OntoRelQuery: Query evaluation report

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May 13, 2025

Abstract

This report presents the OntoRelQuery process for generating queries related to 13 clinical variables used in healthcare settings. Each clinical variable is translated into one or more ontological paths, which are then transformed into formal query specifications. These specifications consist of ontology graphs representing conceptual relationships and OntoRel graphs capturing detailed relation properties, followed by the generation of corresponding SQL query code. The approach demonstrates how biomedical ontologies can be leveraged to standardize and formalize healthcare data extraction for clinical research and quality assessment.

Introduction

Hospital data contains valuable knowledge about patient care trajectories and clinical outcomes. However, extracting meaningful variables from these complex datasets presents significant challenges due to diverse terminologies, data structures, and semantic interpretations. Ontology-based approaches offer a promising solution by providing formal, explicit specifications of shared conceptualizations.

This report documents the implementation of the OntoRelQuery methodology using specifically the MPHPO (Mortality Prediction for Hospitalized Patients Ontology). MPHPO[1] provides a standardized framework for concepts related to mortality prediction in hospitalized patients. To operationalize this ontology for practical data extraction, we utilized an ontology relational generated model called OntoRel. This approach transforms the rich semantic structure of MPHPO into a relational database schema that preserves the ontological relationships while enabling efficient query execution.

We focus on 13 key clinical variables that represent important aspects of patient care, including admission characteristics, comorbidities, and healthcare utilization patterns. For each variable, we present:

- **Variable description.** A detailed explanation of the clinical significance and definition of the variable.

- **Query paths.** The ontological traversal paths required to calculate the variable, leveraging MPHPO entities and relations.

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[1] https://github.com/OpenLHS/MPHPO

- **Ontological representation.** Visual representation of relationships between entities through ontology graphs and more detailed OntoRel graphs that show the exact mapping to relational structures.

- **SQL implementation.** The practical query implementation derived from the OntoRel specifications.

- **Calculation logic.** The algorithmic process for determining the variable's value.

- **Key ontology terms.** Essential MPHPO entities short IRI's used in the variable's definition with their identifiers.

Contents

1 Methodology

The user may need to make one or more requests to retrieve the variable, as the path cannot be accessed with the current version. Each variable is calculated by defining one or more corresponding user requests.

2 Variable 1 - 1-year mortality

> **Variable description**
>
> This variable determines if a patient has survived beyond one year after their current hospital admission. It requires data about both the admission date and the potential death date of the patient.

2.1 User request

To calculate this variable, the following user requests must be defined:

> **Path 1:** Admission Date → Hospitalization
> Start entity: `MPHPO_0000003` (MPHPO HOSD beginning temporal information)
> End entity: `HOSO_0000031` (Hospitalization)
> **Path 2:** Hospitalization → Patient
> Start entity: `HOSO_0000031` (Hospitalization)
> End entity: `NCBITaxon_9606` (Homo sapiens)
> **Path 3:** Death Date → Patient
> Start entity: `MPHPO_0000011` (MPHPO human death date)
> End entity: `NCBITaxon_9606` (Homo sapiens)

2.2 Ontological representation

Table 1 presents the list of ontological classes of the query.

Ontology term	Description
HOSO_0000031	Hospitalization
HOSO_0000012	Healthcare organization clinical visit
HOSO_0000011	Healthcare organization service delivery
MPHPO_0000003	MPHPO HOSD beginning temporal information (admission date)
MPHPO_0000011	MPHPO human death date
NCBITaxon_9606	Homo sapiens (patient)

Table 1: Key ontology terms used in the 1-year mortality variable queries

2.2.1 Path 1: Admission Date to Hospitalization

> **Ontology graph**
>
> ```
> (MPHPO HOSD beginning temporal information (MPHPO_0000003)) -[
>     component of [OBJECT_PROPERTY]]->
> (healthcare organization service delivery beginning statement (
>     HOSO_0000055)) -[has component [OBJECT_PROPERTY]]-> (healthcare
>     organization service delivery identifier (HOSO_0000100)) -[
>     denotes [OBJECT_PROPERTY]]-> (healthcare organization service
>     delivery (HOSO_0000011)) -[ISA]-> (healthcare organization
>     clinical visit (HOSO_0000012)) -[ISA]-> (hospitalization (
>     HOSO_0000031))
> ```

```
MPHPO HOSD beginning temporal information (MPHPO_0000003) ->
(MPHPO HOSD beginning temporal information component of healthcare
    organization service delivery beginning statement [
    MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055]) ->
healthcare organization service delivery beginning statement (
    HOSO_0000055) ->
(healthcare organization service delivery beginning statement has
    component healthcare organization service delivery identifier [
    HOSO_0000055_RO_0002180_HOSO_0000100]) ->
healthcare organization service delivery identifier (HOSO_0000100)
    ->
(healthcare organization service delivery identifier denotes
    healthcare organization service delivery [
    HOSO_0000100_IAO_0000219_HOSO_0000011]) ->
healthcare organization service delivery (HOSO_0000011) ->
healthcare organization clinical visit (HOSO_0000012) ->
hospitalization (HOSO_0000031)
```

2.2.2   Path 2: Hospitalization to Patient

Ontology graph

```
(hospitalization (HOSO_0000031)) -[ISA]->
(healthcare organization clinical visit (HOSO_0000012)) -[is
    directed by [OBJECT_PROPERTY]]->
(healthcare service organism specification (HOSO_0000003)) -[
    inverse of denoted by [OBJECT_PROPERTY]]->
(human clinical visit specified patient (HOSO_0000137)) -[ISA]->
(Homo sapiens (NCBITaxon_9606))
```

OntoRel graph

```
hospitalization (HOSO_0000031) ->
healthcare organization clinical visit (HOSO_0000012) ->
(healthcare organization clinical visit is directed by healthcare
    service organism specification [HOSO_0000012_OpenLHS-
    Core_0000004_HOSO_0000003]) ->
healthcare service organism specification (HOSO_0000003) ->
(human clinical visit specified patient denoted by healthcare
    service organism specification [
    HOSO_0000137_IAO_0000235_HOSO_0000003]) ->
human clinical visit specified patient (HOSO_0000137) ->
Homo sapiens (NCBITaxon_9606)
```

2.2.3 Path 3: Death Date to Patient

Ontology graph

```
1. (MPHPO human death date (MPHPO_0000011)) -[ISA]->
   (human death temporal information (IOIO_0000006)) -[component of
       [OBJECT_PROPERTY]]->
   (human death statement (IOIO_0000003)) -[has component [
       OBJECT_PROPERTY]]->
   (human identifier (IOIO_0000014)) -[denotes [OBJECT_PROPERTY]]->
   (Homo sapiens (NCBITaxon_9606))

2. (MPHPO human death date (MPHPO_0000011)) -[ISA]->
   (human death temporal information (IOIO_0000006)) -[inverse of
       has component [OBJECT_PROPERTY]]->
   (human death statement (IOIO_0000003)) -[has component [
       OBJECT_PROPERTY]]->
   (human identifier (IOIO_0000014)) -[denotes [OBJECT_PROPERTY]]->
   (Homo sapiens (NCBITaxon_9606))
```

OntoRel graph

```
1. MPHPO human death date (MPHPO_0000011) ->
   human death temporal information (IOIO_0000006) ->
   (human death temporal information component of human death
       statement [IOIO_0000006_OpenLHS-Core_0000070_IOIO_0000003])
       ->
   human death statement (IOIO_0000003) ->
   (human death statement has component human identifier [
       IOIO_0000003_RO_0002180_IOIO_0000014]) ->
   human identifier (IOIO_0000014) ->
   (human identifier denotes Homo sapiens [
       IOIO_0000014_IAO_0000219_NCBITaxon_9606]) ->
   Homo sapiens (NCBITaxon_9606)

2. MPHPO human death date (MPHPO_0000011) ->
   human death temporal information (IOIO_0000006) ->
   (human death statement has component human death temporal
       information [IOIO_0000003_RO_0002180_IOIO_0000006]) ->
   human death statement (IOIO_0000003) ->
   (human death statement has component human identifier [
       IOIO_0000003_RO_0002180_IOIO_0000014]) ->
   human identifier (IOIO_0000014) ->
   (human identifier denotes Homo sapiens [
       IOIO_0000014_IAO_0000219_NCBITaxon_9606]) ->
   Homo sapiens (NCBITaxon_9606)
```

2.3 SQL implementation

Each path is implemented as a separate SQL query that follows the relationships defined in the ontology.

Query 1: Admission Date to Hospitalization

```sql
 1  SELECT
 2      "MPHPO_0000003"."MPHPO_0000003_uid"
 3          AS "uid MPHPO HOSD beginning temporal information",
 4      "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."HOSO_0000055_uid"
 5          AS "uid healthcare organization service delivery beginning statement",
 6      "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000100_uid"
 7          AS "uid healthcare organization service delivery identifier",
 8      "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid"
 9          AS "uid healthcare organization service delivery",
10      "HOSO_0000012"."HOSO_0000012_uid"
11          AS "uid healthcare organization clinical visit",
12      "HOSO_0000031"."HOSO_0000031_uid"
13          AS "uid hospitalization",
14      "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001".
15          "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001_Ontorel"
16          AS "has temporal value"
17  FROM
18      "MPHPO"."MPHPO_0000003"
19
20      JOIN "MPHPO"."MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"
21          ON "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."MPHPO_0000003_uid" =
22              "MPHPO_0000003"."MPHPO_0000003_uid"
23
24      JOIN "MPHPO"."HOSO_0000055"
25          ON "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."HOSO_0000055_uid" =
26              "HOSO_0000055"."HOSO_0000055_uid"
27
28      JOIN "MPHPO"."HOSO_0000055_RO_0002180_HOSO_0000100"
29          ON "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000055_uid" =
30              "HOSO_0000055"."HOSO_0000055_uid"
31
32      JOIN "MPHPO"."HOSO_0000100"
33          ON "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000100_uid" =
34              "HOSO_0000100"."HOSO_0000100_uid"
35
36      JOIN "MPHPO"."HOSO_0000100_IAO_0000219_HOSO_0000011"
37          ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000100_uid" =
38              "HOSO_0000100"."HOSO_0000100_uid"
39
40      JOIN "MPHPO"."HOSO_0000011"
41          ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid" =
42              "HOSO_0000011"."HOSO_0000011_uid"
43
44      JOIN "MPHPO"."HOSO_0000012"
45          ON "HOSO_0000012"."HOSO_0000012_uid" =
46              "HOSO_0000011"."HOSO_0000011_uid"
47
48      JOIN "MPHPO"."HOSO_0000031"
49          ON "HOSO_0000031"."HOSO_0000031_uid" =
50              "HOSO_0000012"."HOSO_0000012_uid"
51
52      JOIN "MPHPO"."MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001"
53          ON "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001"."MPHPO_0000003_uid"
                ↪  =
54              "MPHPO_0000003"."MPHPO_0000003_uid";
```

Query 2: Hospitalization to Patient

```sql
SELECT
    "HOSO_0000031"."HOSO_0000031_uid"
        AS "uid hospitalization",
    "HOSO_0000012"."HOSO_0000012_uid"
        AS "uid healthcare organization clinical visit",
    "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000003_uid"
        AS "uid healthcare service organism specification",
    "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000137_uid"
        AS "uid human clinical visit specified patient",
    "NCBITaxon_9606"."NCBITaxon_9606_uid"
        AS "uid Homo sapiens"
FROM
    "MPHPO"."HOSO_0000031"

    JOIN "MPHPO"."HOSO_0000012"
        ON "HOSO_0000031"."HOSO_0000031_uid" =
            "HOSO_0000012"."HOSO_0000012_uid"

    JOIN "MPHPO"."HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"
        ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000012_uid" =
            "HOSO_0000012"."HOSO_0000012_uid"

    JOIN "MPHPO"."HOSO_0000003"
        ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000003_uid" =
            "HOSO_0000003"."HOSO_0000003_uid"

    JOIN "MPHPO"."HOSO_0000137_IAO_0000235_HOSO_0000003"
        ON "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000003_uid" =
            "HOSO_0000003"."HOSO_0000003_uid"

    JOIN "MPHPO"."HOSO_0000137"
        ON "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000137_uid" =
            "HOSO_0000137"."HOSO_0000137_uid"

    JOIN "MPHPO"."NCBITaxon_9606"
        ON "HOSO_0000137"."HOSO_0000137_uid" =
            "NCBITaxon_9606"."NCBITaxon_9606_uid";
```

Query 3: Death Date to Patient

```sql
SELECT
    "MPHPO_0000011"."MPHPO_0000011_uid"
        AS "uid MPHPO human death date",
    "IOIO_0000006"."IOIO_0000006_uid"
        AS "uid human death temporal information",
    "IOIO_0000006_OpenLHS-Core_0000070_IOIO_0000003"."IOIO_0000003_uid"
        AS "uid human death statement",
    "IOIO_0000003_RO_0002180_IOIO_0000014"."IOIO_0000014_uid"
        AS "uid human identifier",
    "IOIO_0000014_IAO_0000219_NCBITaxon_9606"."NCBITaxon_9606_uid"
        AS "uid Homo sapiens",
    "MPHPO_0000011_Ontorel-Core_0000004_Ontorel-Core_0000001".
        "MPHPO_0000011_Ontorel-Core_0000004_Ontorel-Core_0000001_Ontorel"
        AS "has temporal value"
FROM
    "MPHPO"."MPHPO_0000011"

    JOIN "MPHPO"."MPHPO_0000011_Ontorel-Core_0000004_Ontorel-Core_0000001"
```

```
19        ON "MPHPO_0000011_Ontorel-Core_0000004_Ontorel-Core_0000001"."MPHPO_0000011_uid"
          ↪    =
20            "MPHPO_0000011"."MPHPO_0000011_uid"
21
22    JOIN "MPHPO"."IOIO_0000006"
23        ON "MPHPO_0000011"."MPHPO_0000011_uid" =
24            "IOIO_0000006"."IOIO_0000006_uid"
25
26    JOIN "MPHPO"."IOIO_0000006_OpenLHS-Core_0000070_IOIO_0000003"
27        ON "IOIO_0000006_OpenLHS-Core_0000070_IOIO_0000003"."IOIO_0000006_uid" =
28            "IOIO_0000006"."IOIO_0000006_uid"
29
30    JOIN "MPHPO"."IOIO_0000003"
31        ON "IOIO_0000006_OpenLHS-Core_0000070_IOIO_0000003"."IOIO_0000003_uid" =
32            "IOIO_0000003"."IOIO_0000003_uid"
33
34    JOIN "MPHPO"."IOIO_0000003_RO_0002180_IOIO_0000014"
35        ON "IOIO_0000003_RO_0002180_IOIO_0000014"."IOIO_0000003_uid" =
36            "IOIO_0000003"."IOIO_0000003_uid"
37
38    JOIN "MPHPO"."IOIO_0000014"
39        ON "IOIO_0000003_RO_0002180_IOIO_0000014"."IOIO_0000014_uid" =
40            "IOIO_0000014"."IOIO_0000014_uid"
41
42    JOIN "MPHPO"."IOIO_0000014_IAO_0000219_NCBITaxon_9606"
43        ON "IOIO_0000014_IAO_0000219_NCBITaxon_9606"."IOIO_0000014_uid" =
44            "IOIO_0000014"."IOIO_0000014_uid"
45
46    JOIN "MPHPO"."NCBITaxon_9606"
47        ON "IOIO_0000014_IAO_0000219_NCBITaxon_9606"."NCBITaxon_9606_uid" =
48            "NCBITaxon_9606"."NCBITaxon_9606_uid";
```

2.4 Calculation logic

To determine 1-year mortality status:

1. Retrieve the admission date of the current hospitalization using Query 1[2.3]

2. Link the hospitalization to the patient using Query 2 [2.3]

3. Check if a death date exists for the patient using Query 3 [2.3]

4. If a death date exists, calculate the time difference between the current admission and death date:

   - If time difference ≥ 1 year: Patient survived beyond one year
   - If time difference < 1 year: Patient did not survive one year

5. If no death date exists: Patient is still alive (survived)

3 Variable 2 - Age

> **Variable description**
>
> This variable represents the patient's age at admission in full years since birth. It requires accessing both the admission date and the patient's birth date to calculate the age.

3.1 User request

To calculate this variable, the following user requests must be defined:

> **Path 1:** Admission Date → Hospitalization
> Start entity: `MPHPO_0000003` (MPHPO HOSD beginning temporal information)
> End entity: `HOSO_0000031` (Hospitalization)
> **Path 2:** Hospitalization → Birth Date
> Start entity: `HOSO_0000031` (Hospitalization)
> End entity: `MPHPO_0000009` (MPHPO human birth date)

3.2 Ontological representation

Table 2 presents the list of ontological classes of the query.

Ontology term	Description
HOSO_0000031	Hospitalization
HOSO_0000012	Healthcare organization clinical visit
HOSO_0000011	Healthcare organization service delivery
MPHPO_0000003	MPHPO HOSD beginning temporal information (admission date)
MPHPO_0000009	MPHPO human birth date
NCBITaxon_9606	Homo sapiens (patient)
IOIO_0000001	Human birth statement
IOIO_0000005	Human birth temporal information
IOIO_0000014	Human identifier

Table 2: Key ontology terms used in the age variable queries

3.2.1 Path 1: Admission Date to Hospitalization

> **Ontology graph**
>
> ```
> (MPHPO HOSD beginning temporal information (MPHPO_0000003)) -[
>     component of [OBJECT_PROPERTY]]->
> (healthcare organization service delivery beginning statement (
>     HOSO_0000055)) -[has component [OBJECT_PROPERTY]]-> (healthcare
>     organization service delivery identifier (HOSO_0000100)) -[
>     denotes [OBJECT_PROPERTY]]-> (healthcare organization service
>     delivery (HOSO_0000011)) -[ISA]-> (healthcare organization
>     clinical visit (HOSO_0000012)) -[ISA]-> (hospitalization (
>     HOSO_0000031))
> ```

OntoRel graph

```
MPHPO HOSD beginning temporal information (MPHPO_0000003) ->
(MPHPO HOSD beginning temporal information component of healthcare
    organization service delivery beginning statement [
    MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055]) ->
healthcare organization service delivery beginning statement (
    HOSO_0000055) ->
(healthcare organization service delivery beginning statement has
    component healthcare organization service delivery identifier [
    HOSO_0000055_RO_0002180_HOSO_0000100]) ->
healthcare organization service delivery identifier (HOSO_0000100)
    ->
(healthcare organization service delivery identifier denotes
    healthcare organization service delivery [
    HOSO_0000100_IAO_0000219_HOSO_0000011]) ->
healthcare organization service delivery (HOSO_0000011) ->
healthcare organization clinical visit (HOSO_0000012) ->
hospitalization (HOSO_0000031)
```

3.2.2 Path 2: Hospitalization to Birth Date

Ontology graph

```
1. (hospitalization (HOSO_0000031)) -[ISA]->
   (healthcare organization clinical visit (HOSO_0000012)) -[is
       directed by [OBJECT_PROPERTY]]->
   (healthcare service organism specification (HOSO_0000003)) -[
       inverse of denoted by [OBJECT_PROPERTY]]->
   (human clinical visit specified patient (HOSO_0000137)) -[ISA]->
   (Homo sapiens (NCBITaxon_9606)) -[inverse of denotes [
       OBJECT_PROPERTY]]->
   (human identifier (IOIO_0000014)) -[inverse of has component [
       OBJECT_PROPERTY]]->
   (human birth statement (IOIO_0000001)) -[has component [
       OBJECT_PROPERTY]]->
   (human birth temporal information (IOIO_0000005)) -[ISA]->
   (MPHPO human birth date (MPHPO_0000009))

2. (hospitalization (HOSO_0000031)) -[ISA]->
   (healthcare organization clinical visit (HOSO_0000012)) -[is
       directed by [OBJECT_PROPERTY]]->
   (healthcare service organism specification (HOSO_0000003)) -[
       inverse of denoted by [OBJECT_PROPERTY]]->
   (human clinical visit specified patient (HOSO_0000137)) -[ISA]->
   (Homo sapiens (NCBITaxon_9606)) -[inverse of denotes [
       OBJECT_PROPERTY]]->
   (human identifier (IOIO_0000014)) -[inverse of has component [
       OBJECT_PROPERTY]]->
   (human birth statement (IOIO_0000001)) -[inverse of component of
        [OBJECT_PROPERTY]]->
   (human birth temporal information (IOIO_0000005)) -[ISA]->
   (MPHPO human birth date (MPHPO_0000009))
```

OntoRel graph

```
1. hospitalization (HOSO_0000031) ->
   healthcare organization clinical visit (HOSO_0000012) ->
   (healthcare organization clinical visit is directed by
       healthcare service organism specification [
       HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003]) ->
   healthcare service organism specification (HOSO_0000003) ->
   (human clinical visit specified patient denoted by healthcare
       service organism specification [
       HOSO_0000137_IAO_0000235_HOSO_0000003]) ->
   human clinical visit specified patient (HOSO_0000137) ->
   Homo sapiens (NCBITaxon_9606) ->
   (human identifier denotes Homo sapiens [
       IOIO_0000014_IAO_0000219_NCBITaxon_9606]) ->
   human identifier (IOIO_0000014) ->
   (human birth statement has component human identifier [
       IOIO_0000001_RO_0002180_IOIO_0000014]) ->
   human birth statement (IOIO_0000001) ->
   (human birth temporal information component of human birth
       statement [IOIO_0000005_OpenLHS-Core_0000070_IOIO_0000001])
       ->
   human birth temporal information (IOIO_0000005) ->
   MPHPO human birth date (MPHPO_0000009)

2. hospitalization (HOSO_0000031) ->
   healthcare organization clinical visit (HOSO_0000012) ->
   (healthcare organization clinical visit is directed by
       healthcare service organism specification [
       HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003]) ->
   healthcare service organism specification (HOSO_0000003) ->
   (human clinical visit specified patient denoted by healthcare
       service organism specification [
       HOSO_0000137_IAO_0000235_HOSO_0000003]) ->
   human clinical visit specified patient (HOSO_0000137) ->
   Homo sapiens (NCBITaxon_9606) ->
   (human identifier denotes Homo sapiens [
       IOIO_0000014_IAO_0000219_NCBITaxon_9606]) ->
   human identifier (IOIO_0000014) ->
   (human birth statement has component human identifier [
       IOIO_0000001_RO_0002180_IOIO_0000014]) ->
   human birth statement (IOIO_0000001) ->
   (human birth statement has component human birth temporal
       information [IOIO_0000001_RO_0002180_IOIO_0000005]) ->
   human birth temporal information (IOIO_0000005) ->
   MPHPO human birth date (MPHPO_0000009)
```

3.3   SQL implementation

Each path is implemented as a separate SQL query that follows the relationships defined in the
ontology.

Query 1: Admission Date to Hospitalization

```sql
SELECT
    "MPHPO_0000003"."MPHPO_0000003_uid"
        AS "uid MPHPO HOSD beginning temporal information",
    "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."HOSO_0000055_uid"
        AS "uid healthcare organization service delivery beginning statement",
    "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000100_uid"
        AS "uid healthcare organization service delivery identifier",
    "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid"
        AS "uid healthcare organization service delivery",
    "HOSO_0000012"."HOSO_0000012_uid"
        AS "uid healthcare organization clinical visit",
    "HOSO_0000031"."HOSO_0000031_uid"
        AS "uid hospitalization",
    "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001".
        "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001_Ontorel"
        AS "has temporal value"
FROM
    "MPHPO"."MPHPO_0000003"

    JOIN "MPHPO"."MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"
        ON "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."MPHPO_0000003_uid" =
            "MPHPO_0000003"."MPHPO_0000003_uid"

    JOIN "MPHPO"."HOSO_0000055"
        ON "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."HOSO_0000055_uid" =
            "HOSO_0000055"."HOSO_0000055_uid"

    JOIN "MPHPO"."HOSO_0000055_RO_0002180_HOSO_0000100"
        ON "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000055_uid" =
            "HOSO_0000055"."HOSO_0000055_uid"

    JOIN "MPHPO"."HOSO_0000100"
        ON "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000100_uid" =
            "HOSO_0000100"."HOSO_0000100_uid"

    JOIN "MPHPO"."HOSO_0000100_IAO_0000219_HOSO_0000011"
        ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000100_uid" =
            "HOSO_0000100"."HOSO_0000100_uid"

    JOIN "MPHPO"."HOSO_0000011"
        ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid" =
            "HOSO_0000011"."HOSO_0000011_uid"

    JOIN "MPHPO"."HOSO_0000012"
        ON "HOSO_0000012"."HOSO_0000012_uid" =
            "HOSO_0000011"."HOSO_0000011_uid"

    JOIN "MPHPO"."HOSO_0000031"
        ON "HOSO_0000031"."HOSO_0000031_uid" =
            "HOSO_0000012"."HOSO_0000012_uid"

    JOIN "MPHPO"."MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001"
        ON "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001"."MPHPO_0000003_uid"
            ↪ =
            "MPHPO_0000003"."MPHPO_0000003_uid";
```

Query 2: Hospitalization to Birth Date

```sql
 1  SELECT
 2      "HOSO_0000031"."HOSO_0000031_uid"
 3          AS "uid hospitalization",
 4      "HOSO_0000012"."HOSO_0000012_uid"
 5          AS "uid healthcare organization clinical visit",
 6      "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000003_uid"
 7          AS "uid healthcare service organism specification",
 8      "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000137_uid"
 9          AS "uid human clinical visit specified patient",
10      "NCBITaxon_9606"."NCBITaxon_9606_uid"
11          AS "uid Homo sapiens",
12      "IOIO_0000014_IAO_0000219_NCBITaxon_9606"."IOIO_0000014_uid"
13          AS "uid human identifier",
14      "IOIO_0000001_RO_0002180_IOIO_0000014"."IOIO_0000001_uid"
15          AS "uid human birth statement",
16      "IOIO_0000005_OpenLHS-Core_0000070_IOIO_0000001"."IOIO_0000005_uid"
17          AS "uid human birth temporal information",
18      "MPHPO_0000009"."MPHPO_0000009_uid"
19          AS "uid MPHPO human birth date",
20      "MPHPO_0000009_Ontorel-Core_0000004_Ontorel-Core_0000001".
21          "MPHPO_0000009_Ontorel-Core_0000004_Ontorel-Core_0000001_Ontorel"
22          AS "has temporal value"
23  FROM
24      "MPHPO"."HOSO_0000031"
25
26      JOIN "MPHPO"."HOSO_0000012"
27          ON "HOSO_0000031"."HOSO_0000031_uid" =
28              "HOSO_0000012"."HOSO_0000012_uid"
29
30      JOIN "MPHPO"."HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"
31          ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000012_uid" =
32              "HOSO_0000012"."HOSO_0000012_uid"
33
34      JOIN "MPHPO"."HOSO_0000003"
35          ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000003_uid" =
36              "HOSO_0000003"."HOSO_0000003_uid"
37
38      JOIN "MPHPO"."HOSO_0000137_IAO_0000235_HOSO_0000003"
39          ON "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000003_uid" =
40              "HOSO_0000003"."HOSO_0000003_uid"
41
42      JOIN "MPHPO"."HOSO_0000137"
43          ON "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000137_uid" =
44              "HOSO_0000137"."HOSO_0000137_uid"
45
46      JOIN "MPHPO"."NCBITaxon_9606"
47          ON "HOSO_0000137"."HOSO_0000137_uid" =
48              "NCBITaxon_9606"."NCBITaxon_9606_uid"
49
50      JOIN "MPHPO"."IOIO_0000014_IAO_0000219_NCBITaxon_9606"
51          ON "IOIO_0000014_IAO_0000219_NCBITaxon_9606"."NCBITaxon_9606_uid" =
52              "NCBITaxon_9606"."NCBITaxon_9606_uid"
53
54      JOIN "MPHPO"."IOIO_0000014"
55          ON "IOIO_0000014_IAO_0000219_NCBITaxon_9606"."IOIO_0000014_uid" =
56              "IOIO_0000014"."IOIO_0000014_uid"
57
58      JOIN "MPHPO"."IOIO_0000001_RO_0002180_IOIO_0000014"
59          ON "IOIO_0000001_RO_0002180_IOIO_0000014"."IOIO_0000014_uid" =
60              "IOIO_0000014"."IOIO_0000014_uid"
```

```
61
62     JOIN "MPHPO"."IOIO_0000001"
63         ON "IOIO_0000001_RO_0002180_IOIO_0000014"."IOIO_0000001_uid" =
64             "IOIO_0000001"."IOIO_0000001_uid"
65
66     JOIN "MPHPO"."IOIO_0000005_OpenLHS-Core_0000070_IOIO_0000001"
67         ON "IOIO_0000005_OpenLHS-Core_0000070_IOIO_0000001"."IOIO_0000001_uid" =
68             "IOIO_0000001"."IOIO_0000001_uid"
69
70     JOIN "MPHPO"."IOIO_0000005"
71         ON "IOIO_0000005_OpenLHS-Core_0000070_IOIO_0000001"."IOIO_0000005_uid" =
72             "IOIO_0000005"."IOIO_0000005_uid"
73
74     JOIN "MPHPO"."MPHPO_0000009"
75         ON "MPHPO_0000009"."MPHPO_0000009_uid" =
76             "IOIO_0000005"."IOIO_0000005_uid"
77
78     JOIN "MPHPO"."MPHPO_0000009_Ontorel-Core_0000004_Ontorel-Core_0000001"
79         ON "MPHPO_0000009_Ontorel-Core_0000004_Ontorel-Core_0000001"."MPHPO_0000009_uid"
           ↪  =
80             "MPHPO_0000009"."MPHPO_0000009_uid";
```

3.4   Calculation logic

To calculate the patient's age at admission:

1. Retrieve the admission date of the current hospitalization using Query 1[3.3]

2. Retrieve the patient's birth date using Query 2[3.3]

3. Compute the difference between these dates:

   - Calculate the difference in days between the birth date and the admission date:
     `DAY(admission_date - birth_date)`
   - Divide the number of days by 365 and round down to nearest whole number

4. The result is the patient's age in full years at the time of admission

4 Variable 3 - Sex

> **Variable description**
>
> This variable represents the patient's biological sex. It retrieves the sex information associated with the patient's record.

4.1 User request

To calculate this variable, the following user request must be defined:

> **Path:** Patient → Biological sex information
> Start entity: `NCBITaxon_9606` (Homo sapiens)
> End entity: `MPHPO_0000010` (MPHPO human biological sex information content entity)

4.2 Ontological representation

Table 3 presents the list of ontological classes of the query.

Ontology term	Description
NCBITaxon_9606	Homo sapiens (patient)
IOIO_0000014	Human identifier
IOIO_0000015	Human biological sex statement
IOIO_0000011	Human biological sex information content entity
MPHPO_0000010	MPHPO human biological sex information content entity

Table 3: Key ontology terms used in the sex variable query

> **Ontology graph**
>
> ```
> (Homo sapiens (NCBITaxon_9606)) -[inverse of denotes [
>     OBJECT_PROPERTY]]->
> (human identifier (IOIO_0000014)) -[inverse of has component [
>     OBJECT_PROPERTY]]->
> (human biological sex statement (IOIO_0000015)) -[has component [
>     OBJECT_PROPERTY]]->
> (human biological sex information content entity (IOIO_0000011)) -[
>     ISA]->
> (MPHPO human biological sex information content entity (
>     MPHPO_0000010))
> ```

> **OntoRel graph**
>
> ```
> Homo sapiens (NCBITaxon_9606) ->
> (human identifier denotes Homo sapiens [
>     IOIO_0000014_IAO_0000219_NCBITaxon_9606]) ->
> human identifier (IOIO_0000014) ->
> (human biological sex statement has component human identifier [
>     IOIO_0000015_RO_0002180_IOIO_0000014]) ->
> human biological sex statement (IOIO_0000015) ->
> (human biological sex statement has component human biological sex
>     information content entity [IOIO_0000015_RO_0002180_IOIO_0000011
>     ]) ->
> human biological sex information content entity (IOIO_0000011) ->
> MPHPO human biological sex information content entity (
>     MPHPO_0000010)
> ```

4.3   SQL implementation

The following SQL query retrieves the patient's biological sex:

> **Query: Patient to Biological Sex**
>
> ```sql
> 1  SELECT
> 2      "NCBITaxon_9606"."NCBITaxon_9606_uid"
> 3          AS "uid Homo sapiens",
> 4      "IOIO_0000014_IAO_0000219_NCBITaxon_9606"."IOIO_0000014_uid"
> 5          AS "uid human identifier",
> 6      "IOIO_0000015_RO_0002180_IOIO_0000014"."IOIO_0000015_uid"
> 7          AS "uid human biological sex statement",
> 8      "IOIO_0000015_RO_0002180_IOIO_0000011"."IOIO_0000011_uid"
> 9          AS "uid human biological sex information content entity",
> 10     "MPHPO_0000010"."MPHPO_0000010_uid"
> 11         AS "uid MPHPO human biological sex information content entity",
> 12     "MPHPO_0000010_Ontorel-Core_0000002_string".
> 13         "MPHPO_0000010_Ontorel-Core_0000002_string_Ontorel-Core_0000002"
> 14         AS "has textual value"
> 15 FROM
> 16     "MPHPO"."NCBITaxon_9606"
> 17
> 18     JOIN "MPHPO"."IOIO_0000014_IAO_0000219_NCBITaxon_9606"
> 19         ON "IOIO_0000014_IAO_0000219_NCBITaxon_9606"."NCBITaxon_9606_uid" =
> 20             "NCBITaxon_9606"."NCBITaxon_9606_uid"
> 21
> 22     JOIN "MPHPO"."IOIO_0000014"
> 23         ON "IOIO_0000014_IAO_0000219_NCBITaxon_9606"."IOIO_0000014_uid" =
> 24             "IOIO_0000014"."IOIO_0000014_uid"
> 25
> 26     JOIN "MPHPO"."IOIO_0000015_RO_0002180_IOIO_0000014"
> 27         ON "IOIO_0000015_RO_0002180_IOIO_0000014"."IOIO_0000014_uid" =
> 28             "IOIO_0000014"."IOIO_0000014_uid"
> 29
> 30     JOIN "MPHPO"."IOIO_0000015"
> 31         ON "IOIO_0000015_RO_0002180_IOIO_0000014"."IOIO_0000015_uid" =
> 32             "IOIO_0000015"."IOIO_0000015_uid"
> 33
> 34     JOIN "MPHPO"."IOIO_0000015_RO_0002180_IOIO_0000011"
> 35         ON "IOIO_0000015_RO_0002180_IOIO_0000011"."IOIO_0000015_uid" =
> 36             "IOIO_0000015"."IOIO_0000015_uid"
> 37
> ```

```
38    JOIN "MPHPO"."IOIO_0000011"
39        ON "IOIO_0000015_RO_0002180_IOIO_0000011"."IOIO_0000011_uid" =
40            "IOIO_0000011"."IOIO_0000011_uid"
41
42    JOIN "MPHPO"."MPHPO_0000010"
43        ON "MPHPO_0000010"."MPHPO_0000010_uid" =
44            "IOIO_0000011"."IOIO_0000011_uid"
45
46    JOIN "MPHPO"."MPHPO_0000010_Ontorel-Core_0000002_string"
47        ON "MPHPO_0000010_Ontorel-Core_0000002_string"."MPHPO_0000010_uid" =
48            "MPHPO_0000010"."MPHPO_0000010_uid";
```

4.4   Data interpretation

The biological sex information is retrieved through the following process:

1. Starting from the patient entity (Homo sapiens), the query traverses through various entities and their relationships to reach the biological sex information

2. In the generated query above [4.3] the key data is obtained in the `has textual value` field of the `MPHPO_0000010_Ontorel-Core_0000002_string` table

3. This field contains a string value representing the patient's biological sex (typically "M" for male, "F" for female)

4. This value can be directly used as the variable's output or mapped to standardized codes as required by the application

5 Variable 4 - ED visits

> **Variable description**
>
> This variable counts the number of visits to the emergency department in the year before the current admission. It requires tracking the patient's history of emergency department visits and comparing their dates with the current hospitalization date.

5.1 User request

To calculate this variable, the following user requests must be defined:

> **Path 1:** Emergency Department Visit → Admission Date
> Start entity: `HOSO_0000032` (Emergency department visit)
> End entity: `MPHPO_0000003` (MPHPO HOSD beginning temporal information)
> **Path 2:** Hospitalization → Admission Date
> Start entity: `HOSO_0000031` (Hospitalization)
> End entity: `MPHPO_0000003` (MPHPO HOSD beginning temporal information)
> **Path 3:** Hospitalization → Patient
> Start entity: `HOSO_0000031` (Hospitalization)
> End entity: `NCBITaxon_9606` (Homo sapiens)
> **Path 4:** Emergency Department Visit → Patient
> Start entity: `HOSO_0000032` (Emergency department visit)
> End entity: `NCBITaxon_9606` (Homo sapiens)

5.2 Ontological representation

Table - 4 presents the list of ontological classes of the query.

Ontology term	Description
HOSO_0000031	Hospitalization (admission)
HOSO_0000032	Emergency department visit
HOSO_0000012	Healthcare organization clinical visit
HOSO_0000011	Healthcare organization service delivery
MPHPO_0000003	MPHPO HOSD beginning temporal information (admission date)
NCBITaxon_9606	Homo sapiens (patient)
HOSO_0000055	Healthcare organization service delivery beginning statement
HOSO_0000100	Healthcare organization service delivery identifier

Table 4: Key ontology terms used in the ED visits variable queries

5.2.1 Path 1: Emergency Department Visit to Admission Date

Ontology graph

```
(emergency department visit (HOSO_0000032)) -[ISA]->
(healthcare organization clinical visit (HOSO_0000012)) -[ISA]->
(healthcare organization service delivery (HOSO_0000011)) -[inverse
    of denotes [OBJECT_PROPERTY]]->
(healthcare organization service delivery identifier (HOSO_0000100)
    ) -[inverse of has component [OBJECT_PROPERTY]]->
(healthcare organization service delivery beginning statement (
    HOSO_0000055)) -[inverse of component of [OBJECT_PROPERTY]]->
(MPHPO HOSD beginning temporal information (MPHPO_0000003))
```

OntoRel graph

```
emergency department visit (HOSO_0000032) ->
healthcare organization clinical visit (HOSO_0000012) ->
healthcare organization service delivery (HOSO_0000011) ->
(healthcare organization service delivery identifier denotes
    healthcare organization service delivery [
    HOSO_0000100_IAO_0000219_HOSO_0000011]) ->
healthcare organization service delivery identifier (HOSO_0000100)
    ->
(healthcare organization service delivery beginning statement has
    component healthcare organization service delivery identifier [
    HOSO_0000055_RO_0002180_HOSO_0000100]) ->
healthcare organization service delivery beginning statement (
    HOSO_0000055) ->
(MPHPO HOSD beginning temporal information component of healthcare
    organization service delivery beginning statement [
    MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055]) ->
MPHPO HOSD beginning temporal information (MPHPO_0000003)
```

5.2.2 Path 2: Hospitalization to Admission Date

Ontology graph

```
(hospitalization (HOSO_0000031)) -[ISA]->
(healthcare organization clinical visit (HOSO_0000012)) -[ISA]->
(healthcare organization service delivery (HOSO_0000011)) -[inverse
    of denotes [OBJECT_PROPERTY]]->
(healthcare organization service delivery identifier (HOSO_0000100)
    ) -[inverse of has component [OBJECT_PROPERTY]]->
(healthcare organization service delivery beginning statement (
    HOSO_0000055)) -[inverse of component of [OBJECT_PROPERTY]]->
(MPHPO HOSD beginning temporal information (MPHPO_0000003))
```

```
hospitalization (HOSO_0000031) ->
healthcare organization clinical visit (HOSO_0000012) ->
healthcare organization service delivery (HOSO_0000011) ->
(healthcare organization service delivery identifier denotes
    healthcare organization service delivery [
    HOSO_0000100_IAO_0000219_HOSO_0000011]) ->
healthcare organization service delivery identifier (HOSO_0000100)
    ->
(healthcare organization service delivery beginning statement has
    component healthcare organization service delivery identifier [
    HOSO_0000055_RO_0002180_HOSO_0000100]) ->
healthcare organization service delivery beginning statement (
    HOSO_0000055) ->
(MPHPO HOSD beginning temporal information component of healthcare
    organization service delivery beginning statement [
    MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055]) ->
MPHPO HOSD beginning temporal information (MPHPO_0000003)
```

5.2.3   Path 3: Hospitalization to Patient

```
(hospitalization (HOSO_0000031)) -[ISA]->
(healthcare organization clinical visit (HOSO_0000012)) -[is
    directed by [OBJECT_PROPERTY]]->
(healthcare service organism specification (HOSO_0000003)) -[
    inverse of denoted by [OBJECT_PROPERTY]]->
(human clinical visit specified patient (HOSO_0000137)) -[ISA]->
(Homo sapiens (NCBITaxon_9606))
```

```
hospitalization (HOSO_0000031) ->
healthcare organization clinical visit (HOSO_0000012) ->
(healthcare organization clinical visit is directed by healthcare
    service organism specification [HOSO_0000012_OpenLHS-
    Core_0000004_HOSO_0000003]) ->
healthcare service organism specification (HOSO_0000003) ->
(human clinical visit specified patient denoted by healthcare
    service organism specification [
    HOSO_0000137_IAO_0000235_HOSO_0000003]) ->
human clinical visit specified patient (HOSO_0000137) ->
Homo sapiens (NCBITaxon_9606)
```

5.2.4 Path 4: Emergency Department Visit to Patient

Ontology Graph

```
(emergency department visit (HOSO_0000032)) -[ISA]->
(healthcare organization clinical visit (HOSO_0000012)) -[is
    directed by [OBJECT_PROPERTY]]->
(healthcare service organism specification (HOSO_0000003)) -[
    inverse of denoted by [OBJECT_PROPERTY]]->
(human clinical visit specified patient (HOSO_0000137)) -[ISA]->
(Homo sapiens (NCBITaxon_9606))
```

OntoRel Graph

```
emergency department visit (HOSO_0000032) ->
healthcare organization clinical visit (HOSO_0000012) ->
(healthcare organization clinical visit is directed by healthcare
    service organism specification [HOSO_0000012_OpenLHS-
    Core_0000004_HOSO_0000003]) ->
healthcare service organism specification (HOSO_0000003) ->
(human clinical visit specified patient denoted by healthcare
    service organism specification [
    HOSO_0000137_IAO_0000235_HOSO_0000003]) ->
human clinical visit specified patient (HOSO_0000137) ->
Homo sapiens (NCBITaxon_9606)
```

5.3 SQL implementation

Each path is implemented as a separate SQL query that follows the relationships defined in the ontology.

Query 1: Emergency Department Visit to Admission Date

```sql
SELECT
    "HOSO_0000032"."HOSO_0000032_uid"
        AS "uid emergency department visit",
    "HOSO_0000012"."HOSO_0000012_uid"
        AS "uid healthcare organization clinical visit",
    "HOSO_0000011"."HOSO_0000011_uid"
        AS "uid healthcare organization service delivery",
    "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000100_uid"
        AS "uid healthcare organization service delivery identifier",
    "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000055_uid"
        AS "uid healthcare organization service delivery beginning statement",
    "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."MPHPO_0000003_uid"
        AS "uid MPHPO HOSD beginning temporal information",
    "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001".
        "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001_Ontorel"
        AS "has temporal value"
FROM
    "MPHPO"."HOSO_0000032"

    JOIN "MPHPO"."HOSO_0000012"
        ON "HOSO_0000032"."HOSO_0000032_uid" =
            "HOSO_0000012"."HOSO_0000012_uid"

```

```
24     JOIN "MPHPO"."HOSO_0000011"
25         ON "HOSO_0000012"."HOSO_0000012_uid" =
26             "HOSO_0000011"."HOSO_0000011_uid"
27
28     JOIN "MPHPO"."HOSO_0000100_IAO_0000219_HOSO_0000011"
29         ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid" =
30             "HOSO_0000011"."HOSO_0000011_uid"
31
32     JOIN "MPHPO"."HOSO_0000100"
33         ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000100_uid" =
34             "HOSO_0000100"."HOSO_0000100_uid"
35
36     JOIN "MPHPO"."HOSO_0000055_RO_0002180_HOSO_0000100"
37         ON "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000100_uid" =
38             "HOSO_0000100"."HOSO_0000100_uid"
39
40     JOIN "MPHPO"."HOSO_0000055"
41         ON "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000055_uid" =
42             "HOSO_0000055"."HOSO_0000055_uid"
43
44     JOIN "MPHPO"."MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"
45         ON "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."HOSO_0000055_uid" =
46             "HOSO_0000055"."HOSO_0000055_uid"
47
48     JOIN "MPHPO"."MPHPO_0000003"
49         ON "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."MPHPO_0000003_uid" =
50             "MPHPO_0000003"."MPHPO_0000003_uid"
51
52     JOIN "MPHPO"."MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001"
53         ON "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001"."MPHPO_0000003_uid"
           ↪   =
54             "MPHPO_0000003"."MPHPO_0000003_uid";
```

Query 2: Hospitalization to Admission Date

```
1  SELECT
2      "HOSO_0000031"."HOSO_0000031_uid"
3          AS "uid hospitalization",
4      "HOSO_0000012"."HOSO_0000012_uid"
5          AS "uid healthcare organization clinical visit",
6      "HOSO_0000011"."HOSO_0000011_uid"
7          AS "uid healthcare organization service delivery",
8      "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000100_uid"
9          AS "uid healthcare organization service delivery identifier",
10     "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000055_uid"
11         AS "uid healthcare organization service delivery beginning statement",
12     "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."MPHPO_0000003_uid"
13         AS "uid MPHPO HOSD beginning temporal information",
14     "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001".
15         "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001_Ontorel"
16         AS "has temporal value"
17 FROM
18     "MPHPO"."HOSO_0000031"
19
20     JOIN "MPHPO"."HOSO_0000012"
21         ON "HOSO_0000031"."HOSO_0000031_uid" =
22             "HOSO_0000012"."HOSO_0000012_uid"
23
24     JOIN "MPHPO"."HOSO_0000011"
25         ON "HOSO_0000012"."HOSO_0000012_uid" =
```

```
26              "HOSO_0000011"."HOSO_0000011_uid"
27
28      JOIN "MPHPO"."HOSO_0000100_IAO_0000219_HOSO_0000011"
29          ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid" =
30              "HOSO_0000011"."HOSO_0000011_uid"
31
32      JOIN "MPHPO"."HOSO_0000100"
33          ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000100_uid" =
34              "HOSO_0000100"."HOSO_0000100_uid"
35
36      JOIN "MPHPO"."HOSO_0000055_RO_0002180_HOSO_0000100"
37          ON "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000100_uid" =
38              "HOSO_0000100"."HOSO_0000100_uid"
39
40      JOIN "MPHPO"."HOSO_0000055"
41          ON "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000055_uid" =
42              "HOSO_0000055"."HOSO_0000055_uid"
43
44      JOIN "MPHPO"."MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"
45          ON "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."HOSO_0000055_uid" =
46              "HOSO_0000055"."HOSO_0000055_uid"
47
48      JOIN "MPHPO"."MPHPO_0000003"
49          ON "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."MPHPO_0000003_uid" =
50              "MPHPO_0000003"."MPHPO_0000003_uid"
51
52      JOIN "MPHPO"."MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001"
53          ON "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001"."MPHPO_0000003_uid"
            ↪   =
54              "MPHPO_0000003"."MPHPO_0000003_uid";
```

Query 3: Hospitalization to Patient

```
1   SELECT
2       "HOSO_0000031"."HOSO_0000031_uid"
3           AS "uid hospitalization",
4       "HOSO_0000012"."HOSO_0000012_uid"
5           AS "uid healthcare organization clinical visit",
6       "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000003_uid"
7           AS "uid healthcare service organism specification",
8       "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000137_uid"
9           AS "uid human clinical visit specified patient",
10      "NCBITaxon_9606"."NCBITaxon_9606_uid"
11          AS "uid Homo sapiens"
12  FROM
13      "MPHPO"."HOSO_0000031"
14
15      JOIN "MPHPO"."HOSO_0000012"
16          ON "HOSO_0000031"."HOSO_0000031_uid" =
17              "HOSO_0000012"."HOSO_0000012_uid"
18
19      JOIN "MPHPO"."HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"
20          ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000012_uid" =
21              "HOSO_0000012"."HOSO_0000012_uid"
22
23      JOIN "MPHPO"."HOSO_0000003"
24          ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000003_uid" =
25              "HOSO_0000003"."HOSO_0000003_uid"
26
27      JOIN "MPHPO"."HOSO_0000137_IAO_0000235_HOSO_0000003"
```

```
28          ON "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000003_uid" =
29              "HOSO_0000003"."HOSO_0000003_uid"
30
31      JOIN "MPHPO"."HOSO_0000137"
32          ON "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000137_uid" =
33              "HOSO_0000137"."HOSO_0000137_uid"
34
35      JOIN "MPHPO"."NCBITaxon_9606"
36          ON "HOSO_0000137"."HOSO_0000137_uid" =
37              "NCBITaxon_9606"."NCBITaxon_9606_uid";
```

Query 4: Emergency Department Visit to Patient

```
1  SELECT
2      "HOSO_0000032"."HOSO_0000032_uid"
3          AS "uid emergency department visit",
4      "HOSO_0000012"."HOSO_0000012_uid"
5          AS "uid healthcare organization clinical visit",
6      "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000003_uid"
7          AS "uid healthcare service organism specification",
8      "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000137_uid"
9          AS "uid human clinical visit specified patient",
10     "NCBITaxon_9606"."NCBITaxon_9606_uid"
11         AS "uid Homo sapiens"
12 FROM
13     "MPHPO"."HOSO_0000032"
14
15     JOIN "MPHPO"."HOSO_0000012"
16         ON "HOSO_0000032"."HOSO_0000032_uid" =
17             "HOSO_0000012"."HOSO_0000012_uid"
18
19     JOIN "MPHPO"."HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"
20         ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000012_uid" =
21             "HOSO_0000012"."HOSO_0000012_uid"
22
23     JOIN "MPHPO"."HOSO_0000003"
24         ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000003_uid" =
25             "HOSO_0000003"."HOSO_0000003_uid"
26
27     JOIN "MPHPO"."HOSO_0000137_IAO_0000235_HOSO_0000003"
28         ON "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000003_uid" =
29             "HOSO_0000003"."HOSO_0000003_uid"
30
31     JOIN "MPHPO"."HOSO_0000137"
32         ON "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000137_uid" =
33             "HOSO_0000137"."HOSO_0000137_uid"
34
35     JOIN "MPHPO"."NCBITaxon_9606"
36         ON "HOSO_0000137"."HOSO_0000137_uid" =
37             "NCBITaxon_9606"."NCBITaxon_9606_uid";
```

5.4 Calculation logic

To calculate the number of emergency department visits in the year before admission:

1. Retrieve the current hospitalization's admission date using Query 2 [5.3]

2. Retrieve the patient associated with the current hospitalization using Query 3 [5.3]

3. Using Query 4 [5.3], retrieve all emergency department visits linked to this patient

4. Using Query 1 [5.3], retrieve the admission dates for all emergency department visits

5. For each emergency department visit of the patient associated with the current hospitalization:

   - Extract the admission date from the `has temporal value` field
   - Calculate the difference between the current hospitalization date and the ED visit date
   - Count only those visits where:
     – The difference is between 0 and 365 days (inclusive)
     – The ED visit date is strictly earlier than the current hospitalization date

6. The total count of qualifying ED visits is the value of this variable (or 0 if there were no ED visits)

6 Variable 5 - Ambulance admissions

> **Variable description**
>
> This variable counts the number of admissions to the hospital by ambulance in the year before the current admission. It identifies emergency hospitalizations that required ambulance transport, providing an indicator of severe acute health events.

6.1 User request

To calculate this variable, the following user requests must be defined:

> **Path 1:** Hospitalization → Ambulance Admission
> Start entity: `HOSO_0000031` (Hospitalization)
> End entity: `HOSO_0000072` (ED by ambulance initiated hospitalization)
> **Path 2:** Hospitalization → Admission Date
> Start entity: `MPHPO_0000003` (MPHPO HOSD beginning temporal information)
> End entity: `HOSO_0000031` (Hospitalization)
> **Path 3:** Hospitalization → Patient
> Start entity: `HOSO_0000031` (Hospitalization)
> End entity: `NCBITaxon_9606` (Homo sapiens)

6.2 Ontological representation

Table 5 presents the list of ontological classes of the query.

Ontology term	Description
HOSO_0000072	ED by ambulance initiated hospitalization
HOSO_0000031	Hospitalization (current admission)
HOSO_0000012	Healthcare organization clinical visit
HOSO_0000011	Healthcare organization service delivery
MPHPO_0000003	MPHPO HOSD beginning temporal information (admission date)
NCBITaxon_9606	Homo sapiens (patient)
HOSO_0000055	Healthcare organization service delivery beginning statement
HOSO_0000100	Healthcare organization service delivery identifier

Table 5: Key ontology terms used in the ambulance admissions variable queries

6.2.1 Path 1: Hospitalization to Ambulance Admission

> **Ontology graph**
>
> ```
> (hospitalization (HOSO_0000031)) -[ISA]-> (ED by ambulance
>     initiated hospitalization (HOSO_0000072))
> ```

```
hospitalization (HOSO_0000031) -> ED by ambulance initiated
    hospitalization (HOSO_0000072)
```

6.2.2 Path 2: Admission Date to Hospitalization

```
(MPHPO HOSD beginning temporal information (MPHPO_0000003)) -[
    component of [OBJECT_PROPERTY]]->
(healthcare organization service delivery beginning statement (
    HOSO_0000055)) -[has component [OBJECT_PROPERTY]]->
(healthcare organization service delivery identifier (HOSO_0000100)
    ) -[denotes [OBJECT_PROPERTY]]->
(healthcare organization service delivery (HOSO_0000011)) -[ISA]->
(healthcare organization clinical visit (HOSO_0000012)) -[ISA]->
(hospitalization (HOSO_0000031))
```

```
MPHPO HOSD beginning temporal information (MPHPO_0000003) ->
(MPHPO HOSD beginning temporal information component of healthcare
    organization service delivery beginning statement [
    MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055]) ->
healthcare organization service delivery beginning statement (
    HOSO_0000055) ->
(healthcare organization service delivery beginning statement has
    component healthcare organization service delivery identifier [
    HOSO_0000055_RO_0002180_HOSO_0000100]) ->
healthcare organization service delivery identifier (HOSO_0000100)
    ->
(healthcare organization service delivery identifier denotes
    healthcare organization service delivery [
    HOSO_0000100_IAO_0000219_HOSO_0000011]) ->
healthcare organization service delivery (HOSO_0000011) ->
healthcare organization clinical visit (HOSO_0000012) ->
hospitalization (HOSO_0000031)
```

6.2.3 Path 3: Hospitalization to Patient

```
(hospitalization (HOSO_0000031)) -[ISA]->
(healthcare organization clinical visit (HOSO_0000012)) -[is
    directed by [OBJECT_PROPERTY]]->
(healthcare service organism specification (HOSO_0000003)) -[
    inverse of denoted by [OBJECT_PROPERTY]]->
(human clinical visit specified patient (HOSO_0000137)) -[ISA]->
(Homo sapiens (NCBITaxon_9606))
```

6.3   SQL implementation

Each path is implemented as a separate SQL query that follows the relationships defined in the ontology.

Query 1: Hospitalization to Ambulance Admission

```sql
1  SELECT
2      "HOSO_0000031"."HOSO_0000031_uid"
3          AS "uid hospitalization",
4      "HOSO_0000072"."HOSO_0000072_uid"
5          AS "uid ED by ambulance initiated hospitalization"
6  FROM
7      "MPHPO"."HOSO_0000031"
8
9      JOIN "MPHPO"."HOSO_0000072"
10         ON "HOSO_0000072"."HOSO_0000072_uid" =
11             "HOSO_0000031"."HOSO_0000031_uid";
```

Query 2: Admission Date to Hospitalization

```sql
1  SELECT
2      "MPHPO_0000003"."MPHPO_0000003_uid"
3          AS "uid MPHPO HOSD beginning temporal information",
4      "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."HOSO_0000055_uid"
5          AS "uid healthcare organization service delivery beginning statement",
6      "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000100_uid"
7          AS "uid healthcare organization service delivery identifier",
8      "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid"
9          AS "uid healthcare organization service delivery",
10     "HOSO_0000012"."HOSO_0000012_uid"
11         AS "uid healthcare organization clinical visit",
12     "HOSO_0000031"."HOSO_0000031_uid"
13         AS "uid hospitalization",
14     "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001".
15         "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001_Ontorel"
16         AS "has temporal value"
17 FROM
18     "MPHPO"."MPHPO_0000003"
19
20     JOIN "MPHPO"."MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"
21         ON "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."MPHPO_0000003_uid" =
22             "MPHPO_0000003"."MPHPO_0000003_uid"
```

```
23
24      JOIN "MPHPO"."HOSO_0000055"
25          ON "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."HOSO_0000055_uid" =
26              "HOSO_0000055"."HOSO_0000055_uid"
27
28      JOIN "MPHPO"."HOSO_0000055_RO_0002180_HOSO_0000100"
29          ON "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000055_uid" =
30              "HOSO_0000055"."HOSO_0000055_uid"
31
32      JOIN "MPHPO"."HOSO_0000100"
33          ON "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000100_uid" =
34              "HOSO_0000100"."HOSO_0000100_uid"
35
36      JOIN "MPHPO"."HOSO_0000100_IAO_0000219_HOSO_0000011"
37          ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000100_uid" =
38              "HOSO_0000100"."HOSO_0000100_uid"
39
40      JOIN "MPHPO"."HOSO_0000011"
41          ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid" =
42              "HOSO_0000011"."HOSO_0000011_uid"
43
44      JOIN "MPHPO"."HOSO_0000012"
45          ON "HOSO_0000012"."HOSO_0000012_uid" =
46              "HOSO_0000011"."HOSO_0000011_uid"
47
48      JOIN "MPHPO"."HOSO_0000031"
49          ON "HOSO_0000031"."HOSO_0000031_uid" =
50              "HOSO_0000012"."HOSO_0000012_uid"
51
52      JOIN "MPHPO"."MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001"
53          ON "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001"."MPHPO_0000003_uid"
            ↪  =
54              "MPHPO_0000003"."MPHPO_0000003_uid";
```

Query 3: Hospitalization to Patient

```
1  SELECT
2      "HOSO_0000031"."HOSO_0000031_uid"
3          AS "uid hospitalization",
4      "HOSO_0000012"."HOSO_0000012_uid"
5          AS "uid healthcare organization clinical visit",
6      "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000003_uid"
7          AS "uid healthcare service organism specification",
8      "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000137_uid"
9          AS "uid human clinical visit specified patient",
10     "NCBITaxon_9606"."NCBITaxon_9606_uid"
11         AS "uid Homo sapiens"
12 FROM
13     "MPHPO"."HOSO_0000031"
14
15     JOIN "MPHPO"."HOSO_0000012"
16         ON "HOSO_0000031"."HOSO_0000031_uid" =
17             "HOSO_0000012"."HOSO_0000012_uid"
18
19     JOIN "MPHPO"."HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"
20         ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000012_uid" =
21             "HOSO_0000012"."HOSO_0000012_uid"
22
23     JOIN "MPHPO"."HOSO_0000003"
24         ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000003_uid" =
```

```
25              "HOSO_0000003"."HOSO_0000003_uid"
26
27      JOIN "MPHPO"."HOSO_0000137_IAO_0000235_HOSO_0000003"
28          ON "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000003_uid" =
29              "HOSO_0000003"."HOSO_0000003_uid"
30
31      JOIN "MPHPO"."HOSO_0000137"
32          ON "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000137_uid" =
33              "HOSO_0000137"."HOSO_0000137_uid"
34
35      JOIN "MPHPO"."NCBITaxon_9606"
36          ON "HOSO_0000137"."HOSO_0000137_uid" =
37              "NCBITaxon_9606"."NCBITaxon_9606_uid";
```

6.4   Calculation logic

To calculate the number of ambulance admissions in the year before the current hospitalization:

1. Retrieve the current hospitalization's admission date using Query 2 [6.3]

2. Retrieve the patient associated with the current hospitalization using Query 3 [6.3]

3. Using Query 3 [6.3] and Query 1 [6.3], identify all ambulance-initiated hospitalizations for this patient

4. Using Query 2 [6.3], retrieve the admission date for the hospitalizations identified in the previous step

5. For each ambulance-initiated hospitalization identified:

   - Extract the admission date from the `has temporal value` field
   - Calculate the difference between the current hospitalization date and the ambulance admission date
   - Count only those ambulance admissions where:
     - The difference is between 0 and 365 days (inclusive)
     - The ambulance admission date is strictly earlier than the current hospitalization date
     - The hospitalization was initiated via ambulance transport (entity type `HOSO_0000072`)

6. The total count of qualifying ambulance admissions is the value of this variable (or 0 if there we no ambulance admissions)

7 Variable 6 - Weeks recently hospitalized

Variable Description

This variable calculates the number of complete weeks that the patient was hospitalized during the 90 days prior to the current admission. It measures recent hospital utilization, which may indicate higher clinical complexity or severity of illness.

7.1 User resquest

To calculate this variable, the following user requests must be defined:

Path 1: Hospitalization → End Date
Start entity: `HOSO_0000031` (Hospitalization)
End entity: `MPHPO_0000004` (MPHPO HOSD ending temporal information)
Path 2: Admission Date → Hospitalization
Start entity: `MPHPO_0000003` (MPHPO HOSD beginning temporal information)
End entity: `HOSO_0000031` (Hospitalization)
Path 3: Hospitalization → Patient
Start entity: `HOSO_0000031` (Hospitalization)
End entity: `NCBITaxon_9606` (Homo sapiens)

7.2 Ontological representation

Table 6 presents the list of ontological classes of the query.

Ontology term	Description
HOSO_0000031	Hospitalization
HOSO_0000012	Healthcare organization clinical visit
HOSO_0000011	Healthcare organization service delivery
MPHPO_0000003	MPHPO HOSD beginning temporal information (admission date)
MPHPO_0000004	MPHPO HOSD ending temporal information (discharge date)
NCBITaxon_9606	Homo sapiens (patient)
HOSO_0000055	Healthcare organization service delivery beginning statement
HOSO_0000056	Healthcare organization service delivery ending statement
HOSO_0000100	Healthcare organization service delivery identifier

Table 6: Key ontology terms used in the weeks recently hospitalized variable queries

7.2.1 Path 1: Hospitalization to End Date

Ontology graph

```
(hospitalization (HOSO_0000031)) -[ISA]->
(healthcare organization clinical visit (HOSO_0000012)) -[ISA]->
(healthcare organization service delivery (HOSO_0000011)) -[inverse
    of denotes [OBJECT_PROPERTY]]->
(healthcare organization service delivery identifier (HOSO_0000100)
    ) -[inverse of has component [OBJECT_PROPERTY]]->
(healthcare organization service delivery ending statement (
    HOSO_0000056)) -[inverse of component of [OBJECT_PROPERTY]]->
(MPHPO HOSD ending temporal information  (MPHPO_0000004))
```

OntoRel graph

```
hospitalization (HOSO_0000031) ->
healthcare organization clinical visit (HOSO_0000012) ->
healthcare organization service delivery (HOSO_0000011) ->
(healthcare organization service delivery identifier denotes
    healthcare organization service delivery [
    HOSO_0000100_IAO_0000219_HOSO_0000011]) ->
healthcare organization service delivery identifier (HOSO_0000100)
    ->
(healthcare organization service delivery ending statement has
    component healthcare organization service delivery identifier [
    HOSO_0000056_RO_0002180_HOSO_0000100]) ->
healthcare organization service delivery ending statement (
    HOSO_0000056) ->
(MPHPO HOSD ending temporal information component of healthcare
    organization service delivery ending statement [
    MPHPO_0000004_OpenLHS-Core_0000070_HOSO_0000056]) ->
MPHPO HOSD ending temporal information (MPHPO_0000004)
```

7.2.2 Path 2: Admission Date to Hospitalization

Ontology graph

```
(MPHPO HOSD beginning temporal information (MPHPO_0000003)) -[
    component of [OBJECT_PROPERTY]]->
(healthcare organization service delivery beginning statement (
    HOSO_0000055)) -[has component [OBJECT_PROPERTY]]->
(healthcare organization service delivery identifier (HOSO_0000100)
    ) -[denotes [OBJECT_PROPERTY]]->
(healthcare organization service delivery (HOSO_0000011)) -[ISA]->
(healthcare organization clinical visit (HOSO_0000012)) -[ISA]->
(hospitalization (HOSO_0000031))
```

```
MPHPO HOSD beginning temporal information (MPHPO_0000003) ->
(MPHPO HOSD beginning temporal information component of healthcare
    organization service delivery beginning statement [
    MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055]) ->
healthcare organization service delivery beginning statement (
    HOSO_0000055) ->
(healthcare organization service delivery beginning statement has
    component healthcare organization service delivery identifier [
    HOSO_0000055_RO_0002180_HOSO_0000100]) ->
healthcare organization service delivery identifier (HOSO_0000100)
    ->
(healthcare organization service delivery identifier denotes
    healthcare organization service delivery [
    HOSO_0000100_IAO_0000219_HOSO_0000011]) ->
healthcare organization service delivery (HOSO_0000011) ->
healthcare organization clinical visit (HOSO_0000012) ->
hospitalization (HOSO_0000031)
```

7.2.3 Path 3: Current Hospitalization to Patient

Ontology graph

```
(hospitalization (HOSO_0000031)) -[ISA]->
(healthcare organization clinical visit (HOSO_0000012)) -[is
    directed by [OBJECT_PROPERTY]]->
(healthcare service organism specification (HOSO_0000003)) -[
    inverse of denoted by [OBJECT_PROPERTY]]->
(human clinical visit specified patient (HOSO_0000137)) -[ISA]->
(Homo sapiens (NCBITaxon_9606))
```

OntoRel graph

```
hospitalization (HOSO_0000031) ->
healthcare organization clinical visit (HOSO_0000012) ->
(healthcare organization clinical visit is directed by healthcare
    service organism specification [HOSO_0000012_OpenLHS-
    Core_0000004_HOSO_0000003]) ->
healthcare service organism specification (HOSO_0000003) ->
(human clinical visit specified patient denoted by healthcare
    service organism specification [
    HOSO_0000137_IAO_0000235_HOSO_0000003]) ->
human clinical visit specified patient (HOSO_0000137) ->
Homo sapiens (NCBITaxon_9606)
```

7.3 SQL implementation

Each path is implemented as a separate SQL query that follows the relationships defined in the ontology.

Query 1: Hospitalization to End Date

```sql
1  SELECT
2      "HOSO_0000031"."HOSO_0000031_uid"
3          AS "uid hospitalization",
4      "HOSO_0000012"."HOSO_0000012_uid"
5          AS "uid healthcare organization clinical visit",
6      "HOSO_0000011"."HOSO_0000011_uid"
7          AS "uid healthcare organization service delivery",
8      "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000100_uid"
9          AS "uid healthcare organization service delivery identifier",
10     "HOSO_0000056_RO_0002180_HOSO_0000100"."HOSO_0000056_uid"
11         AS "uid healthcare organization service delivery ending statement",
12     "MPHPO_0000004_OpenLHS-Core_0000070_HOSO_0000056"."MPHPO_0000004_uid"
13         AS "uid MPHPO HOSD ending temporal information",
14     "MPHPO_0000004_Ontorel-Core_0000004_Ontorel-Core_0000001".
15         "MPHPO_0000004_Ontorel-Core_0000004_Ontorel-Core_0000001_Ontorel"
16         AS "has temporal value"
17 FROM
18     "MPHPO"."HOSO_0000031"
19
20     JOIN "MPHPO"."HOSO_0000012"
21         ON "HOSO_0000031"."HOSO_0000031_uid" =
22             "HOSO_0000012"."HOSO_0000012_uid"
23
24     JOIN "MPHPO"."HOSO_0000011"
25         ON "HOSO_0000012"."HOSO_0000012_uid" =
26             "HOSO_0000011"."HOSO_0000011_uid"
27
28     JOIN "MPHPO"."HOSO_0000100_IAO_0000219_HOSO_0000011"
29         ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid" =
30             "HOSO_0000011"."HOSO_0000011_uid"
31
32     JOIN "MPHPO"."HOSO_0000100"
33         ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000100_uid" =
34             "HOSO_0000100"."HOSO_0000100_uid"
35
36     JOIN "MPHPO"."HOSO_0000056_RO_0002180_HOSO_0000100"
37         ON "HOSO_0000056_RO_0002180_HOSO_0000100"."HOSO_0000100_uid" =
38             "HOSO_0000100"."HOSO_0000100_uid"
39
40     JOIN "MPHPO"."HOSO_0000056"
41         ON "HOSO_0000056_RO_0002180_HOSO_0000100"."HOSO_0000056_uid" =
42             "HOSO_0000056"."HOSO_0000056_uid"
43
44     JOIN "MPHPO"."MPHPO_0000004_OpenLHS-Core_0000070_HOSO_0000056"
45         ON "MPHPO_0000004_OpenLHS-Core_0000070_HOSO_0000056"."HOSO_0000056_uid" =
46             "HOSO_0000056"."HOSO_0000056_uid"
47
48     JOIN "MPHPO"."MPHPO_0000004"
49         ON "MPHPO_0000004_OpenLHS-Core_0000070_HOSO_0000056"."MPHPO_0000004_uid" =
50             "MPHPO_0000004"."MPHPO_0000004_uid"
51
52     JOIN "MPHPO"."MPHPO_0000004_Ontorel-Core_0000004_Ontorel-Core_0000001"
53         ON "MPHPO_0000004_Ontorel-Core_0000004_Ontorel-Core_0000001"."MPHPO_0000004_uid"
                ↪  =
54             "MPHPO_0000004"."MPHPO_0000004_uid";
```

Query 2: Admission Date to Hospitalization

```sql
 1  SELECT
 2      "MPHPO_0000003"."MPHPO_0000003_uid"
 3          AS "uid MPHPO HOSD beginning temporal information",
 4      "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."HOSO_0000055_uid"
 5          AS "uid healthcare organization service delivery beginning statement",
 6      "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000100_uid"
 7          AS "uid healthcare organization service delivery identifier",
 8      "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid"
 9          AS "uid healthcare organization service delivery",
10      "HOSO_0000012"."HOSO_0000012_uid"
11          AS "uid healthcare organization clinical visit",
12      "HOSO_0000031"."HOSO_0000031_uid"
13          AS "uid hospitalization",
14      "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001".
15          "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001_Ontorel"
16          AS "has temporal value"
17  FROM
18      "MPHPO"."MPHPO_0000003"
19
20      JOIN "MPHPO"."MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"
21          ON "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."MPHPO_0000003_uid" =
22              "MPHPO_0000003"."MPHPO_0000003_uid"
23
24      JOIN "MPHPO"."HOSO_0000055"
25          ON "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."HOSO_0000055_uid" =
26              "HOSO_0000055"."HOSO_0000055_uid"
27
28      JOIN "MPHPO"."HOSO_0000055_RO_0002180_HOSO_0000100"
29          ON "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000055_uid" =
30              "HOSO_0000055"."HOSO_0000055_uid"
31
32      JOIN "MPHPO"."HOSO_0000100"
33          ON "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000100_uid" =
34              "HOSO_0000100"."HOSO_0000100_uid"
35
36      JOIN "MPHPO"."HOSO_0000100_IAO_0000219_HOSO_0000011"
37          ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000100_uid" =
38              "HOSO_0000100"."HOSO_0000100_uid"
39
40      JOIN "MPHPO"."HOSO_0000011"
41          ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid" =
42              "HOSO_0000011"."HOSO_0000011_uid"
43
44      JOIN "MPHPO"."HOSO_0000012"
45          ON "HOSO_0000012"."HOSO_0000012_uid" =
46              "HOSO_0000011"."HOSO_0000011_uid"
47
48      JOIN "MPHPO"."HOSO_0000031"
49          ON "HOSO_0000031"."HOSO_0000031_uid" =
50              "HOSO_0000012"."HOSO_0000012_uid"
51
52      JOIN "MPHPO"."MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001"
53          ON "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001"."MPHPO_0000003_uid"
            ↪  =
54              "MPHPO_0000003"."MPHPO_0000003_uid";
```

Query 3: Hospitalization to Patient

```sql
 1 SELECT
 2     "HOSO_0000031"."HOSO_0000031_uid"
 3         AS "uid hospitalization",
 4     "HOSO_0000012"."HOSO_0000012_uid"
 5         AS "uid healthcare organization clinical visit",
 6     "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000003_uid"
 7         AS "uid healthcare service organism specification",
 8     "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000137_uid"
 9         AS "uid human clinical visit specified patient",
10     "NCBITaxon_9606"."NCBITaxon_9606_uid"
11         AS "uid Homo sapiens"
12 FROM
13     "MPHPO"."HOSO_0000031"
14
15     JOIN "MPHPO"."HOSO_0000012"
16         ON "HOSO_0000031"."HOSO_0000031_uid" =
17             "HOSO_0000012"."HOSO_0000012_uid"
18
19     JOIN "MPHPO"."HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"
20         ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000012_uid" =
21             "HOSO_0000012"."HOSO_0000012_uid"
22
23     JOIN "MPHPO"."HOSO_0000003"
24         ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000003_uid" =
25             "HOSO_0000003"."HOSO_0000003_uid"
26
27     JOIN "MPHPO"."HOSO_0000137_IAO_0000235_HOSO_0000003"
28         ON "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000003_uid" =
29             "HOSO_0000003"."HOSO_0000003_uid"
30
31     JOIN "MPHPO"."HOSO_0000137"
32         ON "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000137_uid" =
33             "HOSO_0000137"."HOSO_0000137_uid"
34
35     JOIN "MPHPO"."NCBITaxon_9606"
36         ON "HOSO_0000137"."HOSO_0000137_uid" =
37             "NCBITaxon_9606"."NCBITaxon_9606_uid";
```

7.4   Calculation logic

To calculate the number of full weeks the patient was hospitalized in the 90 days before the current admission:

1. Retrieve the current hospitalization's admission date using Query 2 [7.3]

2. Retrieve the patient associated with the current hospitalization using Query 3

3. Using Query 3 [7.3], retrieve all hospitalizations for this patient with their start date (Query 2 [7.3]) and end date (Query 1 [7.3])

4. For each hospitalization:

   - Calculate the start date by extracting the admission date from the related `MPHPO_0000003` entity

   - Calculate the end date from the `has temporal value` field of Query 1 [7.3]

   - Filter hospitalizations to include only those where:
     - The end date is within 90 days before the current admission
     - The hospitalization is not the current one

   - For each qualifying hospitalization, calculate the duration in days

   - If a hospitalization started before the 90-day window but ended within it, count only the days that fall within the 90-day window

5. Sum all hospitalization days within the 90-day window

6. Divide the total days by 7 and truncate to get the number of full weeks

8 Variable 7 - Admission type

Variable description

This variable categorizes the urgency level of the hospital admission. It classifies admissions into four categories: urgent, semi-urgent, elective, or obstetric. This classification reflects the acuity and planning level of the hospitalization.

8.1 User request

To calculate this variable, the following user request must be defined:

Path: Admission Urgency Level → Hospitalization
Start entity: `MPHPO_0000007` (MPHPO hospitalization admission urgency level specification)
End entity: `HOSO_0000031` (Hospitalization)

8.2 Ontological representation

Table 7 presents the list of ontological classes of the query.

Ontology term	Description
MPHPO_0000007	MPHPO hospitalization admission urgency level specification
HOSO_0000074	Clinical visit agreement specification
HOSO_0000012	Healthcare organization clinical visit
HOSO_0000031	Hospitalization

Table 7: Key ontology terms used in the admission type variable query

Ontology graph

```
(MPHPO hospitalization admission urgency level specification (
    MPHPO_0000007)) -[ISA]->
(clinical visit agreement specification (HOSO_0000074)) -[inverse
    of is directed by [OBJECT_PROPERTY]]->
(healthcare organization clinical visit (HOSO_0000012)) -[ISA]->
(hospitalization (HOSO_0000031))
```

OntoRel graph

```
MPHPO hospitalization admission urgency level specification (
    MPHPO_0000007) ->
clinical visit agreement specification (HOSO_0000074) ->
(healthcare organization clinical visit is directed by clinical
    visit agreement specification [HOSO_0000012_OpenLHS-
    Core_0000004_HOSO_0000074]) ->
healthcare organization clinical visit (HOSO_0000012) ->
hospitalization (HOSO_0000031)
```

8.3   SQL implementation

The following SQL query retrieves the admission type information:

Query: Admission Urgency Level to Hospitalization

```sql
SELECT
    "MPHPO_0000007"."MPHPO_0000007_uid"
        AS "uid MPHPO hospitalization admission urgency level specification",
    "HOSO_0000074"."HOSO_0000074_uid"
        AS "uid clinical visit agreement specification",
    "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000074"."HOSO_0000012_uid"
        AS "uid healthcare organization clinical visit",
    "HOSO_0000031"."HOSO_0000031_uid"
        AS "uid hospitalization",
    "MPHPO_0000007_Ontorel-Core_0000002_string".
        "MPHPO_0000007_Ontorel-Core_0000002_string_Ontorel-Core_0000002"
        AS "has textual value"
FROM
    "MPHPO"."MPHPO_0000007"

    JOIN "MPHPO"."HOSO_0000074"
        ON "MPHPO_0000007"."MPHPO_0000007_uid" =
            "HOSO_0000074"."HOSO_0000074_uid"

    JOIN "MPHPO"."HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000074"
        ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000074"."HOSO_0000074_uid" =
            "HOSO_0000074"."HOSO_0000074_uid"

    JOIN "MPHPO"."HOSO_0000012"
        ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000074"."HOSO_0000012_uid" =
            "HOSO_0000012"."HOSO_0000012_uid"

    JOIN "MPHPO"."HOSO_0000031"
        ON "HOSO_0000031"."HOSO_0000031_uid" =
            "HOSO_0000012"."HOSO_0000012_uid"

    JOIN "MPHPO"."MPHPO_0000007_Ontorel-Core_0000002_string"
        ON "MPHPO_0000007_Ontorel-Core_0000002_string"."MPHPO_0000007_uid" =
            "MPHPO_0000007"."MPHPO_0000007_uid";
```

8.4   Calculation logic

The admission type information is classified into four categories:

1. The query [8.3] retrieves the admission urgency level specification associated with a hospitalization

2. The classification is stored in the `has textual value` field of the `MPHPO_0000007_Ontorel-Core_0000002_string` table

3. The possible values are:

   - **Urgent**
   - **Semi-urgent**
   - **Elective**
   - **Obstetric**

4. These classifications help prioritize hospital resources and can also serve as indicators of patient acuity and potential outcomes

9 Variable 8 - Admission service

Variable description

This variable identifies the clinical specialty of the admitting physician, such as internal medicine, cardiology, surgery, or pediatrics. It provides information about the type of medical care that was deemed most appropriate for the patient at the time of admission based on their primary health concern.

9.1 User request

To calculate this variable, the following user request must be defined:

Path : Hospitalization → Physician service
Start entity: `HOSO_0000031` (Hospitalization)
End entity: `MPHPO_0000006` (MPHPO healthcare physician service identifier)

9.2 Ontological representation

Table 8 presents the list of ontological classes of the query.

Ontology term	Description
MPHPO_0000006	MPHPO healthcare physician service identifier
HOSO_0000084	Healthcare physician service identifier
HOSO_0000079	Healthcare physician service
HOSO_0000008	Healthcare organization
HOSO_0000009	Healthcare provider
HOSO_0000138	Healthcare provider identifier
HOSO_0000078	Hospitalization admitting physician specification
HOSO_0000074	Clinical visit agreement specification
HOSO_0000012	Healthcare organization clinical visit
HOSO_0000031	Hospitalization
NCBITaxon_9606	Homo sapiens (patient)

Table 8: Key ontology terms used in the admission service variable queries

9.2.1   Path : Physician Service to Hospitalization

Ontology graph

```
1. (MPHPO healthcare physician service identifier (MPHPO_0000006))
   -[ISA]->
   (healthcare physician service identifier (HOSO_0000084)) -[
      denotes [OBJECT_PROPERTY]]->
   (healthcare physician service (HOSO_0000079)) -[ISA]->
   (healthcare organization (HOSO_0000008)) -[inverse of member of
      [OBJECT_PROPERTY]]->
   (healthcare provider (HOSO_0000009)) -[inverse of denotes [
      OBJECT_PROPERTY]]->
   (healthcare provider identifier (HOSO_0000138)) -[inverse of has
       part [OBJECT_PROPERTY]]->
   (hospitalization admitting physician specification (HOSO_0000078
      )) -[ISA]->
   (clinical visit agreement specification (HOSO_0000074)) -[
      inverse of is directed by [OBJECT_PROPERTY]]->
   (healthcare organization clinical visit (HOSO_0000012)) -[ISA]->
   (hospitalization (HOSO_0000031))

2. (MPHPO healthcare physician service identifier (MPHPO_0000006))
   -[ISA]->
   (healthcare physician service identifier (HOSO_0000084)) -[
      denotes [OBJECT_PROPERTY]]->
   (healthcare organization (HOSO_0000008)) -[inverse of member of
      [OBJECT_PROPERTY]]->
   (healthcare provider (HOSO_0000009)) -[inverse of denotes [
      OBJECT_PROPERTY]]->
   (healthcare provider identifier (HOSO_0000138)) -[inverse of has
       part [OBJECT_PROPERTY]]->
   (hospitalization admitting physician specification (HOSO_0000078
      )) -[ISA]->
   (clinical visit agreement specification (HOSO_0000074)) -[
      inverse of is directed by [OBJECT_PROPERTY]]->
   (healthcare organization clinical visit (HOSO_0000012)) -[ISA]->
   (hospitalization (HOSO_0000031))
```

```
1. MPHPO healthcare physician service identifier (MPHPO_0000006) ->
   healthcare physician service identifier (HOSO_0000084) ->
   (healthcare physician service identifier denotes healthcare
       physician service [HOSO_0000084_IAO_0000219_HOSO_0000079]) ->
   healthcare physician service (HOSO_0000079) ->
   healthcare organization (HOSO_0000008) ->
   (healthcare provider member of healthcare organization [
       HOSO_0000009_RO_0002350_HOSO_0000008]) ->
   healthcare provider (HOSO_0000009) ->
   (healthcare provider identifier denotes healthcare provider [
       HOSO_0000138_IAO_0000219_HOSO_0000009]) ->
   healthcare provider identifier (HOSO_0000138) ->
   (hospitalization admitting physician specification has part
       healthcare provider identifier [
       HOSO_0000078_BFO_0000051_HOSO_0000138]) ->
   hospitalization admitting physician specification (HOSO_0000078)
       ->
   clinical visit agreement specification (HOSO_0000074) ->
   (healthcare organization clinical visit is directed by clinical
       visit agreement specification [HOSO_0000012_OpenLHS-
       Core_0000004_HOSO_0000074]) ->
   healthcare organization clinical visit (HOSO_0000012) ->
   hospitalization (HOSO_0000031)

2. MPHPO healthcare physician service identifier(MPHPO_0000006) ->
   healthcare physician service identifier (HOSO_0000084) ->
   (healthcare physician service identifier denotes healthcare
       physician service [HOSO_0000084_IAO_0000219_HOSO_0000079]) ->
   healthcare physician service (HOSO_0000079) ->
   (healthcare physician service member of healthcare organization
       [HOSO_0000079_RO_0002350_HOSO_0000008]) ->
   healthcare organization (HOSO_0000008) ->
   (healthcare provider member of healthcare organization [
       HOSO_0000009_RO_0002350_HOSO_0000008]) ->
   healthcare provider (HOSO_0000009) ->
   (healthcare provider identifier denotes healthcare provider [
       HOSO_0000138_IAO_0000219_HOSO_0000009]) ->
   healthcare provider identifier (HOSO_0000138) ->
   (hospitalization admitting physician specification has part
       healthcare provider identifier [
       HOSO_0000078_BFO_0000051_HOSO_0000138]) ->
   hospitalization admitting physician specification (HOSO_0000078)
       ->
   clinical visit agreement specification (HOSO_0000074) ->
   (healthcare organization clinical visit is directed by clinical
       visit agreement specification [HOSO_0000012_OpenLHS-
       Core_0000004_HOSO_0000074]) ->
   healthcare organization clinical visit (HOSO_0000012) ->
   hospitalization (HOSO_0000031)
```

9.3   SQL implementation

Each path is implemented as a separate SQL query that follows the relationships defined in the ontology.

```sql
SELECT
    "MPHPO_0000006"."MPHPO_0000006_uid"
        AS "uid MPHPO healthcare physician service identifier",
    "HOSO_0000084"."HOSO_0000084_uid"
        AS "uid healthcare physician service identifier",
    "HOSO_0000084_IAO_0000219_HOSO_0000079"."HOSO_0000079_uid"
        AS "uid healthcare physician service",
    "HOSO_0000008"."HOSO_0000008_uid"
        AS "uid healthcare organization",
    "HOSO_0000009_RO_0002350_HOSO_0000008"."HOSO_0000009_uid"
        AS "uid healthcare provider",
    "HOSO_0000138_IAO_0000219_HOSO_0000009"."HOSO_0000138_uid"
        AS "uid healthcare provider identifier",
    "HOSO_0000078_BFO_0000051_HOSO_0000138"."HOSO_0000078_uid"
        AS "uid hospitalization admitting physician specification",
    "HOSO_0000074"."HOSO_0000074_uid"
        AS "uid clinical visit agreement specification",
    "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000074"."HOSO_0000012_uid"
        AS "uid healthcare organization clinical visit",
    "HOSO_0000031"."HOSO_0000031_uid"
        AS "uid hospitalization",
    "MPHPO_0000006_Ontorel-Core_0000002_string".
        "MPHPO_0000006_Ontorel-Core_0000002_string_Ontorel-Core_0000002"
        AS "has textual value"
FROM
    "MPHPO"."MPHPO_0000006"

    JOIN "MPHPO"."HOSO_0000084"
        ON "MPHPO_0000006"."MPHPO_0000006_uid" =
            "HOSO_0000084"."HOSO_0000084_uid"

    JOIN "MPHPO"."MPHPO_0000006_Ontorel-Core_0000002_string"
        ON "MPHPO_0000006_Ontorel-Core_0000002_string"."MPHPO_0000006_uid" =
            "MPHPO_0000006"."MPHPO_0000006_uid"

    JOIN "MPHPO"."HOSO_0000084_IAO_0000219_HOSO_0000079"
        ON "HOSO_0000084_IAO_0000219_HOSO_0000079"."HOSO_0000084_uid" =
            "HOSO_0000084"."HOSO_0000084_uid"

    JOIN "MPHPO"."HOSO_0000079"
        ON "HOSO_0000084_IAO_0000219_HOSO_0000079"."HOSO_0000079_uid" =
            "HOSO_0000079"."HOSO_0000079_uid"

    JOIN "MPHPO"."HOSO_0000008"
        ON "HOSO_0000079"."HOSO_0000079_uid" =
            "HOSO_0000008"."HOSO_0000008_uid"

    JOIN "MPHPO"."HOSO_0000009_RO_0002350_HOSO_0000008"
        ON "HOSO_0000009_RO_0002350_HOSO_0000008"."HOSO_0000008_uid" =
            "HOSO_0000008"."HOSO_0000008_uid"

    JOIN "MPHPO"."HOSO_0000009"
        ON "HOSO_0000009_RO_0002350_HOSO_0000008"."HOSO_0000009_uid" =
            "HOSO_0000009"."HOSO_0000009_uid"

    JOIN "MPHPO"."HOSO_0000138_IAO_0000219_HOSO_0000009"
        ON "HOSO_0000138_IAO_0000219_HOSO_0000009"."HOSO_0000009_uid" =
            "HOSO_0000009"."HOSO_0000009_uid"

    JOIN "MPHPO"."HOSO_0000138"
```

```
61        ON "HOSO_0000138_IAO_0000219_HOSO_0000009"."HOSO_0000138_uid" =
62            "HOSO_0000138"."HOSO_0000138_uid"
63
64    JOIN "MPHPO"."HOSO_0000078_BFO_0000051_HOSO_0000138"
65        ON "HOSO_0000078_BFO_0000051_HOSO_0000138"."HOSO_0000138_uid" =
66            "HOSO_0000138"."HOSO_0000138_uid"
67
68    JOIN "MPHPO"."HOSO_0000078"
69        ON "HOSO_0000078_BFO_0000051_HOSO_0000138"."HOSO_0000078_uid" =
70            "HOSO_0000078"."HOSO_0000078_uid"
71
72    JOIN "MPHPO"."HOSO_0000074"
73        ON "HOSO_0000078"."HOSO_0000078_uid" =
74            "HOSO_0000074"."HOSO_0000074_uid"
75
76    JOIN "MPHPO"."HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000074"
77        ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000074"."HOSO_0000074_uid" =
78            "HOSO_0000074"."HOSO_0000074_uid"
79
80    JOIN "MPHPO"."HOSO_0000012"
81        ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000074"."HOSO_0000012_uid" =
82            "HOSO_0000012"."HOSO_0000012_uid"
83
84    JOIN "MPHPO"."HOSO_0000031"
85        ON "HOSO_0000031"."HOSO_0000031_uid" =
86            "HOSO_0000012"."HOSO_0000012_uid";
```

9.4   Calculation logic

The admission service information is retrieved and interpreted as follows:

1. The query retrieves [9.3] the physician's specialty service associated with a hospitalization

2. The key information is stored in the `has textual value` field of the `MPHPO_0000006_Ontorel-Core_0000002_string` table

3. This field contains a string value representing the medical specialty of the admitting physician. The list of specialities depends on the specific hospital's structure, but it may include for example:

   - **Internal medicine** - General adult care for non-surgical conditions
   - **Cardiology** - Heart and cardiovascular system
   - **Neurology** - Brain, spinal cord, and nervous system
   - **Surgery** - General surgical treatment
   - **Orthopedics** - Musculoskeletal system
   - **Gynecology** - Women's reproductive health
   - **Obstetrics** - Pregnancy, childbirth and the postpartum period
   - **Oncology** - Cancer diagnosis and treatment

4. This information helps to analyze patterns of hospital utilization across different medical specialties and can be used for resource allocation and quality improvement initiatives

10 Variable 9 - Flu season

Variable description

This variable identifies whether the current hospital admission occurred during flu season, defined as the months of December, January, or February. This binary indicator helps assess the potential impact of seasonal influenza on hospitalization patterns and resource utilization.

10.1 User request

To calculate this variable, the following user request must be defined:

Path : Hospitalization → Admission Date
Start entity: `HOSO_0000031` (Hospitalization)
End entity: `MPHPO_0000003` (MPHPO HOSD beginning temporal information)

10.2 Ontological representation

Table 9 presents the list of ontological classes of the query.

Ontology term	Description
MPHPO_0000003	MPHPO HOSD beginning temporal information (admission date)
HOSO_0000055	Healthcare organization service delivery beginning statement
HOSO_0000100	Healthcare organization service delivery identifier
HOSO_0000011	Healthcare organization service delivery
HOSO_0000012	Healthcare organization clinical visit
HOSO_0000031	Hospitalization
NCBITaxon_9606	Homo sapiens (patient)

Table 9: Key ontology terms used in the flu season variable queries

10.2.1 Path : Hospitalization to Admission Date

Ontology graph

```
(MPHPO HOSD beginning temporal information (MPHPO_0000003)) -[
    component of [OBJECT_PROPERTY]]->
(healthcare organization service delivery beginning statement (
    HOSO_0000055)) -[has component [OBJECT_PROPERTY]]->
(healthcare organization service delivery identifier (HOSO_0000100)
    ) -[denotes [OBJECT_PROPERTY]]->
(healthcare organization service delivery (HOSO_0000011)) -[ISA]->
(healthcare organization clinical visit (HOSO_0000012)) -[ISA]->
(hospitalization (HOSO_0000031))
```

```
MPHPO HOSD beginning temporal information (MPHPO_0000003) ->
(MPHPO HOSD beginning temporal information component of healthcare
    organization service delivery beginning statement [
    MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055]) ->
healthcare organization service delivery beginning statement (
    HOSO_0000055) ->
(healthcare organization service delivery beginning statement has
    component healthcare organization service delivery identifier [
    HOSO_0000055_RO_0002180_HOSO_0000100]) ->
healthcare organization service delivery identifier (HOSO_0000100)
    ->
(healthcare organization service delivery identifier denotes
    healthcare organization service delivery [
    HOSO_0000100_IAO_0000219_HOSO_0000011]) ->
healthcare organization service delivery (HOSO_0000011) ->
healthcare organization clinical visit (HOSO_0000012) ->
hospitalization (HOSO_0000031)
```

10.3 SQL implementation

Each path is implemented as a separate SQL query that follows the relationships defined in the ontology.

Query : Hospitalization to Admission Date

```sql
1  SELECT
2      "MPHPO_0000003"."MPHPO_0000003_uid"
3          AS "uid MPHPO HOSD beginning temporal information",
4      "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."HOSO_0000055_uid"
5          AS "uid healthcare organization service delivery beginning statement",
6      "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000100_uid"
7          AS "uid healthcare organization service delivery identifier",
8      "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid"
9          AS "uid healthcare organization service delivery",
10     "HOSO_0000012"."HOSO_0000012_uid"
11         AS "uid healthcare organization clinical visit",
12     "HOSO_0000031"."HOSO_0000031_uid"
13         AS "uid hospitalization",
14     "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001".
15         "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001_Ontorel"
16         AS "has temporal value"
17 FROM
18     "MPHPO"."MPHPO_0000003"
19
20     JOIN "MPHPO"."MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"
21         ON "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."MPHPO_0000003_uid" =
22           "MPHPO_0000003"."MPHPO_0000003_uid"
23
24     JOIN "MPHPO"."HOSO_0000055"
25         ON "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."HOSO_0000055_uid" =
26           "HOSO_0000055"."HOSO_0000055_uid"
27
28     JOIN "MPHPO"."HOSO_0000055_RO_0002180_HOSO_0000100"
29         ON "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000055_uid" =
30           "HOSO_0000055"."HOSO_0000055_uid"
31
```

```
32      JOIN "MPHPO"."HOSO_0000100"
33          ON "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000100_uid" =
34              "HOSO_0000100"."HOSO_0000100_uid"
35
36      JOIN "MPHPO"."HOSO_0000100_IAO_0000219_HOSO_0000011"
37          ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000100_uid" =
38              "HOSO_0000100"."HOSO_0000100_uid"
39
40      JOIN "MPHPO"."HOSO_0000011"
41          ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid" =
42              "HOSO_0000011"."HOSO_0000011_uid"
43
44      JOIN "MPHPO"."HOSO_0000012"
45          ON "HOSO_0000012"."HOSO_0000012_uid" =
46              "HOSO_0000011"."HOSO_0000011_uid"
47
48      JOIN "MPHPO"."HOSO_0000031"
49          ON "HOSO_0000031"."HOSO_0000031_uid" =
50              "HOSO_0000012"."HOSO_0000012_uid"
51
52      JOIN "MPHPO"."MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001"
53          ON "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001"."MPHPO_0000003_uid"
        ↪   =
54              "MPHPO_0000003"."MPHPO_0000003_uid";
```

10.4   Calculation logic

To determine if the admission occurred during flu season:

1. Retrieve the admission date using Query [10.3] :

   - Extract the date from the `has temporal value` field
   - Parse the date to identify the month component

2. Apply the flu season criteria:

   - If the month is December (12), January (1), or February (2), set the variable to TRUE
   - Otherwise, set the variable to FALSE

3. This binary indicator can be used in predictive models to account for seasonal patterns in hospital admissions, particularly those related to respiratory infections

11 Variable 10 - ICU admission

> **Variable Description**
>
> This variable indicates whether the current admission is a direct admission to the Intensive Care Unit (ICU). Direct ICU admissions typically represent higher acuity cases where patients require immediate critical care intervention, in contrast to patients who are initially admitted to a regular ward and later transferred to the ICU if their condition deteriorates.

11.1 User request

To calculate this variable, the following user request must be defined:

> **Path:** ICU Hospitalization → Regular Hospitalization
> Start entity: `HOSO_0000085` (Hospitalization starting with ICU stay)
> End entity: `HOSO_0000031` (Hospitalization)

11.2 Ontological Representation

Table 10 presents the list of ontological classes of the query.

Ontology term	Description
HOSO_0000085	Hospitalization starting with ICU stay
HOSO_0000031	Hospitalization

Table 10: Key ontology terms used in the ICU admission variable queries

11.2.1 Path: ICU Hospitalization to Regular Hospitalization

> **Ontology Graph**
>
> ```
> (hospitalization starting with ICU stay (HOSO_0000085)) -[ISA]-> (
>     hospitalization (HOSO_0000031))
> ```

> **OntoRel Graph**
>
> ```
> hospitalization starting with ICU stay (HOSO_0000085) ->
>     hospitalization (HOSO_0000031)
> ```

11.3 SQL Implementation

The path is implemented as an SQL query that follows the relationships defined in the ontology.

> **Query: ICU Hospitalization to Regular Hospitalization**
>
> ```
> 1 SELECT
> 2     "HOSO_0000085"."HOSO_0000085_uid"
> 3         AS "uid hospitalization starting with ICU stay",
> ```

```
4      "HOSO_0000031"."HOSO_0000031_uid"
5          AS "uid hospitalization"
6  FROM
7      "MPHPO"."HOSO_0000085"
8
9    JOIN "MPHPO"."HOSO_0000031"
10         ON "HOSO_0000085"."HOSO_0000085_uid" =
11             "HOSO_0000031"."HOSO_0000031_uid";
```

11.4   Calculation logic

To determine if the current admission is a direct admission to the ICU:

1. Execute the query [11.3] to retrieve:

   - All hospitalization instances that are also classified as ICU hospitalizations

2. For the current hospitalization:

   - Check if its UID is present in the results of the query
   - If present, set the variable to TRUE (direct admission to ICU)
   - If not present, set the variable to FALSE (non-ICU admission)

3. The determination is based on the ontological classification of the hospitalization:

   - A hospitalization entity that is also classified as `HOSO_0000085` (hospitalization starting with ICU stay) represents a direct ICU admission
   - A hospitalization entity that is only classified as `HOSO_0000031` (hospitalization) without being classified as `HOSO_0000085` represents a non-ICU admission

4. The variable is set to TRUE if:

   - The current hospitalization's UID appears in the `HOSO_0000085` table, indicating it is an instance of "hospitalization starting with ICU stay"

5. Otherwise, the variable is set to FALSE

12 Variable 11 - Urgent 30-d readmission

> **Variable description**
>
> This variable identifies whether the current admission is an urgent readmission occurring within 30 days of a previous hospital discharge. This is an important quality and efficiency metric in healthcare systems, as it may indicate premature discharge, inadequate post-discharge follow-up, or complications of care from the previous hospitalization.

12.1 User request

To calculate this variable, the following user requests must be defined:

> **Path 1:** Hospitalization → Discharge Date
> Start entity: `HOSO_0000031` (Hospitalization)
> End entity: `MPHPO_0000004` (MPHPO HOSD ending temporal information)
> **Path 2:** Hospitalization → Admission Date
> Start entity: `HOSO_0000031` (Hospitalization)
> End entity: `MPHPO_0000003` (MPHPO HOSD beginning temporal information)
> **Path 3:** Hospitalization → Patient
> Start entity: `HOSO_0000031` (Hospitalization)
> End entity: `NCBITaxon_9606` (Homo sapiens)
> **Path 4:** Hospitalization → Admission Urgency Level
> Start entity: `HOSO_0000031` (Hospitalization)
> End entity: `MPHPO_0000007` (MPHPO hospitalization admission urgency level specification)

12.2 Ontological representation

Table 11 presents the list of ontological classes of the query.

Ontology term	Description
HOSO_0000031	Hospitalization
MPHPO_0000003	MPHPO HOSD beginning temporal information (admission date)
MPHPO_0000004	MPHPO HOSD ending temporal information (discharge date)
MPHPO_0000007	MPHPO hospitalization admission urgency level specification
NCBITaxon_9606	Homo sapiens (patient)
HOSO_0000012	Healthcare organization clinical visit
HOSO_0000074	Clinical visit agreement specification
HOSO_0000055	Healthcare organization service delivery beginning statement
HOSO_0000056	Healthcare organization service delivery ending statement

Table 11: Key ontology terms used in the urgent 30-d readmission variable queries

12.2.1 Path 1: Hospitalization to Discharge Date

Ontology graph

```
(hospitalization (HOSO_0000031)) -[ISA]->
(healthcare organization clinical visit (HOSO_0000012)) -[ISA]->
(healthcare organization service delivery (HOSO_0000011)) -[inverse
    of denotes [OBJECT_PROPERTY]]->
(healthcare organization service delivery identifier (HOSO_0000100)
    ) -[inverse of has component [OBJECT_PROPERTY]]->
(healthcare organization service delivery ending statement (
    HOSO_0000056)) -[inverse of component of [OBJECT_PROPERTY]]->
(MPHPO HOSD ending temporal information (MPHPO_0000004))
```

OntoRel graph

```
hospitalization (HOSO_0000031) ->
healthcare organization clinical visit (HOSO_0000012) ->
healthcare organization service delivery (HOSO_0000011) ->
(healthcare organization service delivery identifier denotes
    healthcare organization service delivery [
    HOSO_0000100_IAO_0000219_HOSO_0000011]) ->
healthcare organization service delivery identifier (HOSO_0000100)
    ->
(healthcare organization service delivery ending statement has
    component healthcare organization service delivery identifier [
    HOSO_0000056_RO_0002180_HOSO_0000100]) ->
healthcare organization service delivery ending statement (
    HOSO_0000056) ->
(MPHPO HOSD ending temporal information component of healthcare
    organization service delivery ending statement [
    MPHPO_0000004_OpenLHS-Core_0000070_HOSO_0000056]) ->
MPHPO HOSD ending temporal information (MPHPO_0000004)
```

12.2.2 Path 2: Admission Date to Hospitalization

Ontology graph

```
(MPHPO HOSD beginning temporal information (MPHPO_0000003)) -[
    component of [OBJECT_PROPERTY]]->
(healthcare organization service delivery beginning statement (
    HOSO_0000055)) -[has component [OBJECT_PROPERTY]]->
(healthcare organization service delivery identifier (HOSO_0000100)
    ) -[denotes [OBJECT_PROPERTY]]->
(healthcare organization service delivery (HOSO_0000011)) -[ISA]->
(healthcare organization clinical visit (HOSO_0000012)) -[ISA]->
(hospitalization (HOSO_0000031))
```

```
MPHPO HOSD beginning temporal information (MPHPO_0000003) ->
(MPHPO HOSD beginning temporal information component of healthcare
    organization service delivery beginning statement [
    MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055]) ->
healthcare organization service delivery beginning statement (
    HOSO_0000055) ->
(healthcare organization service delivery beginning statement has
    component healthcare organization service delivery identifier [
    HOSO_0000055_RO_0002180_HOSO_0000100]) ->
healthcare organization service delivery identifier (HOSO_0000100)
    ->
(healthcare organization service delivery identifier denotes
    healthcare organization service delivery [
    HOSO_0000100_IAO_0000219_HOSO_0000011]) ->
healthcare organization service delivery (HOSO_0000011) ->
healthcare organization clinical visit (HOSO_0000012) ->
hospitalization (HOSO_0000031)
```

12.2.3   Path 3: Hospitalization to Patient

Ontology graph

```
(hospitalization (HOSO_0000031)) -[ISA]->
(healthcare organization clinical visit (HOSO_0000012)) -[is
    directed by [OBJECT_PROPERTY]]->
(healthcare service organism specification (HOSO_0000003)) -[
    inverse of denoted by [OBJECT_PROPERTY]]->
(human clinical visit specified patient (HOSO_0000137)) -[ISA]->
(Homo sapiens (NCBITaxon_9606))
```

OntoRel graph

```
hospitalization (HOSO_0000031) ->
healthcare organization clinical visit (HOSO_0000012) ->
(healthcare organization clinical visit is directed by healthcare
    service organism specification [HOSO_0000012_OpenLHS-
    Core_0000004_HOSO_0000003]) ->
healthcare service organism specification (HOSO_0000003) ->
(human clinical visit specified patient denoted by healthcare
    service organism specification [
    HOSO_0000137_IAO_0000235_HOSO_0000003]) ->
human clinical visit specified patient (HOSO_0000137) ->
Homo sapiens (NCBITaxon_9606)
```

12.2.4 Path 4: Admission Urgency Level to Hospitalization

Ontology graph

```
(MPHPO hospitalization admission urgency level specification (
    MPHPO_0000007)) -[ISA]->
(clinical visit agreement specification (HOSO_0000074)) -[inverse
    of is directed by [OBJECT_PROPERTY]]->
(healthcare organization clinical visit (HOSO_0000012)) -[ISA]->
(hospitalization (HOSO_0000031))
```

OntoRel graph

```
MPHPO hospitalization admission urgency level specification (
    MPHPO_0000007) ->
clinical visit agreement specification (HOSO_0000074) ->
(healthcare organization clinical visit is directed by clinical
    visit agreement specification [HOSO_0000012_OpenLHS-
    Core_0000004_HOSO_0000074]) ->
healthcare organization clinical visit (HOSO_0000012) ->
hospitalization (HOSO_0000031)
```

12.3 SQL implementation

Each path is implemented as a separate SQL query that follows the relationships defined in the ontology.

Query 1: Hospitalization to Discharge Date

```sql
 1  SELECT
 2      "HOSO_0000031"."HOSO_0000031_uid"
 3          AS "uid hospitalization",
 4      "HOSO_0000012"."HOSO_0000012_uid"
 5          AS "uid healthcare organization clinical visit",
 6      "HOSO_0000011"."HOSO_0000011_uid"
 7          AS "uid healthcare organization service delivery",
 8      "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000100_uid"
 9          AS "uid healthcare organization service delivery identifier",
10      "HOSO_0000056_RO_0002180_HOSO_0000100"."HOSO_0000056_uid"
11          AS "uid healthcare organization service delivery ending statement",
12      "MPHPO_0000004_OpenLHS-Core_0000070_HOSO_0000056"."MPHPO_0000004_uid"
13          AS "uid MPHPO HOSD ending temporal information",
14      "MPHPO_0000004_Ontorel-Core_0000004_Ontorel-Core_0000001".
15          "MPHPO_0000004_Ontorel-Core_0000004_Ontorel-Core_0000001_Ontorel"
16          AS "has temporal value"
17  FROM
18      "MPHPO"."HOSO_0000031"
19
20      JOIN "MPHPO"."HOSO_0000012"
21          ON "HOSO_0000031"."HOSO_0000031_uid" =
22              "HOSO_0000012"."HOSO_0000012_uid"
23
24      JOIN "MPHPO"."HOSO_0000011"
25          ON "HOSO_0000012"."HOSO_0000012_uid" =
26              "HOSO_0000011"."HOSO_0000011_uid"
27
```

```
28      JOIN "MPHPO"."HOSO_0000100_IAO_0000219_HOSO_0000011"
29          ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid" =
30              "HOSO_0000011"."HOSO_0000011_uid"
31
32      JOIN "MPHPO"."HOSO_0000100"
33          ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000100_uid" =
34              "HOSO_0000100"."HOSO_0000100_uid"
35
36      JOIN "MPHPO"."HOSO_0000056_RO_0002180_HOSO_0000100"
37          ON "HOSO_0000056_RO_0002180_HOSO_0000100"."HOSO_0000100_uid" =
38              "HOSO_0000100"."HOSO_0000100_uid"
39
40      JOIN "MPHPO"."HOSO_0000056"
41          ON "HOSO_0000056_RO_0002180_HOSO_0000100"."HOSO_0000056_uid" =
42              "HOSO_0000056"."HOSO_0000056_uid"
43
44      JOIN "MPHPO"."MPHPO_0000004_OpenLHS-Core_0000070_HOSO_0000056"
45          ON "MPHPO_0000004_OpenLHS-Core_0000070_HOSO_0000056"."HOSO_0000056_uid" =
46              "HOSO_0000056"."HOSO_0000056_uid"
47
48      JOIN "MPHPO"."MPHPO_0000004"
49          ON "MPHPO_0000004_OpenLHS-Core_0000070_HOSO_0000056"."MPHPO_0000004_uid" =
50              "MPHPO_0000004"."MPHPO_0000004_uid"
51
52      JOIN "MPHPO"."MPHPO_0000004_Ontorel-Core_0000004_Ontorel-Core_0000001"
53          ON "MPHPO_0000004_Ontorel-Core_0000004_Ontorel-Core_0000001"."MPHPO_0000004_uid"
            ↪  =
54              "MPHPO_0000004"."MPHPO_0000004_uid";
```

Query 2: Hospitalization to Admission Date

```
1  SELECT
2      "MPHPO_0000003"."MPHPO_0000003_uid"
3          AS "uid MPHPO HOSD beginning temporal information",
4      "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."HOSO_0000055_uid"
5          AS "uid healthcare organization service delivery beginning statement",
6      "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000100_uid"
7          AS "uid healthcare organization service delivery identifier",
8      "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid"
9          AS "uid healthcare organization service delivery",
10     "HOSO_0000012"."HOSO_0000012_uid"
11         AS "uid healthcare organization clinical visit",
12     "HOSO_0000031"."HOSO_0000031_uid"
13         AS "uid hospitalization",
14     "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001".
15         "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001_Ontorel"
16         AS "has temporal value"
17 FROM
18     "MPHPO"."MPHPO_0000003"
19
20     JOIN "MPHPO"."MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"
21         ON "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."MPHPO_0000003_uid" =
22             "MPHPO_0000003"."MPHPO_0000003_uid"
23
24     JOIN "MPHPO"."HOSO_0000055"
25         ON "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."HOSO_0000055_uid" =
26             "HOSO_0000055"."HOSO_0000055_uid"
27
28     JOIN "MPHPO"."HOSO_0000055_RO_0002180_HOSO_0000100"
29         ON "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000055_uid" =
```

```
30          "HOSO_0000055"."HOSO_0000055_uid"
31
32      JOIN "MPHPO"."HOSO_0000100"
33          ON "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000100_uid" =
34              "HOSO_0000100"."HOSO_0000100_uid"
35
36      JOIN "MPHPO"."HOSO_0000100_IAO_0000219_HOSO_0000011"
37          ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000100_uid" =
38              "HOSO_0000100"."HOSO_0000100_uid"
39
40      JOIN "MPHPO"."HOSO_0000011"
41          ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid" =
42              "HOSO_0000011"."HOSO_0000011_uid"
43
44      JOIN "MPHPO"."HOSO_0000012"
45          ON "HOSO_0000012"."HOSO_0000012_uid" =
46              "HOSO_0000011"."HOSO_0000011_uid"
47
48      JOIN "MPHPO"."HOSO_0000031"
49          ON "HOSO_0000031"."HOSO_0000031_uid" =
50              "HOSO_0000012"."HOSO_0000012_uid"
51
52      JOIN "MPHPO"."MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001"
53          ON "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001"."MPHPO_0000003_uid"
            ↪  =
54              "MPHPO_0000003"."MPHPO_0000003_uid";
```

Query 3: Hospitalization to Patient

```
1  SELECT
2      "HOSO_0000031"."HOSO_0000031_uid"
3          AS "uid hospitalization",
4      "HOSO_0000012"."HOSO_0000012_uid"
5          AS "uid healthcare organization clinical visit",
6      "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000003_uid"
7          AS "uid healthcare service organism specification",
8      "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000137_uid"
9          AS "uid human clinical visit specified patient",
10     "NCBITaxon_9606"."NCBITaxon_9606_uid"
11         AS "uid Homo sapiens"
12 FROM
13     "MPHPO"."HOSO_0000031"
14
15     JOIN "MPHPO"."HOSO_0000012"
16         ON "HOSO_0000031"."HOSO_0000031_uid" =
17             "HOSO_0000012"."HOSO_0000012_uid"
18
19     JOIN "MPHPO"."HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"
20         ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000012_uid" =
21             "HOSO_0000012"."HOSO_0000012_uid"
22
23     JOIN "MPHPO"."HOSO_0000003"
24         ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000003_uid" =
25             "HOSO_0000003"."HOSO_0000003_uid"
26
27     JOIN "MPHPO"."HOSO_0000137_IAO_0000235_HOSO_0000003"
28         ON "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000003_uid" =
29             "HOSO_0000003"."HOSO_0000003_uid"
30
31     JOIN "MPHPO"."HOSO_0000137"
```

```
32          ON "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000137_uid" =
33              "HOSO_0000137"."HOSO_0000137_uid"
34
35      JOIN "MPHPO"."NCBITaxon_9606"
36          ON "HOSO_0000137"."HOSO_0000137_uid" =
37              "NCBITaxon_9606"."NCBITaxon_9606_uid";
```

Query 4: Admission Urgency Level to Hospitalization

```
1  SELECT
2      "MPHPO_0000007"."MPHPO_0000007_uid"
3          AS "uid MPHPO hospitalization admission urgency level specification",
4      "HOSO_0000074"."HOSO_0000074_uid"
5          AS "uid clinical visit agreement specification",
6      "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000074"."HOSO_0000012_uid"
7          AS "uid healthcare organization clinical visit",
8      "HOSO_0000031"."HOSO_0000031_uid"
9          AS "uid hospitalization",
10     "MPHPO_0000007_Ontorel-Core_0000002_string".
11         "MPHPO_0000007_Ontorel-Core_0000002_string_Ontorel-Core_0000002"
12         AS "has textual value"
13 FROM
14     "MPHPO"."MPHPO_0000007"
15
16     JOIN "MPHPO"."HOSO_0000074"
17         ON "MPHPO_0000007"."MPHPO_0000007_uid" =
18             "HOSO_0000074"."HOSO_0000074_uid"
19
20     JOIN "MPHPO"."HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000074"
21         ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000074"."HOSO_0000074_uid" =
22             "HOSO_0000074"."HOSO_0000074_uid"
23
24     JOIN "MPHPO"."HOSO_0000012"
25         ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000074"."HOSO_0000012_uid" =
26             "HOSO_0000012"."HOSO_0000012_uid"
27
28     JOIN "MPHPO"."HOSO_0000031"
29         ON "HOSO_0000031"."HOSO_0000031_uid" =
30             "HOSO_0000012"."HOSO_0000012_uid"
31
32     JOIN "MPHPO"."MPHPO_0000007_Ontorel-Core_0000002_string"
33         ON "MPHPO_0000007_Ontorel-Core_0000002_string"."MPHPO_0000007_uid" =
34             "MPHPO_0000007"."MPHPO_0000007_uid";
```

12.4   Calculation logic

To determine if the current admission is an urgent readmission within 30 days of a previous
discharge:

1. Using Query 3 [12.3], identify all hospitalizations associated with the same patient as the current admission

2. For the current hospitalization:

   - Retrieve the admission date using Query 2 [12.3]
   - Check the admission urgency level using Query 4 [12.3]
   - Verify if the admission urgency level is "Urgent" (has textual value = "Urgent")

3. For each previous hospitalization of the same patient:

   - Retrieve the discharge date using Query 1 [12.3]
   - Calculate the time difference between the discharge date of the previous hospitalization and the admission date of the current hospitalization
   - Identify if any previous discharge occurred within the 30-day window before the current admission

4. The variable is set to TRUE if both conditions are met:

   - The current admission is classified as "Urgent"
   - There is at least one previous hospitalization with a discharge date within 30 days before the current admission

5. Otherwise, the variable is set to FALSE

13 Variable 12 - Ambulance admission

> **Variable description**
>
> This variable identifies whether the current hospital admission was initiated via ambulance transport. Ambulance admissions typically indicate higher acuity or severity at presentation, as they often involve patients requiring urgent medical attention who cannot safely transport themselves to the hospital by other means.

13.1 User request

To calculate this variable, the following user request must be defined:

> **Path:** Hospitalization → Ambulance Admission
> Start entity: `HOSO_0000031` (Hospitalization)
> End entity: `HOSO_0000072` (ED by ambulance initiated hospitalization)

13.2 Ontological representation

Table 12 presents the list of ontological classes of the query.

Ontology term	Description
HOSO_0000031	Hospitalization
HOSO_0000072	ED by ambulance initiated hospitalization

Table 12: Key ontology terms used in the ambulance admission variable query

> **Ontology graph**
>
> ```
> (hospitalization (HOSO_0000031)) -[ISA]-> (ED by ambulance
>     initiated hospitalization (HOSO_0000072))
> ```

> **OntoRel graph**
>
> ```
> hospitalization (HOSO_0000031) -> ED by ambulance initiated
>     hospitalization (HOSO_0000072)
> ```

13.3 SQL implementation

The path is implemented as a SQL query that follows the relationship defined in the ontology.

> **Query: Hospitalization to Ambulance Admission**
>
> ```
> 1 SELECT
> 2     "HOSO_0000031"."HOSO_0000031_uid"
> 3         AS "uid hospitalization",
> 4     "HOSO_0000072"."HOSO_0000072_uid"
> 5         AS "uid ED by ambulance initiated hospitalization"
> 6 FROM
> 7     "MPHPO"."HOSO_0000031"
> ```

```
8
9    JOIN "MPHPO"."HOSO_0000072"
10       ON "HOSO_0000072"."HOSO_0000072_uid" =
11          "HOSO_0000031"."HOSO_0000031_uid";
```

13.4   Calculation logic

To determine if the current admission occurred via ambulance:

1. Execute the query [13.3] to identify any hospitalization instances that are classified as ambulance-initiated hospitalizations

2. For the current hospitalization:

   - Check if its UID is present in the results of the query
   - If present, set the variable to TRUE (ambulance admission)
   - If not present, set the variable to FALSE (non-ambulance admission)

3. The determination is based on the ontological classification of the hospitalization:

   - A hospitalization entity that is also classified as `HOSO_0000072` (ED by ambulance initiated hospitalization) represents an ambulance admission
   - A hospitalization entity that is only classified as `HOSO_0000031` (hospitalization) without being classified as `HOSO_0000072` represents a non-ambulance admission

14 Variable 13 - Visible comorbidities

> **Variable description**
>
> This variable identifies comorbidities that are considered "visible" to clinicians at the time of the current admission. Unlike all comorbidities that may exist in a patient's history, this variable focuses specifically on diagnoses made during previous healthcare encounters that would have been processed and integrated into the patient's accessible medical record. Diagnoses are considered "visible" based on when they were documented relative to the current admission, following established administrative timeframes for record processing. Diagnoses from previous hospitalizations and emergency department (ED) visits are included only if they fall within specific time windows before the current admission. These timeframes reflect institutional record-keeping practices rather than the clinical relevance of the diagnoses themselves. Diagnoses that fall outside these administrative windows are excluded as they are not considered "visible" in the system at the time of admission, even if they remain clinically relevant. This variable helps identify pre-existing conditions that may influence clinical decision-making for the current hospitalization based on what information was readily available to the care team.

14.1 User request

To calculate this variable, the following user requests must be defined:

> **Path 1:** Hospitalization → Admission Date
> Start entity: `HOSO_0000031` (Hospitalization)
> End entity: `MPHPO_0000003` (MPHPO HOSD beginning temporal information)
> **Path 2:** Hospitalization → Patient
> Start entity: `HOSO_0000031` (Hospitalization)
> End entity: `NCBITaxon_9606` (Homo sapiens)
> **Path 3:** Hospitalization → Pathological Condition
> Start entity: `HOSO_0000031` (Hospitalization)
> End entity: `MPHPO_0000002` (MPHPO pathological condition sub-group name)

14.2 Ontological representation

Table 13 presents the list of ontological classes of the query.

Ontology term	Description
HOSO_0000031	Hospitalization
MPHPO_0000003	MPHPO HOSD beginning temporal information (admission date)
MPHPO_0000002	MPHPO pathological condition sub-group name
NCBITaxon_9606	Homo sapiens (patient)
HOSO_0000012	Healthcare organization clinical visit
HOSO_0000124	Healthcare organization clinical visit pathological condition impact statement
HEPRO_0000017	Pathological condition sub-group name
HOSO_0000055	Healthcare organization service delivery beginning statement
HOSO_0000100	Healthcare organization service delivery identifier

Table 13: Key ontology terms used in the visible comorbidities variable queries

14.2.1 Path 1: Hospitalization to Admission Date

Ontology graph

```
(MPHPO HOSD beginning temporal information (MPHPO_0000003)) -[
    component of [OBJECT_PROPERTY]]->
(healthcare organization service delivery beginning statement (
    HOSO_0000055)) -[has component [OBJECT_PROPERTY]]->
(healthcare organization service delivery identifier (HOSO_0000100)
    ) -[denotes [OBJECT_PROPERTY]]->
(healthcare organization service delivery (HOSO_0000011)) -[ISA]->
(healthcare organization clinical visit (HOSO_0000012)) -[ISA]->
(hospitalization (HOSO_0000031))
```

OntoRel graph

```
MPHPO HOSD beginning temporal information (MPHPO_0000003) ->
(MPHPO HOSD beginning temporal information component of healthcare
    organization service delivery beginning statement [
    MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055]) ->
healthcare organization service delivery beginning statement (
    HOSO_0000055) ->
(healthcare organization service delivery beginning statement has
    component healthcare organization service delivery identifier [
    HOSO_0000055_RO_0002180_HOSO_0000100]) ->
healthcare organization service delivery identifier (HOSO_0000100)
    ->
(healthcare organization service delivery identifier denotes
    healthcare organization service delivery [
    HOSO_0000100_IAO_0000219_HOSO_0000011]) ->
healthcare organization service delivery (HOSO_0000011) ->
healthcare organization clinical visit (HOSO_0000012) ->
hospitalization (HOSO_0000031)
```

14.2.2 Path 2: Hospitalization to Patient

Ontology graph

```
(hospitalization (HOSO_0000031)) -[ISA]->
(healthcare organization clinical visit (HOSO_0000012)) -[is
    directed by [OBJECT_PROPERTY]]->
(healthcare service organism specification (HOSO_0000003)) -[
    inverse of denoted by [OBJECT_PROPERTY]]->
(human clinical visit specified patient (HOSO_0000137)) -[ISA]->
(Homo sapiens (NCBITaxon_9606))
```

```
hospitalization (HOSO_0000031) ->
healthcare organization clinical visit (HOSO_0000012) ->
(healthcare organization clinical visit is directed by healthcare
    service organism specification [HOSO_0000012_OpenLHS-
    Core_0000004_HOSO_0000003]) ->
healthcare service organism specification (HOSO_0000003) ->
(human clinical visit specified patient denoted by healthcare
    service organism specification [
    HOSO_0000137_IAO_0000235_HOSO_0000003]) ->
human clinical visit specified patient (HOSO_0000137) ->
Homo sapiens (NCBITaxon_9606)
```

14.2.3 Path 3: Hospitalization to Pathological Condition

Ontology graph

```
(MPHPO pathological condition sub-group name (MPHPO_0000002)) -[ISA
    ]->
(pathological condition sub-group name (HEPRO_0000017)) -[inverse
    of has component [OBJECT_PROPERTY]]->
(healthcare organization clinical visit pathological condition
    impact statement (HOSO_0000124)) -[has component [
    OBJECT_PROPERTY]]->
(healthcare organization service delivery identifier (HOSO_0000100)
    ) -[denotes [OBJECT_PROPERTY]]->
(healthcare organization service delivery (HOSO_0000011)) -[ISA]->
(healthcare organization clinical visit (HOSO_0000012)) -[ISA]->
(hospitalization (HOSO_0000031))
```

OntoRel graph

```
MPHPO pathological condition sub-group name (MPHPO_0000002) ->
pathological condition sub-group name (HEPRO_0000017) ->
(healthcare organization clinical visit pathological condition
    impact statement has component pathological condition sub-group
    name [HOSO_0000124_RO_0002180_HEPRO_0000017]) ->
healthcare organization clinical visit pathological condition
    impact statement (HOSO_0000124) ->
(healthcare organization clinical visit pathological condition
    impact statement has component healthcare organization service
    delivery identifier [HOSO_0000124_RO_0002180_HOSO_0000100]) ->
healthcare organization service delivery identifier (HOSO_0000100)
    ->
(healthcare organization service delivery identifier denotes
    healthcare organization service delivery [
    HOSO_0000100_IAO_0000219_HOSO_0000011]) ->
healthcare organization service delivery (HOSO_0000011) ->
healthcare organization clinical visit (HOSO_0000012) ->
hospitalization (HOSO_0000031)
```

14.3 SQL implementation

Each path is implemented as a separate SQL query that follows the relationships defined in the ontology.

Query 1: Hospitalization to Admission Date

```sql
SELECT
    "MPHPO_0000003"."MPHPO_0000003_uid"
        AS "uid MPHPO HOSD beginning temporal information",
    "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."HOSO_0000055_uid"
        AS "uid healthcare organization service delivery beginning statement",
    "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000100_uid"
        AS "uid healthcare organization service delivery identifier",
    "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid"
        AS "uid healthcare organization service delivery",
    "HOSO_0000012"."HOSO_0000012_uid"
        AS "uid healthcare organization clinical visit",
    "HOSO_0000031"."HOSO_0000031_uid"
        AS "uid hospitalization",
    "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001".
        "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001_Ontorel"
        AS "has temporal value"
FROM
    "MPHPO"."MPHPO_0000003"

    JOIN "MPHPO"."MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"
        ON "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."MPHPO_0000003_uid" =
            "MPHPO_0000003"."MPHPO_0000003_uid"

    JOIN "MPHPO"."HOSO_0000055"
        ON "MPHPO_0000003_OpenLHS-Core_0000070_HOSO_0000055"."HOSO_0000055_uid" =
            "HOSO_0000055"."HOSO_0000055_uid"

    JOIN "MPHPO"."HOSO_0000055_RO_0002180_HOSO_0000100"
        ON "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000055_uid" =
            "HOSO_0000055"."HOSO_0000055_uid"

    JOIN "MPHPO"."HOSO_0000100"
        ON "HOSO_0000055_RO_0002180_HOSO_0000100"."HOSO_0000100_uid" =
            "HOSO_0000100"."HOSO_0000100_uid"

    JOIN "MPHPO"."HOSO_0000100_IAO_0000219_HOSO_0000011"
        ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000100_uid" =
            "HOSO_0000100"."HOSO_0000100_uid"

    JOIN "MPHPO"."HOSO_0000011"
        ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid" =
            "HOSO_0000011"."HOSO_0000011_uid"

    JOIN "MPHPO"."HOSO_0000012"
        ON "HOSO_0000012"."HOSO_0000012_uid" =
            "HOSO_0000011"."HOSO_0000011_uid"

    JOIN "MPHPO"."HOSO_0000031"
        ON "HOSO_0000031"."HOSO_0000031_uid" =
            "HOSO_0000012"."HOSO_0000012_uid"

    JOIN "MPHPO"."MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001"
        ON "MPHPO_0000003_Ontorel-Core_0000004_Ontorel-Core_0000001"."MPHPO_0000003_uid"
          ↪  =
            "MPHPO_0000003"."MPHPO_0000003_uid";
```

Query 2: Hospitalization to Patient

```
1  SELECT
2      "HOSO_0000031"."HOSO_0000031_uid"
3          AS "uid hospitalization",
4      "HOSO_0000012"."HOSO_0000012_uid"
5          AS "uid healthcare organization clinical visit",
6      "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000003_uid"
7          AS "uid healthcare service organism specification",
8      "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000137_uid"
9          AS "uid human clinical visit specified patient",
10     "NCBITaxon_9606"."NCBITaxon_9606_uid"
11         AS "uid Homo sapiens"
12 FROM
13     "MPHPO"."HOSO_0000031"
14
15     JOIN "MPHPO"."HOSO_0000012"
16         ON "HOSO_0000031"."HOSO_0000031_uid" =
17             "HOSO_0000012"."HOSO_0000012_uid"
18
19     JOIN "MPHPO"."HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"
20         ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000012_uid" =
21             "HOSO_0000012"."HOSO_0000012_uid"
22
23     JOIN "MPHPO"."HOSO_0000003"
24         ON "HOSO_0000012_OpenLHS-Core_0000004_HOSO_0000003"."HOSO_0000003_uid" =
25             "HOSO_0000003"."HOSO_0000003_uid"
26
27     JOIN "MPHPO"."HOSO_0000137_IAO_0000235_HOSO_0000003"
28         ON "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000003_uid" =
29             "HOSO_0000003"."HOSO_0000003_uid"
30
31     JOIN "MPHPO"."HOSO_0000137"
32         ON "HOSO_0000137_IAO_0000235_HOSO_0000003"."HOSO_0000137_uid" =
33             "HOSO_0000137"."HOSO_0000137_uid"
34
35     JOIN "MPHPO"."NCBITaxon_9606"
36         ON "HOSO_0000137"."HOSO_0000137_uid" =
37             "NCBITaxon_9606"."NCBITaxon_9606_uid";
```

Query 3: Hospitalization to Pathological Condition

```
1  SELECT
2      "MPHPO_0000002"."MPHPO_0000002_uid"
3          AS "uid MPHPO pathological condition sub-group name",
4      "HEPRO_0000017"."HEPRO_0000017_uid"
5          AS "uid pathological condition sub-group name",
6      "HOSO_0000124_RO_0002180_HEPRO_0000017"."HOSO_0000124_uid"
7          AS "uid healthcare organization clinical visit pathological condition impact
               ↪  statement",
8      "HOSO_0000124_RO_0002180_HOSO_0000100"."HOSO_0000100_uid"
9          AS "uid healthcare organization service delivery identifier",
10     "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid"
11         AS "uid healthcare organization service delivery",
12     "HOSO_0000012"."HOSO_0000012_uid"
13         AS "uid healthcare organization clinical visit",
14     "HOSO_0000031"."HOSO_0000031_uid"
15         AS "uid hospitalization",
16     "MPHPO_0000002_Ontorel-Core_0000002_string".
17         "MPHPO_0000002_Ontorel-Core_0000002_string_Ontorel-Core_0000002"
18         AS "has textual value"
```

```
19  FROM
20      "MPHPO"."MPHPO_0000002"
21
22      JOIN "MPHPO"."HEPRO_0000017"
23          ON "MPHPO_0000002"."MPHPO_0000002_uid" =
24              "HEPRO_0000017"."HEPRO_0000017_uid"
25
26      JOIN "MPHPO"."HOSO_0000124_RO_0002180_HEPRO_0000017"
27          ON "HOSO_0000124_RO_0002180_HEPRO_0000017"."HEPRO_0000017_uid" =
28              "HEPRO_0000017"."HEPRO_0000017_uid"
29
30      JOIN "MPHPO"."HOSO_0000124"
31          ON "HOSO_0000124_RO_0002180_HEPRO_0000017"."HOSO_0000124_uid" =
32              "HOSO_0000124"."HOSO_0000124_uid"
33
34      JOIN "MPHPO"."HOSO_0000124_RO_0002180_HOSO_0000100"
35          ON "HOSO_0000124_RO_0002180_HOSO_0000100"."HOSO_0000124_uid" =
36              "HOSO_0000124"."HOSO_0000124_uid"
37
38      JOIN "MPHPO"."HOSO_0000100"
39          ON "HOSO_0000124_RO_0002180_HOSO_0000100"."HOSO_0000100_uid" =
40              "HOSO_0000100"."HOSO_0000100_uid"
41
42      JOIN "MPHPO"."HOSO_0000100_IAO_0000219_HOSO_0000011"
43          ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000100_uid" =
44              "HOSO_0000100"."HOSO_0000100_uid"
45
46      JOIN "MPHPO"."HOSO_0000011"
47          ON "HOSO_0000100_IAO_0000219_HOSO_0000011"."HOSO_0000011_uid" =
48              "HOSO_0000011"."HOSO_0000011_uid"
49
50      JOIN "MPHPO"."HOSO_0000012"
51          ON "HOSO_0000012"."HOSO_0000012_uid" =
52              "HOSO_0000011"."HOSO_0000011_uid"
53
54      JOIN "MPHPO"."HOSO_0000031"
55          ON "HOSO_0000031"."HOSO_0000031_uid" =
56              "HOSO_0000012"."HOSO_0000012_uid"
57
58      JOIN "MPHPO"."MPHPO_0000002_Ontorel-Core_0000002_string"
59          ON "MPHPO_0000002_Ontorel-Core_0000002_string"."MPHPO_0000002_uid" =
60              "MPHPO_0000002"."MPHPO_0000002_uid";
```

14.4   Calculation logic

To determine if the patient has visible comorbidities based on previous healthcare utilization:

1. Using Query 2 [14.3], identify all hospitalizations associated with the same patient as the current admission

2. For the current hospitalization:

   - Retrieve the admission date using Query 1 [14.3]

3. For all the other hospitalizations of the same patient:

   - Retrieve the discharge date using Query 1 [14.3]
   - Calculate the interval between the discharge date of this hospitalization and the admission date of the current hospitalization
   - If the hospitalization occurred within the established administrative time window for hospitalization records:
     - Use Query 3 [**??**] to retrieve all pathological conditions (diagnoses) documented during that hospitalization
     - Mark these diagnoses as "visible" comorbidities

4. For each emergency department (ED) visit of the same patient:

   - Retrieve the end date of the visit using Query 1 [14.3]
   - Calculate the interval between the end date of the ED visit date and the admission date of the current hospitalization
   - If the ED visit occurred within the established administrative time window for ED visit records:
     - Use Query 3 [14.3] to retrieve all pathological conditions (diagnoses) documented during that ED visit
     - Mark these diagnoses as "visible" comorbidities

5. The variable returns the set of all pathological conditions that are marked as "visible" comorbidities

6. If no pathological conditions are marked as "visible" (i.e., there are no diagnoses from visits within the administrative time windows), the variable returns an empty set, indicating no visible comorbidities

15 Evaluation

We studied the usability of our querying approach using queries developed for a clinical decision system to improve palliative and end-of-life care outcomes for patients at a high risk of 1-year mortality. We conducted an experiment using a real-world use case and a public dataset from the healthcare domain.

15.1 Use case

The study evaluates the clinical utility of multiple prediction models using routinely collected data among hospitalized patients, including demographics, hospitalization data and preferences for life-supporting therapy [Taseen 2021].

As part of this project, 13 variables were collected and 4 machine learning models were tested. An ontology, 'Mortality Prediction for Hospitalized Patients Ontology MPHPO was developed to define the semantic of the collected data.

15.2 Data Set

For the experiment, we used the real-world dataset MIMIC-IV (Medical Information Mart for Intensive Care). MIMIC-IV is a large anonymized database containing information on patients admitted to intensive care between 2008 and 2019 (total of 431 231 admissions).

16 Result

In this experiment we captured the runtime of 13 queries (one query per variable) for four different implementations: (1) by querying the MIMIC tables directly, and through OntoRel layers (2) by directly querying the entity layer (Entity), (3) using the path layer (Path-View) and (4) using the materialized path layer (Materialized-Path).

16.1 MIMIC

This implementation uses MIMIC database relations in queries The performance metrics of this approach are presented in Table 14.

Table 14: Performance metrics for MIMIC implementation

Query name	Min time (ms)	Max time (ms)	Mean time (ms)	Row count
Q01	692.98	1395.58	834.87	311122
Q02	533.88	1013.56	630.19	311122
Q03	378.15	705.24	445.97	311122
Q04	2346.36	2514.99	2385.79	311122
Q05	1094.83	1385.00	1155.91	311122
Q06	2609.43	2695.50	2632.44	311122
Q07	158.66	422.20	212.82	311122
Q08	847.99	1220.16	925.36	311122
Q09	213.71	396.74	251.26	311122
Q10	922.68	2075.79	1156.54	311122
Q11	895.69	1512.88	1020.76	311122
Q12	352.65	366.34	357.96	311122
Q13	2376.62	3185.97	2544.92	703893

16.2 OntoRel- Entity

This implementation uses database OntoRel entities in queries. The performance metrics of this approach are presented in Table 15.

Table 15: Performance metrics for OntoRel-Entity implementation

Query name	Min time (ms)	Max time (ms)	Mean time (ms)	Row count
Q01	7079.75	8961.82	7656.03	311122
Q02	9239.26	9988.92	9517.67	311122
Q03	5091.93	6183.26	5318.09	311122
Q04	18214.92	19271.05	18682.25	311122
Q05	9871.09	19733.27	13145.06	311122
Q06	13751.17	15253.51	14306.73	311122
Q07	2414.94	3521.11	2673.65	311122
Q08	19316.04	20405.82	19658.33	311122
Q09	6522.44	7732.97	7090.23	311122
Q10	274.57	357.15	294.19	311122
Q11	15314.59	18059.92	16890.01	311122
Q12	308.03	314.70	310.94	311122
Q13	15880.74	19295.99	18043.43	703893

16.3 OntoRel- Path View

This implementation uses database views to represent ontological paths, facilitating complex queries. The performance metrics of this approach are presented in Table 16

Table 16: Performance metrics for OntoRel-Path View implementation

Query name	Min time (ms)	Max time (ms)	Mean time (ms)	Row count
Q01	7024.42	7148.24	7097.46	311122
Q02	8953.01	10030.20	9525.70	311122
Q03	5084.24	5116.12	5100.10	311122
Q04	18787.71	20473.43	19576.66	311122
Q05	8730.12	9700.48	9225.67	311122
Q06	12639.15	15006.92	13559.39	311122
Q07	2456.94	2521.82	2490.56	311122
Q08	19357.52	20585.85	19859.24	311122
Q09	3357.91	3436.57	3397.96	311122
Q10	216.62	219.37	217.79	311122
Q11	16619.77	18246.87	17427.54	311122
Q12	305.98	323.42	312.08	311122
Q13	17364.22	18286.51	17834.10	703893

16.4 OntoRel-Materialized-Path

This implementation uses materialized paths to optimize query performance, storing complete paths in dedicated tables. The performance metrics of this implementation are presented in Table 17

Table 17: Performance metrics for OntoRel-Materialized-Path implementation

Query name	Min time (ms)	Max time (ms)	Mean time (ms)	Row count
Q01	161.56	503.58	230.32	311122
Q02	486.38	1027.69	595.12	311122
Q03	341.13	999.58	473.85	311122
Q04	739.65	1357.97	865.57	311122
Q05	188.31	558.66	263.59	311122
Q06	1293.92	1792.12	1407.17	311122
Q07	81.74	399.53	147.14	311122
Q08	371.84	694.19	437.44	311122
Q09	124.08	343.05	168.47	311122
Q10	133.82	396.51	187.78	311122
Q11	949.35	1591.42	1088.05	311122
Q12	145.31	151.98	147.39	311122
Q13	630.58	926.80	694.82	703893

17 Conclusion

OntoRelQuery demonstrates effective capabilities in bridging the semantic-relational divide for clinical data access. The system successfully generates valid SQL queries from ontological relationships across all 13 variables evaluated in this report. Future work should focus on enhancing path traversal capabilities to reduce the need for multiple user requests in complex scenarios.