not expressive enough to account for all time related linguistic phenomena that can be encountered in natural language.

This document provides representational tools for "explicit" time-related information. It does not allow (nor encourage) the ad hoc interpretation of implicit temporal information. In an expression such as "diabetes since childhood", "since childhood" is an explicit temporal reference for the diabetes, but the implicit information what "childhood" might mean (e.g. starting at the age of 2?), is not addressed. However, the framework presented in this document has enough expressive power to allow a specific provider of information to state explicitly what his or her understanding is of "childhood" is.

This document describes some conformance characteristics by means of which developers of health care information systems can label specific modules of their systems as to the degree they are compliant with the document. Although the framework itself does not deal with temporal reasoning, the conformance characteristics can be used to evaluate to what level temporal reasoning is possible with the information collected in a given system.

# Health informatics — Explicit time-related expressions for healthcare-specific problems

## 1 Scope

This document specifies a set of representational primitives and semantic relations needed for an unambiguous representation of explicit time-related expressions in health informatics. This document does not introduce or force a specific ontology of time, nor does it force the use of a fixed representation scheme for such an ontology. Rather this document provides a set of principles for syntactic and semantic representation that allow the comparability of specific ontologies on time, and the exchange of time-related information that is expressed explicitly.

This document applies to both the representation of actual phenomena occurring in the real world (e.g. registrations in medical records) and to the description of concepts (e.g. medical knowledge bases).

This document is applicable to

a)   developers of medical information systems where there might be a need for explicit time-related concepts for internal organization (e.g. temporal data bases, temporal reasoning systems),

b)   information modellers or knowledge engineers building models for the systems mentioned in a),

c)   experts involved in the development of semantic standards on precise subdomains in health care where time-related information needs to be covered, (e.g. in the study of pathochronology, i.e. the discipline dealing with the time course of specific diseases), and

d)   developers of interchange formats for messages in which time-related information is embedded.

This document is not intended to be used directly for

—   representing what is true in time,

—   reasoning about time, or

—   representation of metrological time.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8601-1, *Data elements and interchange formats — Information interchange — Representation of dates and times — Part 1: Basic rules*

ISO 8601-2, *Data elements and interchange formats — Information interchange —  Representation of dates and times — Part 2: Extensions*

ISO 80000-3, *Quantities and units — Part 3: Space and time*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

**3.1**
**situation**
phenomenon occurring (or having the potential to occur) at a particular time or over a particular time period, in a given world context

Note 1 to entry: Situations cover phenomena which can occur in past, present or future time.

EXAMPLE        "The patient suffered from pain which occurred over night", "pain occurring overnight."

**3.2**
**property**
attribute, quality, or characteristic of something

EXAMPLE        "The temperature of a person."

**3.3**
**time interval**
portion of time of which the duration in a given context is considered to be significant and relevant

**3.4**
**time point**
portion of time of which the duration in a given context is considered to be insignificant or irrelevant

Note 1 to entry: This document does not specify any requirements on what entities should occupy time points, and what entities should occupy time intervals, users are responsible for making such decisions (Clause 5). Temporal references such as "Friday the 13th" can thus refer to a time point or a time interval, depending on the context.

**3.5**
**episode**
*situation* (3.1) considered to occupy a *time interval* (3.3)

Note 1 to entry: Whether a situation is to be considered an episode or an event, is a decision taken by the provider of the information, based on his or her perception of the phenomenon in a given context.

Note 2 to entry: It is possible to further subcategorize episodes into "states", "culminations", "processes", "actions", or other conceptual entities that can be defined using additional conceptual aspects describing particular properties of each of the various episodes. However, there is no need to do so within the scope of this document.

EXAMPLE        A patient's stay in the hospital, the "episode of care" related to a medical problem.

**3.6**
**event**
*situation* (3.1) considered to occur at a *time point* (3.4)

**3.7**
**predication**
representation of a *situation* (3.1) in a language

EXAMPLE        "The removal of Mr Jones' appendix on 21 July 1994, at 9 o'clock in the morning."

**3.8**
**temporal reference**
component of a *predication* (3.7) representing information related to time

**3.9**
**propositional clause**
component of a *predication* (3.7) to which *temporal references* (3.8) refer implicitly or explicitly

EXAMPLE        In the expression "taking syrup three times a day for 2 weeks", the propositional clause is "taking syrup". To it are attached the temporal references "three times a day" and "for 2 weeks".

Note 1 to entry: The term propositional clause is used here in a broader sense than in formal logic where a proposition denotes a statement on what is true in a given world. In the context of this document, propositional clauses do not impose a truth-value on the phenomena that are represented.

Note 2 to entry: This document allows for a recursive representation of information related to time (see Annex A for a formal description). In expressions such as "severe headache lasting for half an hour after each meal", both "severe headache" and "severe headache lasting for half an hour" are propositional clauses, each at a different level in the recursion. A propositional clause that is at the deepest level of recursion, i.e. to which no temporal references are attached, is called propositional clause zero. In this example: "severe headache" is propositional clause zero.

**3.10**
**temporal link**
component of a *temporal reference* (3.8) capturing the semantic relation in a *predication* (3.7) between the *propositional clause* (3.9) and the *temporal expression* (3.13)

Note 1 to entry: In natural language, the temporal link can be grammaticalized with prepositions or other constructs, such as in "on Monday". Often, the link is not expressed explicitly, as in "tomorrow". In formal representations in conformity to this document, the temporal link shall be represented explicitly, or should be unambiguously derivable from a data model.

**3.11**
**basic temporal link**
*temporal link* (3.10) specifying purely time-related information

EXAMPLE        Has-occurrence, has-duration (see 4.4).

**3.12**
**complex temporal link**
*temporal link* (3.10) composed of a *basic temporal link* (3.11) and an embedded *propositional clause* (3.9)

Note 1 to entry: Complex temporal links can be used to express the contents of relational data bases according to the provisions of this document.

EXAMPLE        The predication "Severe headache this morning" can be analyzed into the propositional clause "severe headache" and the temporal reference "this morning". In a database management system, such predications can be represented in a table with fields "ProblemId", "Problem" and "TimeOfHappening".

| Problem Id | Problem | Time of happen-ing |
|---|---|---|
| I1 | severe headache | this morning |
| I2 ... | ingestion of acetylsalicylic acid | immediately after I1 |

In this table, the contents of the "Problem" column refer to situations, and hence shall be considered propositional clauses and the contents of the "Time of Happening" column are all temporal references.

Often, the time of recording of problems is also recorded as useful meta-information. According to the model above, this should be done by adding two records in the table:

| I3 | recording of I1 | 1994-07-01:18:00:32 |
|---|---|---|

| I4 | recording of I2 | 1994-07-01:18:00:35 |
|----|-----------------|----------------------|

In fact, this could be repeated for each record, even for the records in which the recording of the recording of the ... is recorded. Because only the recording time of a problem is of interest, and not the recording event itself, the above scheme is simplified by adding an additional field, labelled "TimeOfRecording", which is a complex temporal link.

| Problem Id | Problem | Time of happening | Time Of Recording |
|------------|---------|-------------------|-------------------|
| I1 | severe headache | this morning | 1994-07-01:18:00:32 |
| I2 | ingestion of acetylsalicylic acid | immediately after I1 | 1994-07-01:18:00:35 |
| ... | | | |

Other examples of complex temporal links are: StartDateOfSampleCollection (laboratory context), DateOfBirth (administrative context), StartDateOfProblem, EndDateOfProblem (clinical history or diagnostic module of electronic medical record systems), ...

**3.13**
**temporal expression**
component of a *temporal reference* (3.8) specifying a *time point* (3.4), a *time interval* (3.3) or any allowed combination of time points and time intervals.

Note 1 to entry: This document does not imply any restrictions on what combinations of time points and time intervals are "allowed" as this depends entirely on the ontology of time defined in a particular context. However, such an ontology can only be claimed to conform to this document when such combinations can be represented by the temporal expressions described in this document.

**3.14**
**absolute temporal expression**
*temporal expression* (3.13) whose exact meaning in a given context can directly be derived from the temporal expression itself

EXAMPLE        "9'oclock", "1994-04-12", "Christmas"

Note 1 to entry: "exact meaning" refers here to the fact that absolute temporal expressions (by definition) contain all the information required to relate the situation to a calendar.

**3.15**
**relative temporal expression**
*temporal expression* (3.13) whose exact meaning in a given context can only be derived from the *temporal references* (3.8) of the *predications* (3.7) referred to in the temporal expression

EXAMPLE        "headache starting after eating chocolate". When the headache starts can only be known if it is known when the eating of chocolate takes place.

Note 1 to entry: The "relativeness" or "absoluteness" of a temporal expression does not imply any qualitative preference. For pure temporal reasoning issues, absolute temporal expressions shall be preferred, but for medical reasoning, this is not true. Reducing the two predications "eating chocolate at three o'clock" and "headache after eating chocolate", to "headache after three o'clock" would imply a dramatic loss of information from the clinical point of view.

**3.16**
**deictic temporal expression**
*temporal expression* (3.13) whose exact meaning in a given context can only be derived from information outside that context

EXAMPLE        Expressions such as "now", "yesterday", "last Monday", "in three weeks", can only be given precise meaning if the time of utterance is known.

**3.17**
**time interval expression**
*temporal expression* (3.13) denoting a *time interval* (3.3)

**3.18**
**duration expression**
*temporal expression* (3.13) referring to the length of a *time interval* (3.3)

EXAMPLE        "Three years", "a long time".

**3.19**
**rate expression**
*temporal expression* (3.13) denoting the change of a *property* (3.2) over a *time interval* (3.3)

Note 1 to entry: The change of the property is to be considered the situation on which information related to time is given.

EXAMPLE        "The patient's temperature dropped 0,5 degrees Celsius per hour".

**3.20**
**frequency expression**
*temporal expression* (3.13) denoting the number of repetitions of a phenomenon during a *time interval* (3.3)

Note 1 to entry: A frequency may be considered a special case of a rate ("number rate").

Note 2 to entry: The time interval does not need to be represented explicitly as is the case in the examples below of "often", "frequently" and "after each meal".

EXAMPLE        "Twice a day", "every 5 minutes", "often", "frequently", "after each meal", "never" "always".

**3.21**
**time series expression**
*temporal expression* (3.13) denoting the occurrence of a *situation* (3.1) in a series of *time point* (3.4) or *time interval* (3.3)

**3.22**
**temporal comparator**
specifier of the temporal relation expressed by the *temporal link* (3.10) between the *propositional clause* (3.9) and a *temporal expression* (3.13)

EXAMPLE        Temporal comparators that can be added to the temporal link has-occurrence are amongst others: "AT, BEFORE, AFTER,..." (see 5.6).

# 4   Explicit semantic labelling of predicational components

## 4.1   General

Temporal references do not necessarily give unambiguous meaning to the temporal relationship they bear with the propositional clause of the predication. Also, from expressions in natural language, it cannot always be deduced whether the situations described are to be considered events or episodes. For this reason, this document requires the explicit labelling of the various components of a predication. In this document, a frame-based notation is used to represent predications in a more formal way. A full syntactic specification of the notation is given in Annex A. In Clause 4, the semantic building blocks are presented. Predications that are represented according to the syntactic semantic rules of this notation, are called standard predications.

## 4.2   Labelling of temporal expressions

Each temporal expression shall be labelled by the originator of the information as being a time point expression, time interval expression, frequency expression, rate expression, time series expression, or

duration expression. If the exact temporal nature is not known or not relevant, it shall be marked as temporal expression without further subcategorization.

The labels to be used for temporal expressions in standard predications are: "TP" for a time point expression, "TI" for a time interval expression, "FQ" for a frequency expression, "RT" for a rate expression, "TS" for a time-series expression, "DR" for a duration expression, and "TE" for temporal expressions further not subcategorized.

EXAMPLE 1    TP("3 o'clock in the morning"): time point expression referring to one precise moment (namely 03:00 in an unspecified day.

EXAMPLE 2    TI(EPISODE("eating chocolate")): relative temporal expression referring to the time interval during which an episode of eating chocolate takes place.

EXAMPLE 3    FQ("twice a day"): frequency expression.

EXAMPLE 4    RT("two tablets a day"): rate expression.

This document does not impose any obligations on whether a situation such as "the taking of 2 tablets of Vitamin C a day", shall be represented by means of a frequency expression or a rate expression. Both are possible, and the decision shall be taken by the provider of the information on the basis of contextual knowledge.

EVENT("taking Vit C tablet)(has-frequency FQ("twice a day)), or EVENT("taking Vit C")(has-rate RT("two tablets a day"))

EXAMPLE 5    TS("3 o'clock in the morning"): time-series expression used if one wants to describe situations that are repetitively related to 3 o'clock in the morning.

EXAMPLE 6    DR("two minutes"): duration expression referring to a duration of two minutes.

## 4.3    Labelling of basic temporal links

### 4.3.1    General

In order to conform to this document, four basic temporal links shall be used.

### 4.3.2    has-occurrence

Indicates the temporal link between the propositional clause and the temporal expression as referring to the time point at which or time interval over which the situation did/does/will occur. The temporal expression associated with this temporal link shall answer the question "When did (does, will) the situation occur?". Valid temporal expressions related to this temporal link are time-point expressions, time-interval expressions and time-series expressions. Both events and episodes can be associated with this temporal link.

### 4.3.3    has-rate

Indicates the temporal link between the propositional clause and the temporal expression as referring to the change of a property over a time interval. The temporal expression associated with this temporal link shall answer the question: "How much did/does/will the property change over time in a given period?". Only rate expressions can be associated with this temporal link. The situation referred to can only be an episode.

### 4.3.4    has-frequency

Indicates the temporal link between the propositional clause and the temporal expression as referring to the frequency or repetition by which a situation happens. The temporal expression associated with this temporal link shall answer the question "How often in a given period did (does, will) the situation

occur?". Only frequency expressions can be associated with this temporal link. The situation referred to can be an event or an episode.

### 4.3.5    has-duration

Indicates the temporal link between the propositional clause and the temporal expression as referring to the duration of the episode represented in the propositional clause. The temporal expression associated with this temporal link shall answer the question "How long did (does, will) the situation last?". Only duration expressions can be associated with this temporal link. The situation referred to can only be an episode.

Table 1 summarizes the combinations of situations, temporal links and temporal expressions allowed.

**Table 1 — Combinations of situations, temporal links and temporal expressions**

| Situation | Temporal link | Temporal expression |
|---|---|---|
| Event | Has-occurrence | Time point expression |
| | | Time interval expression |
| | | Time-series expression |
| | Has-frequency | Frequency expression |
| Episode | Has-occurrence | Time point expression |
| | | Time interval expression |
| | | Time-series expression |
| | Has-frequency | Frequency expression |
| | Has-duration | Duration expression |
| | Has-rate | Rate expression |

## 4.4    Labelling of complex temporal links

When representing situations according to this document or when translating source information into the metalanguage of this document, complex temporal links may be defined on the basis of basic temporal links. These complex temporal links shall be used in the same way as the basic temporal links they originate from. All restrictions that shall apply for a basic temporal link shall also apply for the complex temporal links.

NOTE        Although this document does not provide a full syntactic specification on how to indicate this labelling, in the standard predications of this document, complex temporal links appear in the same position as their basic counterparts. The denotation of such a link is preceded by HO_ when it is defined on the basis of hasoccurrence, by HD_ for has-duration, by HR_ for has-rate, and by HF_ for has-frequency.

EXAMPLE        HO_ProblemStartDate: represents a temporal link of the type has-occurrence where (by definition provided by the originator of the information) ProblemStartDate is the starting date of an episode referring to a medical problem.

## 4.5    Temporal comparators

### 4.5.1    General

In this document, thirteen temporal comparators are associated with the temporal link "has-occurrence". Temporal comparators further characterize the temporal relation expressed by the temporal link. The usage (and semantics) of a particular temporal comparator differs according to the temporal nature of the situation referred to by the propositional clause, and the temporal expression that is a component of the predication.

Table 2 specifies the allowed combinations. Empty cells indicate unallowed combinations. The numbers in a cell refer to the examples in 4.5.2 and 4.5.3. For each example, a natural language expression, the standard predication and (when applicable) some additional comments on the semantics are given.

**Table 2 — Allowed combinations of situations, events and episodes**

| Situation | Event | | | Episode | | |
|---|---|---|---|---|---|---|
| Temporal expression | Time interval | Time point | Time series | Time interval | Time point | Time series |
| <AT> | | (1) | (2) | (10) | | (28) |
| <BEFORE> | (3) | (4) | (5) | (11) | (23) | (29) |
| <AFTER> | (6) | (7) | (8) | (12) | (24) | (30) |
| <DURING> | (9) | | | (13) | | (31) |
| <INCLUDES> | | | | (14) | (25) | (32) |
| <UNTIL> | | | | (15) | (26) | (33) |
| <FOLLOWS> | | | | (16) | (27) | (34) |
| <SINCE> | | | | (17) | | (35) |
| <UP-TO> | | | | (18) | | (36) |
| <CO-CONTINUES> | | | | (19) | | (37) |
| <CO-PRECES> | | | | (20) | | (38) |
| <CO-STARTS> | | | | (21) | | (39) |
| <CO-ENDS> | | | | (22) | | (40) |

NOTE      The names of the temporal comparators have been chosen in such a way that their meaning can be captured as much as possible by referring to their natural language counterpart. For some, however, the meaning attached to a specific temporal comparator might be different from that in natural language (e.g. the use of AT with a time interval).

### 4.5.2   Temporal comparators in combination with events

The following temporal comparators are allowed to be used in combination with events.

### 4.5.2.1   AT

Refers to a time point or time-series indicating the moment(s) at which the event happens. If the temporal expression refers to a time-series, the happening of the event is repeated in accordance with the specifications of the time-series.

EXAMPLE 1      "Sudden headache at 3 o'clock" (EVENT("sudden headache")(has-occurrence AT TP("3 o'clock"))) The headache appears once at a precise moment, namely three o'clock.

EXAMPLE 2      "Sudden headache which appeared a few times" (EVENT("sudden headache") (has-occurrence DURING TI("past")) (has-occurrence AT TS("a few times"))). The headache is a repeated event that happened in the past.

### 4.5.2.2   BEFORE

Indicates the happening of the event described by the propositional clause as having occurred or as occurring before the time indicated by the temporal expression. If the temporal expression denotes a time interval, the event precedes completely the starting point of the time interval. For a time-series, the event occurred before each element in the time-series.

EXAMPLE 3      "Sudden dizziness before falling down the stairs" (EVENT("sudden dizziness") (has-occurrence BEFORE TI(EPISODE("falling from the stairs")))).

EXAMPLE 4    "Strange smell before very short loss of consciousness" (EVENT("strange smell") (has-occurrence BEFORE TP(EVENT("very short loss of consciousness")))).

EXAMPLE 5    "Blurred vision preceding nausea each morning" (EVENT("blurred vision") (has-occurrence BEFORE TS(EPISODE("nausea " ) (has-occurrence DURING TI("each morning"))))).

### 4.5.2.3    AFTER

Indicates the happening of the event described by the propositional clause as having occurred or as occurring after the time indicated by the temporal expression. If the temporal expression denotes a time interval, the event did/does/will happen after the end-point of the time interval. For a time-series, the event occurs after each element in the time-series.

EXAMPLE 6a    "Bleeding after falling down the stairs" (EVENT("bleeding") (has-occurrence AFTER TI(EPISODE ("falling down the stairs")))).

From the medical point of view, "after" in this statement might alternatively introduce a causal relationship. Decisions about the "true" nature of the relationship shall be made by the source (originator) of the information and are not forced through the use of this document.

EXAMPLE 6b    "When I had heated the solution, it turned blue" (EVENT("The solution turns blue") (hasoccurrence DURING TI("past")) (has-occurrence AFTER TI(EPISODE("me heating the solution") (has-occurrence DURING TI("past"))))).

EXAMPLE 7    "Sudden loss of smell following head injury around 3 o'clock" (EVENT("sudden loss of smell") (has-occurrence AFTER TP(EVENT("head injury") (has-occurrence AT TP("around 3 o'clock"))))).

EXAMPLE 8    "Take 2 tablets after breakfast each day" (EVENT("take 2 tablets") (has-occurrence AFTER TS(EPISODE("breakfast" )))).

### 4.5.2.4    DURING

Refers to a time interval indicating the period during which the event happens. The precise moment of happening is not indicated.

EXAMPLE 9a    "Acute headache which occurred during the night" (EVENT("acute headache") (has-occurrence DURING TI("night"))) The headache appeared once at an unspecified moment during the night.

EXAMPLE 9b    "While heating the solution, it turned blue" (EVENT("The solution turns blue") (has-occurrence DURING TI("past")) (has-occurrence DURING TI(EPISODE("heating the solution")))).

### 4.5.3    Temporal comparators in combination with episodes

### 4.5.3.1    When the temporal expression refers to a time interval

### 4.5.3.1.1    General

The following temporal comparators are allowed to be used in combination with episodes if the temporal expression refers to a time interval.

### 4.5.3.1.2    AT

Refers to a time interval during which entire duration the episode takes place.

EXAMPLE 10    "Continuous headache for the whole week-end" (EPISODE("headache") (has-occurrence AT TI("weekend"))).

NOTE    If the duration of the episode is shorter than the duration of the time interval referred to, the temporal comparators DURING, CO-STARTS, or CO-ENDS apply.

### 4.5.3.1.3 BEFORE

Indicates the happening of the episode described by the propositional clause as having occurred or as occurring before the starting point of the time interval indicated by the temporal expression.

EXAMPLE 11  "The patient will be taken in hospital for 2 weeks before the Summer Holidays" (EPISODE("hospitalization") (has-occurrence BEFORE TI("Summer Holidays")) (has-duration  DR("2 weeks")) (has-occurrence  DURING TI( "future"))).

### 4.5.3.1.4 AFTER

Indicates the happening of the episode described by the propositional clause as having occurred or as occurring after the end-point of the time interval indicated by the temporal expression.

EXAMPLE 12  "The patient was taken in hospital for 2 weeks after the last Summer Holidays" (EPISODE("hospitalization") (has-occurrence AFTER TI("last Summer Holidays")) (has-duration DR("2 weeks")) (has-occurrence DURING TI( "past"))).

### 4.5.3.1.5 DURING

Indicates the happening of the episode described by the propositional clause as having occurred or as occurring during the time interval indicated by the temporal expression. No information is available on the co-occurrence of the starting or end-point of the episode, and the starting or end-point of the time interval.

EXAMPLE 13  "The patient was in hospital during the Summer Holidays" (EPISODE("hospitalization") (hasoccurrence DURING TI("Summer Holidays")) (has-occurrence DURING TI( "past"))).

If the hospital stay took the entire period denoted by "Summer Holidays", the temporal comparator "AT" shall be used.

### 4.5.3.1.6 INCLUDES

Indicates the time interval represented by the temporal expression as being part of the time interval related to the episode described by the propositional clause.

EXAMPLE 14  "The patient was in hospital for three months, including the Summer Holidays" (EPISODE("hospitalization") (has-occurrence INCLUDES TI("Summer Holidays")) (has-occurrence DURING TI( "past")) (has-duration DR("three months"))).

### 4.5.3.1.7 UNTIL

Indicates the happening of the episode described by the propositional clause as having occurred or as occurring until (including) the starting point of the time interval referred to by the temporal expression. No information is available about the starting point of the episode.

EXAMPLE 15  "Take 3 tablets a day until next week" (EPISODE(EVENT "take tablets") (has-frequency  FQ("3 times a day")) (has-occurrence UNTIL TI( "next week"))).

If the starting point of the time interval is to be excluded, BEFORE should be used.

### 4.5.3.1.8 FOLLOWS

Indicates the happening of the episode described by the propositional clause as having occurred or as occurring from (including) the starting point of the time interval referred to by the temporal expression. No information is available about the end-point of the episode.

EXAMPLE 16   "Therapy will be started as soon as the blood pressure stops being over 9/6" (EPISODE("therapy") (has-occurrence FOLLOWS TI(EPISODE("BP being higher than 9/6")))).

#### 4.5.3.1.9 SINCE

Indicates the starting point of the episode described by the propositional clause as being in the time interval referred to by the temporal expression, and its end-point (if any) as being after the end-point of the time interval.

EXAMPLE 17 "Diabetes since childhood" (EPISODE("having diabetes") (has-occurrence SINCE TI("childhood"))) The diabetes has started somewhere during childhood.

#### 4.5.3.1.10 UP-TO

Indicates the end-point of the episode described by the propositional clause as being in the time interval referred to by the temporal expression, and its starting point as being before the starting point of the time interval.

EXAMPLE 18 "Headache attacks up to the age of ten" (EPISODE("headache attacks") (has-occurrence UP-TO TI("the age of ten")).

#### 4.5.3.1.11 CO-CONTINUES

Indicates that the starting point of the episode described by the propositional clause coincides with the starting point of the time interval referred to by the temporal expression, and that its end-point (if any) is after the end-point of the time interval.

EXAMPLE 19 "Diabetes starting from childhood on" (EPISODE("diabetes") (has-occurrence CO-CONTINUES TI("childhood"))).

The diabetes has started at the same time as what is denoted here as "childhood". Note that the exact meaning of the "childhood" related to a time scale does not need to be known in order to arrive at a valid temporal expression.

#### 4.5.3.1.12 CO-PRECEDES

Indicates that the end-point of the episode described by the propositional clause coincides with the end-point of the time interval referred to by the temporal expression, and that its starting point is temporally being located before the starting point of the time interval.

EXAMPLE 20 "The side effects of the drug therapy ceased at the time when the drug therapy was stopped" (EPISODE("side effects") (has-occurrence DURING TI("past")) (has-occurrence CO-PRECEDES TI(EPISODE("drug therapy")))).

#### 4.5.3.1.13 CO-STARTS

Indicates that the starting point of the episode described by the propositional clause coincides with the starting point of the time interval referred to by the temporal expression, and that its end-point is temporally being located before (not coinciding with) the end-point of the time interval.

EXAMPLE 21 "Right at the beginning of drug therapy, the patient felt dizzy but this lasted only a few hours such that the therapy did not have to be interrupted" (EPISODE("feeling dizzy") (has-occurrence DURING TI("past")) (has-duration DR("a few hours")) (has-occurrence CO-STARTS TI(EPISODE("drug therapy")))).

#### 4.5.3.1.14 CO-ENDS

Indicates that the end-point of the episode described by the propositional clause coincides with the end-point of the time interval referred to by the temporal expression, and that its starting point is after (but not coinciding with) the starting point of the time interval.

EXAMPLE 22 "Some time after the beginning of drug therapy, the patient felt dizzy but this lasted only as long as the medication was given" (EPISODE("feeling dizzy") (has-occurrence DURING TI("past")) (has-occurrence CO-ENDS TI(EPISODE("drug therapy")))).

Figure 1 presents an overview of the semantics of the various temporal comparators that are permitted in relation with the has-occurrence temporal link, when an episode is temporally related to a time interval.
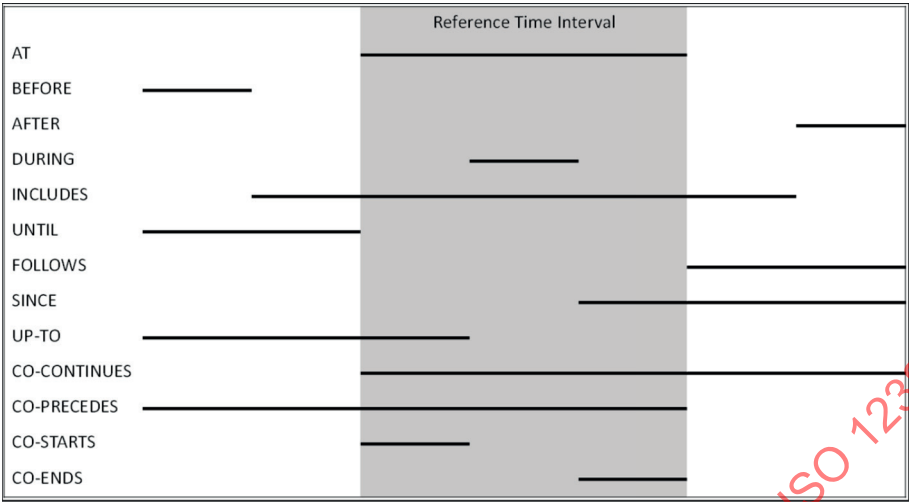


**Figure 1 — Episodes related to a time interval**

### 4.5.3.2    When the temporal expression refers to a time point

#### 4.5.3.2.1    General

The following temporal comparators are permitted in combination with episodes if the temporal expression refers to a time point.

#### 4.5.3.2.2    BEFORE

Indicates the happening of the episode described by the propositional clause as having occurred or as occurring before (but not including) the time point indicated by the temporal expression.

EXAMPLE 23    "The appendectomy will be finished before 2 o'clock" (EPISODE("appendectomy") (hasoccurrence BEFORE TP( "2 o'clock")) (has-occurrence DURING TI( "future"))).

#### 4.5.3.2.3    AFTER

Indicates the happening of the episode described by the propositional clause as having occurred or as occurring after (but not including) the time point indicated by the temporal expression.

EXAMPLE 24    "The patient was in hospital after Christmas" (EPISODE "hospitalisation") (has-occurrence AFTER TP( "Christmas")) (has-occurrence DURING TI( "past"))).

#### 4.5.3.2.4    INCLUDES

Indicates the time point mentioned by the temporal expression as being part of the time interval related to the episode described by the propositional clause.

EXAMPLE 25    "The patient stayed in the hospital over Christmas" (EPISODE("being in hospital") (hasoccurrence INCLUDES TP( "Christmas"))).

### 4.5.3.2.5 UNTIL

Indicates the happening of the episode described by the propositional clause as having occurred or as occurring until (including) the time point referred to by the temporal expression. No information is available on the starting point of the episode.

EXAMPLE 26 "The patient suffered from headache until 5 o'clock" (EPISODE("headache") (has-occurrence UNTIL TP( "5 o'clock")) (has-occurrence DURING TI( "past"))).

If the time point referred to by the temporal expression is to be excluded, BEFORE should be used.

### 4.5.3.2.6 FOLLOWS

Indicates the happening of the episode described by the propositional clause as having occurred or as occurring following (including) the time point referred to by the temporal expression. No information is available on the end-point of the episode.

EXAMPLE 27 "Start taking tablets tomorrow at noon" (EPISODE("taking tablets") (has-occurrence FOLLOWS TP("tomorrow noon"))).

Figure 2 presents an overview of the semantics of the various temporal comparators that are permitted in relation with the has-occurrence temporal link, when an episode is temporally related to a time point.
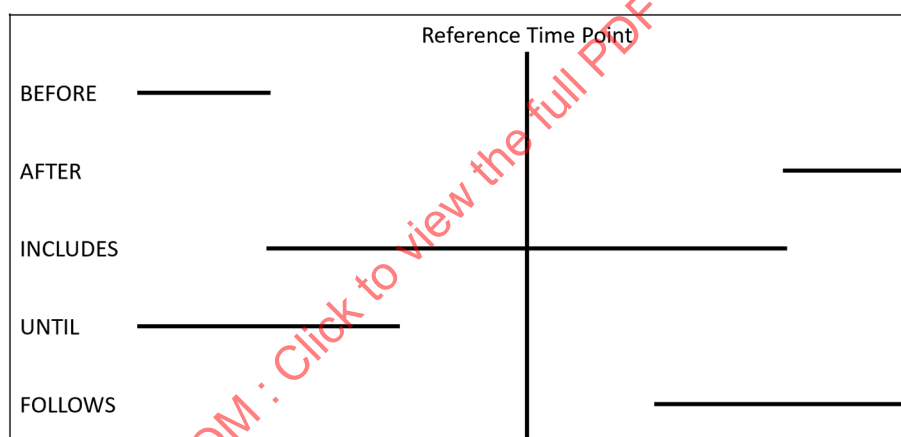


**Figure 2 — Episodes related to a time point**

### 4.5.3.3 When the temporal expression refers to a time-series

All temporal comparators may be used in combination with episodes if the temporal expression refers to a time-series. The meaning for each combination is similar to the one given for time intervals and time points.

EXAMPLE 28 "The patient suffers from headache almost every time it is cold outside" (EPISODE("headache") (has-occurrence AT TS("almost every time it is cold outside"))).

EXAMPLE 29 "Take a tablet before each meal" (EPISODE("take a tablet") (has-occurrence BEFORE TS(EPISODE("meal")))).

EXAMPLE 30 "Take a tablet after each meal" (EPISODE("take a tablet") (has-occurrence AFTER TS(EPISODE("meal")))).

EXAMPLE 31 "Take a tablet every day during breakfast" (EPISODE("take a tablet") (has-occurrence DURING TS(EPISODE("breakfast")))).

EXAMPLE 32 "Every time the patient felt dizzy, there was a sensation of irregular pulse" (EPISODE("a sensation of irregular heartbeats") (has-occurrence INCLUDES TS(EPISODE("feeling of dizziness"))) (has-occurrence DURING TI("past"))).

EXAMPLE 33   "The headache will always last until proper medication is given" (EPISODE("headache") (hasoccurrence UNTIL TS(EPISODE("giving proper medication"))) (has-occurrence DURING TI("future"))).

EXAMPLE 34   "Each headache attack starts immediately after drinking beer." (EPISODE("headache") (hasoccurrence FOLLOWS TS(EPISODE("drinking beer")))).

EXAMPLE 35   "Every time while drinking beer, he starts getting headache." (EPISODE("headache") (hasoccurrence SINCE TS(EPISODE("drinking beer")))).

EXAMPLE 36   "He keeps suffering from headache until he has lied down for a while" (EPISODE("headache") (has-occurrence UP-TO TS(EPISODE("lying down")))).

EXAMPLE 37   "Immediately after starting to drink, he always gets headache lasting for several days" (EPISODE("headache") (has-occurrence CO-CONTINUES TS(EPISODE("drinking beer") (has-duration DR("several days"))))).

EXAMPLE 38   "The headache attacks can only be stopped by lying down for 30 minutes" (EPISODE("headache attack") (has-occurrence CO-PRECEDES  TS(EPISODE("laying down") (has-duration DR("30 minutes"))))).

EXAMPLE 39   "Each week-end begins with a feeling of distress lasting for 30 minutes" (EPISODE("a feeling of distress") (has-occurrence CO-STARTS TS(EPISODE("week-end"))) (has-duration DR("30 minutes")))).

EXAMPLE 40   "Only at the end of the week does he stop feeling tired" (EPISODE("feeling tired") (has-occurrence CO-ENDS TS(EPISODE("the week")))).

# 5   Characteristics of conformance

## 5.1   Provisions for conformance specification

This document allows developers of health care information systems (HIS) to specify to what degree their system can produce or accept information formatted into the elements presented in Clause 4. Conformance shall be specified for each subsystem of the HIS (e.g. medication, clinical history, …), according to the provisions of 5.2 to 5.7.

Similarly, information and data (available in data bases, concept systems, etc…) may also be labelled according to the conformance specifications of this document.

The following subclauses apply only to health care information systems explicitly. The rules for formatting data or information shall be interpreted similarly.

## 5.2   Basic guidelines

For each system for which conformance with this document is claimed, the following characteristics shall be described.

| LSS | level of semantic specification | specifies to what extent the information related to time is distinguished from the rest of the information |
|---|---|---|
| LRE | level of recursive embedding of time related information | specifies whether or not the propositional clauses are further parsed up to the level of propositional clause zero. |
| LDR | level of deictic referential complexity | specifies characteristics related to the use of deictic temporal expressions |
| LCR | level of relative referential complexity | specifies characteristics related to the use of relative temporal expressions |
| LQI | level of formal rigour of temporal expressions | specifies to what extent temporal expressions can be interpreted by a machine |

The labels in the following paragraphs are organized in such a way that a higher number represents a more desirable configuration than a lower number.