

## Modeling Methodology

The inputs for the information model are the terms used by clinicians. These terms can be represented in various ways:

- As items in a spreadsheet.
- As a diagram using mindmaps.

These terms are collected through interviews with subject matter experts and through research of literature. A subject matter expert and a data modeler analyze these terms and represent them in a UML class diagram.

In the Unified Modeling Language (UML), an information model is represented as a Class Diagram which consists of the following parts:

Knowledge	Example Definition	Example	UML Representation
term	A discrete type of data	body temperature value	attribute or class
term value	A value for the type of data	98	example
record	A set of related terms	value, unit of measure, measurement method	instance
file	A set of uniform records	body temperature	class
term relationship	A description of how two or more terms are related to each other.	body temperature is a type of vital sign	association relationship, generalization, composition relationship, aggregation relationship
cardinality	Defines how many of one term are related to another term.	Vital sign consists of many types of measurements	Zero or One to One Zero or One to Many Many to Many

The following example shows how a UML class diagram is constructed.

### **Principle 1: Identifying basic patterns**

Here are 7 data elements listed in a spreadsheet.

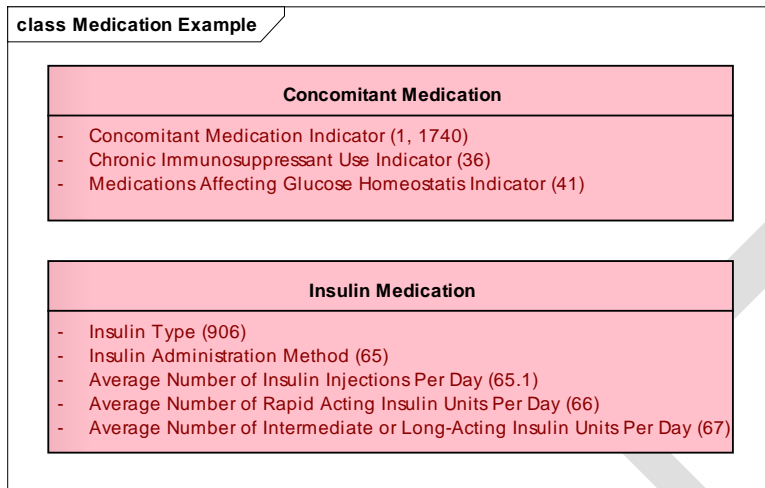
DOMAIN	SUB-DOMAIN	DATA ELEMENT	DEFINITION	PERMISSIBLE VALUES
Endocrinology	Medications	Concomitant Medication Indicator	Indicates whether or not one or more medications are being taken by or administered to the patient .	Yes; No; Unknown
Endocrinology	Medications	Medications Affecting Glucose Homeostasis Indicator	Indicates if a person is currently taking medications that could affect the stabilization of blood sugar levels (glucose homeostasis).	Yes; No; Unknown
Endocrinology	Medications	Insulin Administration Method	The route by which patient receives exogenous insulin.	Insulin Injections; Insulin Pen, Insulin Pump (CSII), Other
Endocrinology	Medications	Average Number of Insulin Injections per Day	The average number of injections of insulin per day that a person is given.	integer
Endocrinology	Medications	Average Number of Rapid Acting Insulin Units Per Day	The average daily amount of rapid acting insulin taken by a person as expressed in units.	
Endocrinology	Medications	Average Number of Intermediate or Long-Acting Insulin Units Per Day	The average daily amount of intermediate or long acting insulin taken by a person as expressed in units.	
General Medicine	Medications	Chronic Immunosuppressant Use Indicator	Indicates whether or not a person used systemic steroids or other immunosuppressive agents	Yes; No; Unknown

Each data element is assigned to a Subject Area (Step 3) and Class within the Subject Area.

Subject Area	Class	DOMAIN	SUB-DOMAIN CATEGORY	DATA ELEMENT
Medication	Concomitant Medication	Endocrinology	Medications	Concomitant Medication Indicator
Medication	Concomitant Medication	General Medicine	Medications	Chronic Immunosuppressant Use Indicator
Medication	Concomitant Medication	Endocrinology	Medications	Medications Affecting Glucose Homeostasis Indicator
Medication	Insulin Medication	Endocrinology	Medications	Insulin Type
Medication	Insulin Medication	Endocrinology	Medications	Insulin Administration Method
Medication	Insulin Medication	Endocrinology	Medications	Average Number of Insulin Injections per Day
Medication	Insulin Medication	Endocrinology	Medications	Average Number of Rapid Acting Insulin Units Per Day

Medication	Insulin Medication	Endocrinology	Medications	Average Number of Intermediate or Long-Acting Insulin Units Per Day
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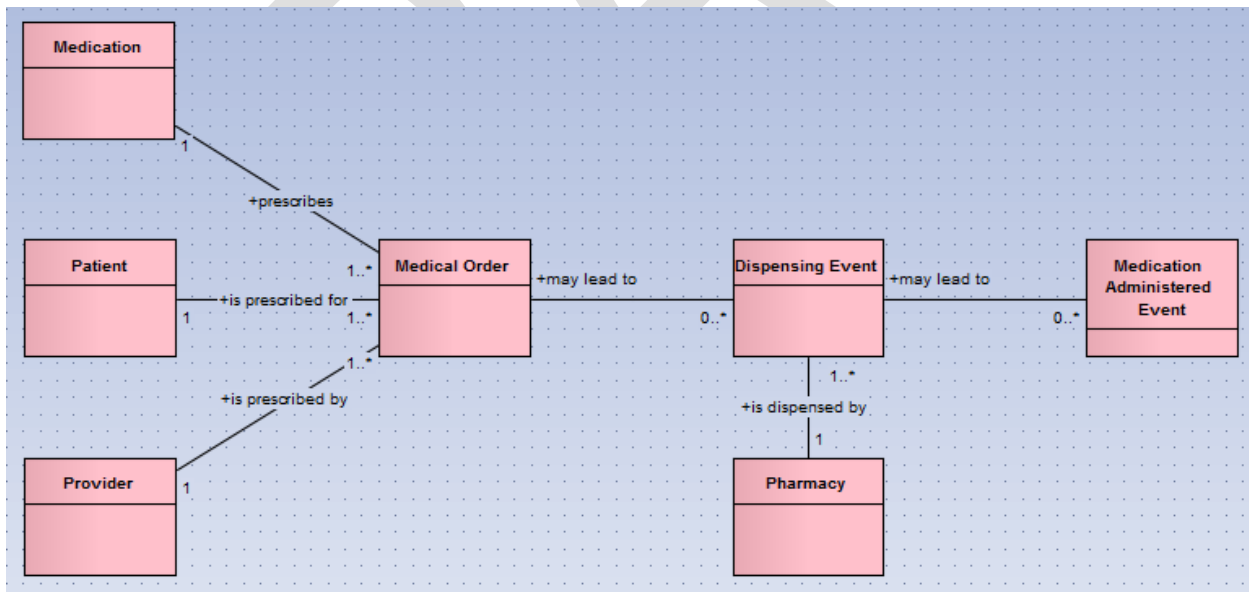
The resulting class diagram follows:



The numbers in parenthesis refer to a unique item number that the data element is assigned in the spreadsheet for traceability.

### **Principle 2: Identifying relationships between concepts**

The relationships between these concepts are depicted as solid lines that connect the rectangular boxes.



The relationships and concepts tell a story as follows:

- A ‘Medical Order’ prescribes a ‘Medication’ for a ‘Patient’ by a ‘Provider’.
- A ‘Medical Order’ may lead to a ‘Dispensing Event’.
- A ‘Dispensing Event’ is dispensed by a ‘Pharmacy’.
- A ‘Dispensing Event’ may lead to a ‘Medication Administered Event’.

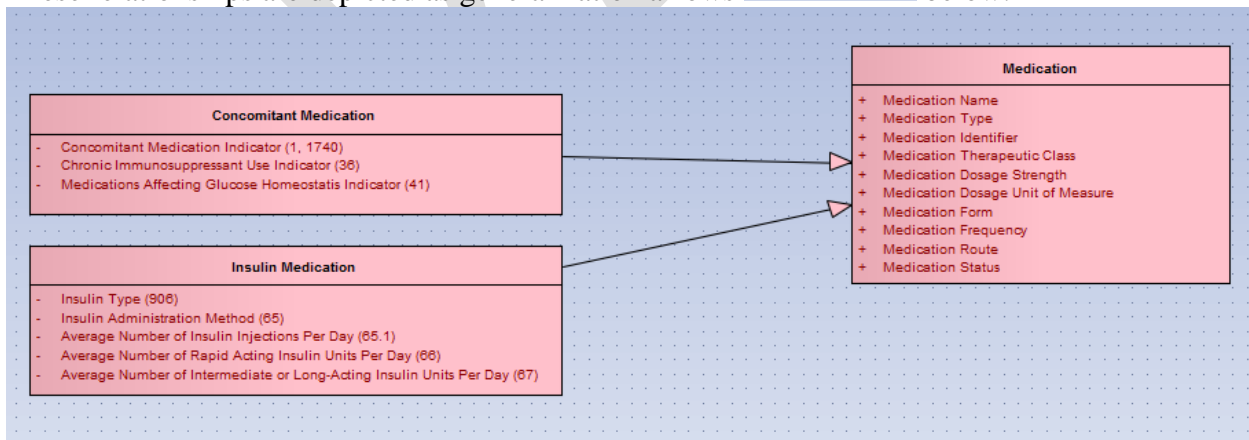
The symbols ‘1’, ‘1..\*’ and ‘0..\*’ denote the cardinality of the relationships.

- ‘1’ means ‘one’ as in one ‘Medication’ per ‘Medical Order’
- ‘1..\*’ means ‘one to many’ as in a ‘Medication’ may be found in one to many ‘Medical Orders’.
- The combination of a ‘1’ and ‘1..\*’ defines a mandatory relationship. For example, at a ‘Medical Order’ must prescribe one Medication.
- ‘0..1’ means ‘zero to many’ as in a ‘Medical Order’ may lead to zero to many ‘Dispensing Event’. ‘Zero’ means that a ‘Medical Order’ may not lead to a ‘Dispensing Event’ as in a prescription that is not filled. This relationship is also referred to as an optional relationship

### **Principle 3: Discovering general patterns**

Similar concepts can be related to each other through a generalization relationship. From Example 1, ‘Concomitant Medication’ and ‘Insulin Medication’ are types of ‘Medication’.

These relationships are depicted as generalization arrows  below.



A generalization relationship enables each specific class (e.g., Concomitant Medication) to inherit the attributes of its generalized class (e.g., Medication). This is a very useful modeling convention to describe common attributes between two different classes. In the example above, ‘Concomitant Medication’ and ‘Insulin Medication’ have a ‘Medication Name’, a ‘Medication Type’, etc.

### ***Enumeration***

An enumeration object is a list of possible values for a characteristic. This is the most detailed level of the model. For the clinician, an enumerated list represents the possible answers to a

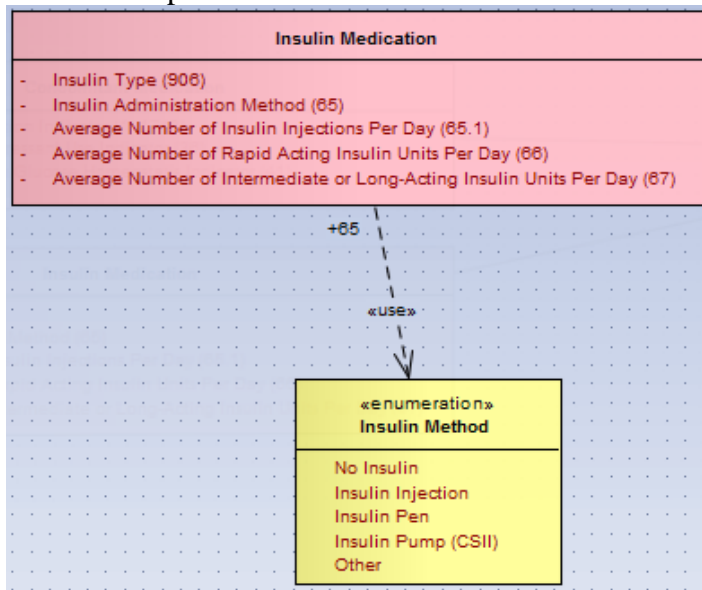
question or the possible values for an attribute. The enumerated lists are often referred to as "value sets". The enumerations or value sets are also bound to reference terminologies. In our projects, the reference terminologies used for value sets were primarily SNOMED CT, Clinical Findings hierarchy.

In the example below, the spreadsheet item "Insulin Administration Method" lists several permissible values.

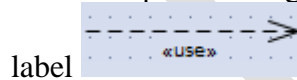
ITEM#	DATA ELEMENT	PERMISSIBLE VALUES
65	Insulin Administration Method	Insulin Injections; Insulin Pen, Insulin Pump (CSII), Other

These

values are represented as follows:



The permissible values are modeled as values (red text) of enumerations (yellow rectangle) in the class diagram. The enumerations are connected to their respective referring attribute (red text inside the pink rectangle) with "use" relationship, drawn as a dashed arrow with a "<<use>>"



label