Nursing Process Model Mapped to Health Level 7 Reference Information Model

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Abstract- The nursing profession generates a large number of documents, and despite a number of terminology standards in existence, lack of interoperability in process and data structure still persists. The purpose of carrying out this study was to develop an integrated, comprehensive structure of nursing process as a domain information model which could be suitable for message development which potentially can be used when implementing clinical information software. We present phases of nursing process modeling, followed by mapping the resultant model to the HL7 Reference Information Model, generating a nursing domain message information model. Also, reviewing the Clinical Document Architecture in relation to the nursing process, we present our proposal for changes required to its object model for better support of nursing documents.

Introduction

With the advent of computers' technology, the health care industry, like other industries, has tended to move toward the computerization of health care delivery system, to achieve a reduction in medical errors and the problems associated with such errors, decreasing costs, improving continuity of care and efficiency. Nurses are key stakeholders in providing care, and are always in direct contact with patients and generate a lot of data as they provide client care. Nurses need to share collected information with other health caregivers. The Health Level Seven (HL7) standard (1) is used for electronic data exchange in healthcare environments. It provides standards for the exchange, sharing, management, care delivery, retrieval and evaluation of health information. It is based on the Reference Information Model (RIM) (2). The RIM is a static model, a simple backbone of five core classes and the root of all information models developed as part of the version 3 development process, represented using visual modeling techniques in object-oriented software development called the Unified Modeling Language (UML). The Domain Message Information Model (DMIM) represents a refined subset of the HL7 RIM model (3), in other words a set of instances of the RIM classes for a specific domain that refers to a particular area of interest in healthcare (i.e. nursing), which further is used to develop HL7 messages for communication purposes.

The Clinical Document Architecture Release 2 (CDA R2) (4), is one of the HL7 standards, pertaining to the RIM. It is a document markup standard that specifies the structure and semantics of "clinical documents" for the purpose of exchange to enable comparison of content from documents created by information systems of widely varying characteristics and attempts to cover diverse reporting content for nursing, radiology, pathology, and others.

The nursing process is based on a problem-solving approach to nursing, recognized in 1977 by WHO. It is a framework for planning and implementation of nursing care, consisting of six steps; the assessment, diagnosis, outcome identification, planning, implementation and evaluation (5,6). Assessment is the first step of the nursing process which begins after the first observation. This includes data collection (nursing history and physical examination) and analysis. Based on the output from this step, nurses can develop their diagnoses. The nursing diagnosis is a clinical judgment about the individual, his or her family, and community responses to actual or potential problems. The outcome identification indicates realistic, measurable expected outcomes and corresponding target dates for care given to the patient. After identifying the desirable outcomes nurses develop a plan of care. The cycle ends with the evaluation phase on assessing achieved goals and

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decisions regarding the care plan.

The few existing studies on developing nursing process models using HL7 RIM classes have focused on specific areas such as patient education in breast cancer (7), medication administration (8), and the other study (9) which used XML technologies for developing nursing model in-home care area.

While the nursing domain is an active area of research interest, earlier efforts have not been able to cover all aspects of the nursing domain. In addition, there are different types of nursing documentation for various purposes such as nursing care plan, progress note, nursing visits, report of the shift change, discharge documentation to name few (10) and in the present study, we wanted a more inclusive coverage of nursing documents. Some efforts used HL7 RIM classes focused on special documentation such as discharge summary (11) and nursing summary (12). In an earlier study (13), the authors hoped to see a partial correlation of their model with that of an HL7 RIM class, and in a later effort on using nursing process model within the HL7 RIM was limited to mapping nursing terminology; examples of International Classification of Functioning, Disability and Health (ICF40) and International Classification for Nursing Practice (ICNP) to the *Observation* class, with little structural model detail (14).

Lack of inclusive nursing model, including all phases of nursing process that support nursing documentation in various areas, was the main impetus to present a comprehensive nursing process model that is mapped to the HL7 RIM, resulting in the generation of a nursing DMIM which could be used for HL7 message development. Furthermore, we propose minor adjustments required to CDA object model for better support of nursing workflows within nursing documents.

Materials and Methods

We reviewed nursing processes and terminologies such as the Omaha System (15), North American Nursing Diagnosis Association International (NANDA-I) (16), and ICNP (17), and used the expert advice of professional nurses for 3 months in our study. We met and engaged with senior hospital nurses regularly during the project to understand the day-to-day requirements of nursing care. We modeled nursing processes and their workflows using Unified Modeling Language (Enterprise Architect ™, developed by Sparx Systems). Modeling the dynamics were done by means of development of storyboards, use case, and activity

diagrams. The storyboards were drawn of example cases, a use case diagram describes a set of actions that are performed in collaboration with one or more external users of the system (actors), i.e. ''Nurse'' is viewed as the actor. Activity diagrams were used to visualize the flow of controls in a system. Then, a class diagram representing the static model and object orientation of the system was designed. The final phase of methodology was to map the nursing process model developed in UML to HL7 standard. The nursing DMIM was derived (or specialized) from the existing HL7 RIM by using the RMIM Designer (18), an Add-in for Microsoft Office Visio™ 2007, and RoseTree (19). DMIM was developed to represent all concepts needed for supporting the communication requirements of a nursing domain.

Results

Modeling nursing process

We employed use case diagrams to base nursing processes as shown in figure 1. It illustrates the behavioral requirements of our system from a nursing perspective. Examples of scenarios are listed in Table 1.

An activity diagram was developed to represent the dynamic aspects of use case view, figure 2. The activity diagram describes the flow between activities within the nursing care, and it is read as follows: in the first encounter between the nurse and patient (or client), the nursing process begins. The nurse assesses the patient (or client, when not in a hospital setting) and makes a diagnosis about which a care plan can be created. The nurse implements interventions based on the care plan, followed by evaluating the patient (or client) response versus the interventions, and based on his/her evaluations, if not satisfied the nurse can start from the beginning of the cycle again. Equally, the nurse after assessing the environment, can create plans and implement interventions and evaluate based on client responses.

In order to map our model to the HL7 RIM, a structural model from the nursing process was needed. As seen in figure 3, the class diagram illustrates the main classes; Assessment, Diagnosis, expected outcomes, Intervention, Evaluation, and other auxiliary classes. The classes used to store patient personal details and nursing history were omitted from Figure 3 in order to decrease the complexity of the figure. The Terminology Type class was developed for using various terminologies such as Systematized Nomenclature of Medicine Clinical Terminology

(SNOMED CT), RxNORM, Current Procedural Terminology (CPT) or especially nursing terminologies like Omaha System, NANDA-I, and ICNP. In a study (20) conducted for documentation of nursing care using a nursing terminology standard identifying, each of the six steps of the nursing process was called the Clinical Care Classification System (CCC).
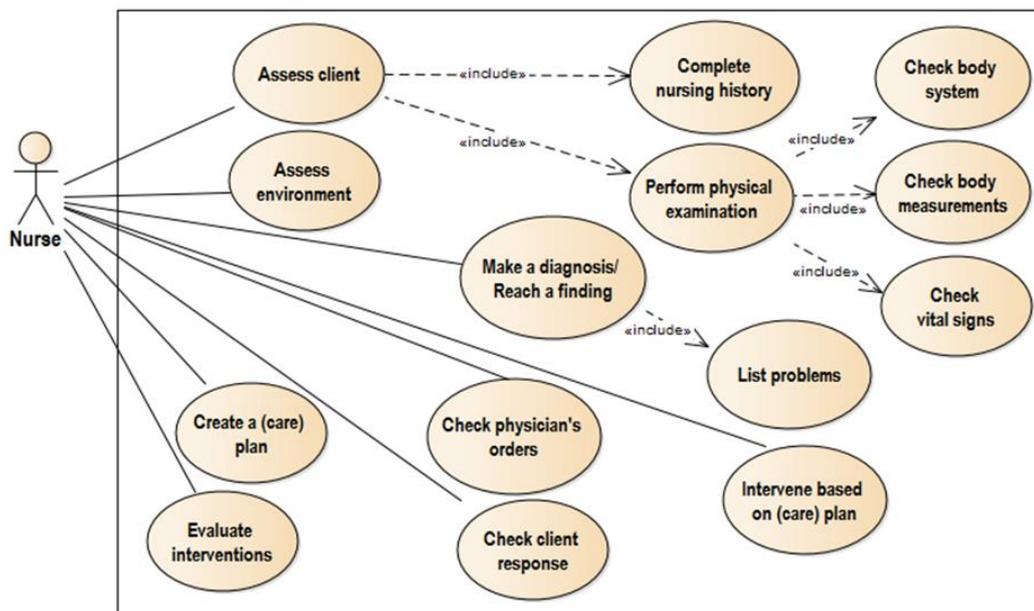

Figure 1. A UML nursing process use-case diagram. The nurse is the primary actor who is playing a role in relation to the system, actions performed are shown in ovals (use cases). A solid line indicates a relationship between the actor and uses case, whereas the "include" dotted-line shows that a use case is part of another use case

Table 1. Examples of medical, occupational and social use cases.

<u>**Scenario 1**</u>: White Male, 43, married with three children. Arrived at the A&E at 0840, complaining of lower abdominal pain. Admitted for suspected appendicitis, and diagnostics performed to confirm this diagnosis. Physical examination; healthy, somewhat obese (212 cm, 95Kg)

Assessment: He has no existing chronic illness, and his primary concern is the abdominal pain in the lower right quadrant. The pain is 8 out of 10. WBC=11,500; CT reveals no abnormalities; vital signs (T= 38.7, BP=132/78, P=78, R=20). He has not eaten anything since about 1930 last night.

Diagnosis: Acute pain due to appendicitis as evidenced by pain level of 8/10 on a 1 to 10 scale. Therefore will require pain and medication management.

Expected Outcomes: The patient will a) Experience a satisfactory relief measure as evidenced by pain level 3/10 or better. b) Increase participation in recovery activities

Intervention: a) Reduce factors that increase pain. b) Provide pain relief by non-pharmacologic and pharmacologic means.

Client response: After one hour of taking the analgesics, the patient reported a pain level of 3/10.

<u>**Scenario 2**</u>: At an electrical components manufacturer worksite, it is noticed that a high percentage of employees have sickness absence.

Assessment and Diagnosis: The employees who were mostly female, working full time (with relatively little daily break) were complaining of pains in their necks, elbows, forearms, and backs. The work involved frequent standing and repetition and particularly screwing of small bolts as part of the assembly procedure.

Expected Outcomes: Significant reduction in work-related musculoskeletal discomforts and sickness absence.

Intervention: a) In order to minimize the effects of manually repetitive tasks, the company was advised to invest in power-driven tools. b) The employees to be provided with stools. c) The employees were given advice on the benefits of exercise.

Evaluation: Following two months after the company accepting the interventions, it was found that work-related incidences of musculoskeletal discomforts had been eliminated.
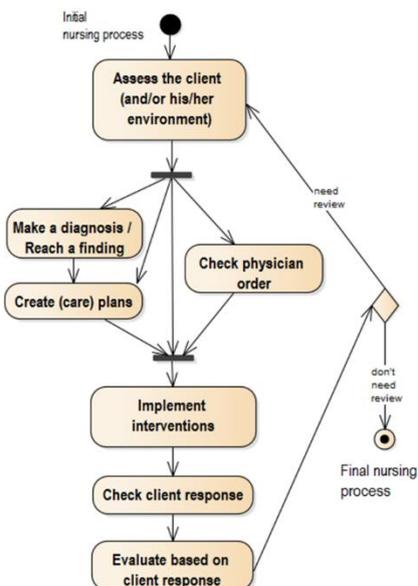
Figure 2. A UML nursing process activity diagram, showing dynamic behavior of a system through control flow between nursing phases from the assessment to the evaluation phase. A rounded rectangle, diamond shape indicate activity and decision respectively
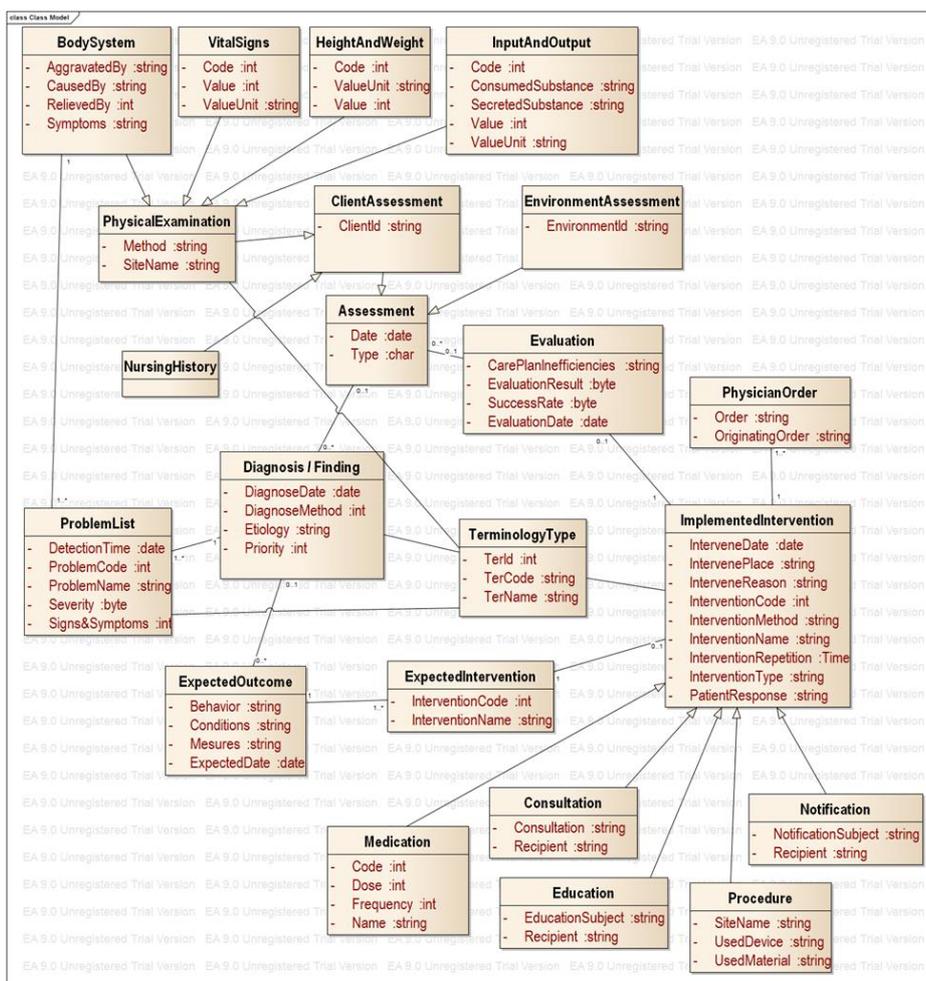

Figure 3. A UML nursing process class diagram, showing classes with attributes, methods, relationships and their dependency on other classes. For simplicity sake, the attributes of Nursing History has been left out

Mapping the nursing information domain model to the HL7 RIM

The nursing class model was mapped to the HL7 RIM. We compared our classes with those of HL7 RIM classes; Act, and Act specialized classes such as Procedure, Observation, Working List, Substance Administration, also Role and Entity of RIM core classes, and their specializations were chosen in order to develop the nursing DMIM. The Common Message Element Type (CMET) is a common type, reusable in other implementations and domains. The CMETs were also developed using the named tools. All phases of nursing process are shown in figure 4.
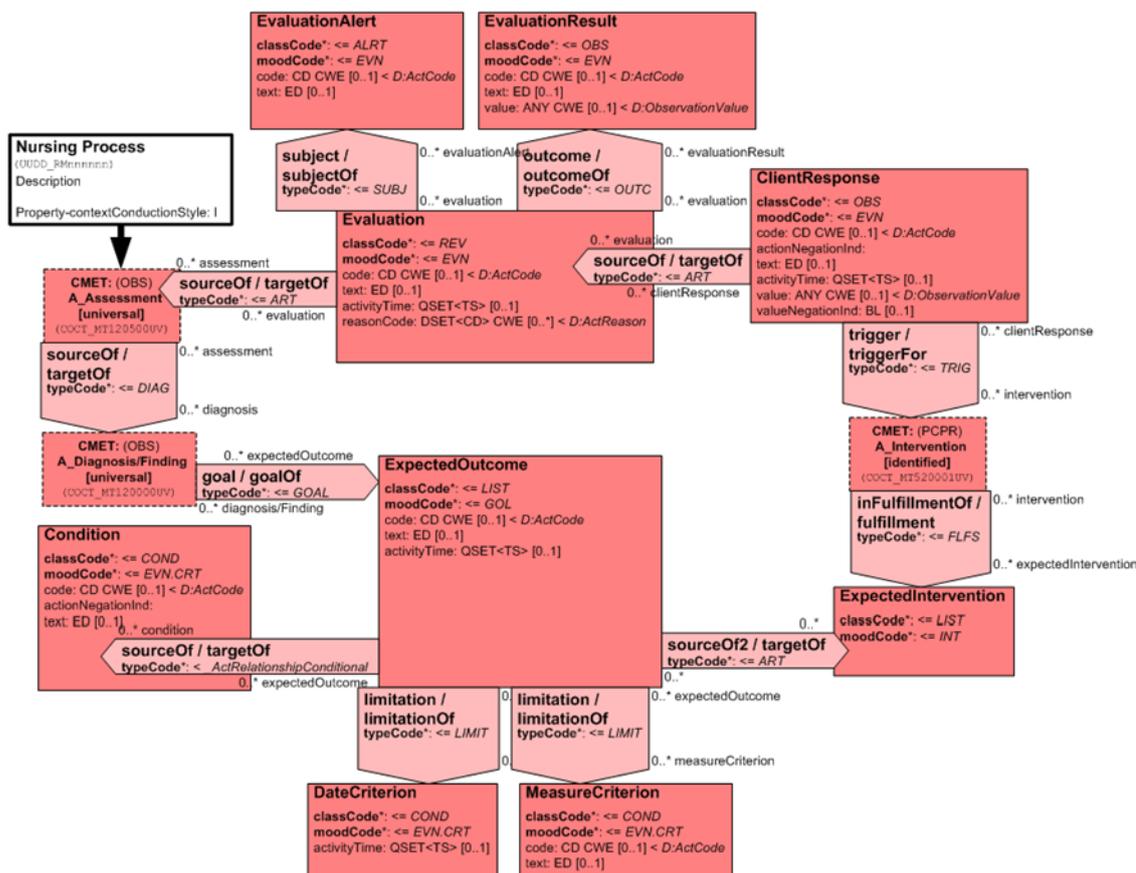

Figure 4. The top level of nursing DMIM. Reading anti-clockwise, beginning with the assessment (see Figure 5), it can lead to a diagnosis or reaching a finding (Figure 6) and then the care plan as modeled by expected outcome and ExpectedIntervention classes. The Intervention (Figure 7) leads to the response which is evaluated generating results and possible alerts

It represents the top level nursing DMIM which is based on A_Assessment, A_Diagnosis/Finding, A_Intervention CMETs which are shown in figures 5 to 7, respectively. The top-level model starts with an entry point named "Nursing Process," so we can navigate the model from the entry point through the Act classes via the Act Relationship connections. A detailed description of key classes is listed in Table 2.

Effects of the nursing information domain model on the CDA

As the CDA can be used for exchanging nursing documents, it was, therefore, appropriate to compare the RIM mapped model with the CDA RMIM.

Table 2. Describes some of the key classes in the DMIM diagrams.

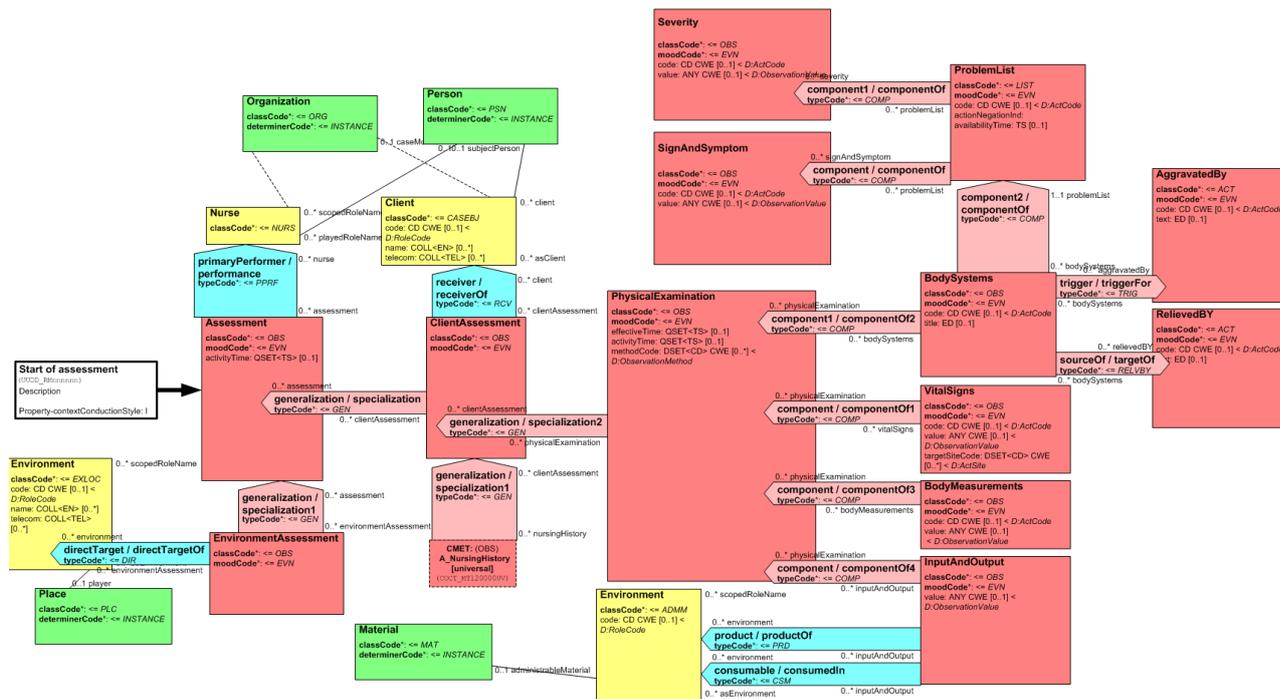|	
A_ Assessment (Figure 4)	Represents the module containing a collection of classes on assessment, please refer to Figure 5 for further details. The A_ Assessment CMET is associated with the A_ Diagnosis/Finding CMET (Figure 6) by means of the Act Relationship having the diagnosis type code.
A_ Diagnosis/Finding (Figure 4)	This CMET encapsulates the classes for the nursing diagnosis or a finding phase and is related to the *Expected Outcome* class via the Act Relationship with the goal type code.
Expected Outcome (Fig. 4)	This class represents a list of goals (with Act Relationship's type code GOAL) and the outcomes that the nurse expects, based on her/his diagnosis. The outcome will be constrained by criteria such as the degree of measurement and date as related to the Date Criterion and Measure Criterion classes.
Expected Intervention (Figure 4)	The Expected Intervention class with the LIST class code represents a list of expected interventions based on expected outcomes. It is related to the A_Intervention CMET (Figure 7) via the Act Relationship with the FLFS type code, indicating that the A_Intervention CMET module fulfills Expected Intervention class.
A_Intervention (Figure 4)	It corresponds to a list of implemented interventions according to the care plan.
Client Response (Figure 4)	Shows response of patient (or client) to the nursing interventions. It is related to the A_Intervention by means of a triggering relationship. The Client Response also relates to the Evaluation class with ART type code Act Relationship. The Microsoft Visio™ modeling tool does not appear to have an appropriate type code to define this relationship and ART is simply a general Act Relationship type code was used.
Evaluation (Figure 4)	It represents an appraisal of the patient (or client) response. The result of the evaluation is modeled by the Evaluation Result class, and perhaps any inefficiencies in the interventions in the care plan are listed in the Evaluation Alert class.
Assessment (Figure 5)	The Client Assessment and Environment Assessment classes are specialized types of the Assessment class. The Client Assessment is related to the physical examination and nursing history. The nursing history can also be represented as CMET, encompassing the physical, laboratory, mental, social, cultural findings.
Physical Examination (Figure 5)	Core components of physical examination are a review of the body system and body measurement, vital signs and input and output of fluids.
Vital Signs (Figure 5)	The vital signs (such as blood pressure, heart and pulse rates, temperature, etc.) measured by a nurse during a physical examination.
Body Measurements (Figure 5)	This class defines other measurements needed during the physical examination (e.g., height, weight, head and waist circumferences, etc.)
Input And Output (Figure 5)	The control the fluids that the client has received or lost.
Body Systems (Figure 5)	Client body systems are reviewed by the nurse and during that problem of client's systems are determined (showed in Problem List class).
Nursing Diagnosis/Finding (Figure 6)	Any nursing diagnosis or finding is composed of a list of problems and possible sign and symptoms.
Intervention (Figure 7)	A nursing intervention can be started by physician order, other care provider's recommendation or independently by the nurse. Therefore, the Intervention class is related to a "Choice of intervention type" box. The "Interventions" box contains types of interventions that the nurse can perform; Substance Administrations , Education , Procedure, Consultation and Notification classes that respectively represent administration of substances, education of patients or their family, administration of procedures, consultation roles and notification of patient.
Nurse (Figure 7)	This class represents a nurse who is the primary performer of interventions. The nurse is related to the Person class.
Agent (Figure 7)	Agent class defines an individual who is assigned by the nurse to perform an intervention
Service Delivery Location (Figure 7)	The facility where the service is given. Maybe a static building or a moving location (e.g., ambulance, helicopter, etc.). The class is related to the Place class.
R_Recipient Party (Figure 7)	A CMET for representing that are service recipients.

Figure 5. The nursing DMIM for the assessment phase. Reading from left to right, the assessment can take the form of client or environmental assessment. The client assessment can lead to a physical examination of the body system and recording of vital signs, body measurements, and input / output fluids
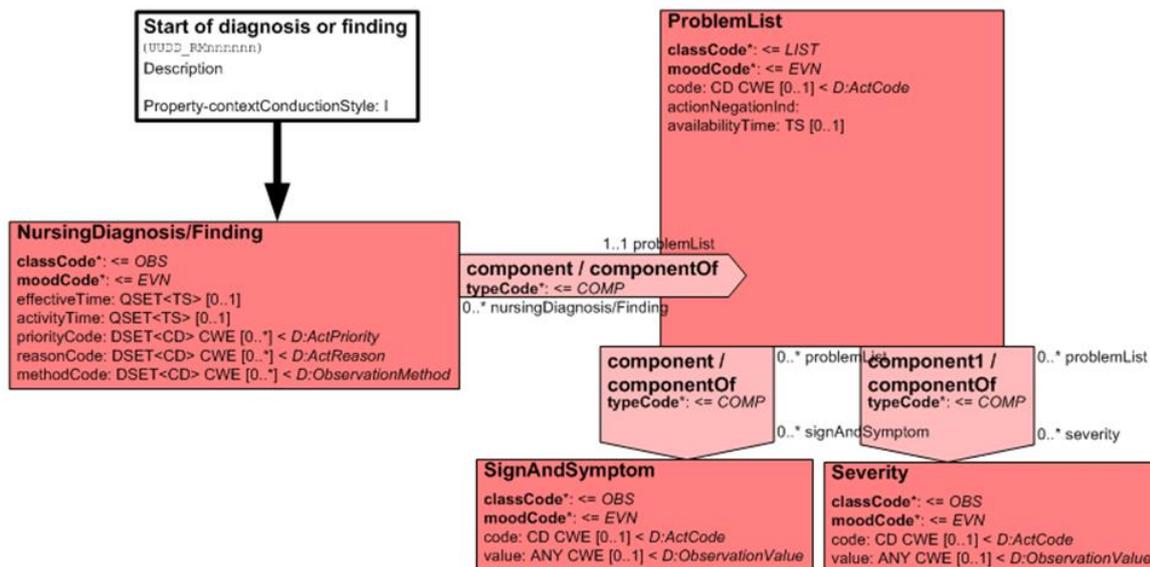

Figure 6. The nursing DMIM for the diagnosis phase. A diagnosis or finding is dependent on at least one or more problems which in turn is associated with signs, symptoms, and degree of severity
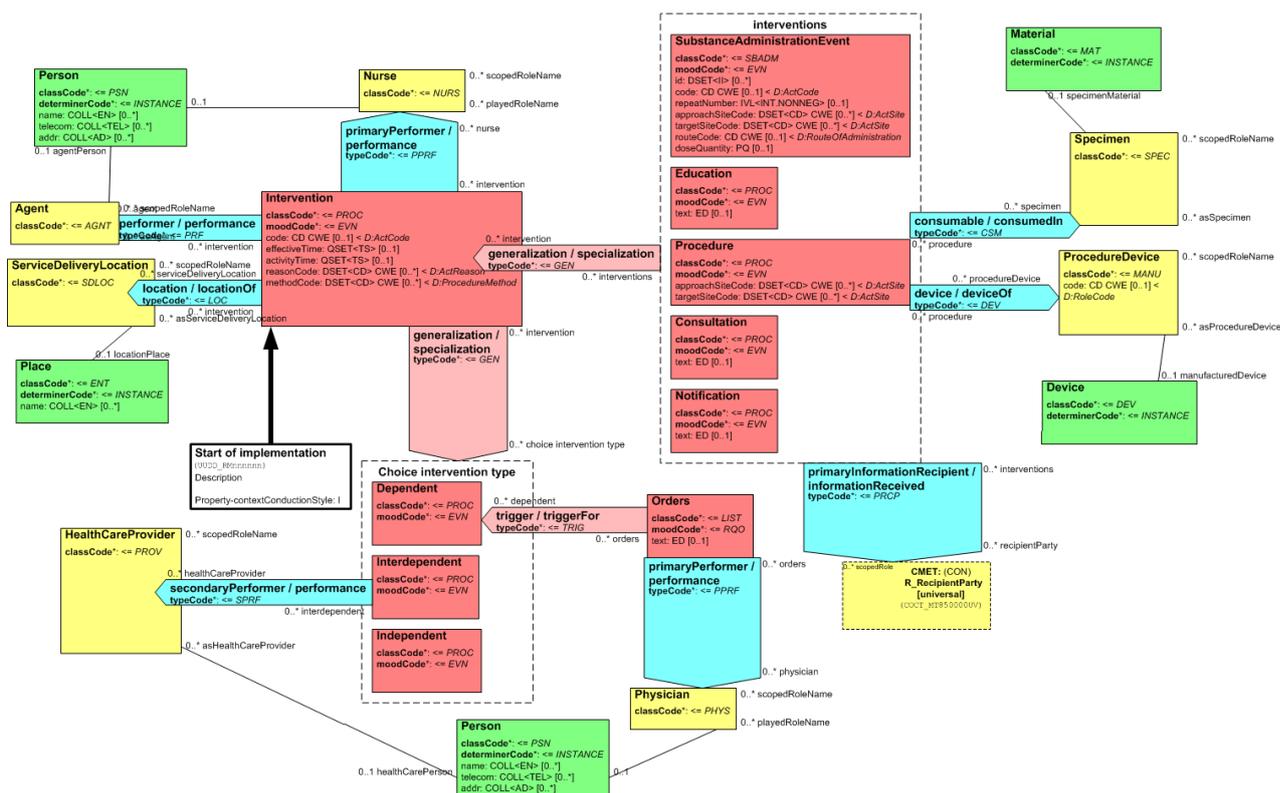
Figure 7. The nursing DMIM for the intervention phase. Reading from left to right, an intervention can be initiated by a nurse or an agent of the nurse (e.g., aide) at a location. This intervention can either be dependent on order, based on the input of another provider or carried out independently by the nurse or the agent. The intervention can take the form of substance administration, procedure, education, notification or consultation

Discussion

Given the variability in clinical notes, including structure, underlying information models, the degree of terminology encoding existing particularly in the nursing environment, it is important that a unified solution for storage and exchange of nursing process to be developed. Previous research efforts in this area have generally been superficial or incomplete, have focused on the particular area of this domain (7-9,21) or phases of the nursing process (11,13,14). We attempted to overcome these shortcomings and present requirements of analysis for all nursing process phases and developed a domain model based on the HL7 RIM. The model developed could ease intercommunication between care providers and improve electronic nursing documentation.

During the DMIM design process, as far as it was possible, appropriate enumerations for *Act Relationship*. Type Code was chosen. However, on three occasions (*expected outcome* and *Expected Intervention*, *Client Response* and *Evaluation*, also *Evaluation* and *A_Assessment*), due to a possible inefficiency in the RMIM Designer modeling tool (or HL7 RIM) not having appropriate type code to define these relationships, therefore ART is a general Act Relationship type code was chosen.

Based on the nursing DMIM that presented, it would be possible to enrich CDA's content by adding appropriate attributes in relation to the exact nursing processes to the CDA RMIM model. According to our comparison between the CDA and the nursing DMIM, the attributes such as *priority Code*, *method Code,* and *reason Code* are required for the CDA *Observation* class in order to represent nursing diagnosis phases in the CDA. Because the CDA consists of sections that can be a component of other section, then it would be possible to generate a nursing workflow to be used in the CDA such that *ClinicalStatement* that set sequentially and nested in each other. Therefore by adding attributes such as DIAG, GOAL, FULFILL, GEN to the CDA *entry Relationship* types, nursing workflows will be supported in the CDA.

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References

1. Health Level Seven Org. (Accessed March 2018, 16, at http://www.hl7.org/implement/standards/index.cfm?ref=nav).

2. Reference Information Model Health Level Seven Org. (Accessed March 2018, 16, at http://www.hl7.org/implement/standards/rim.cfm).

3. Domain Message Information Model Health Level Seven Org. (Accessed March 2018, 16, at http://wiki.hl7.org/index.php?title=Domain_Message_Information_Model).

4. Clinical Document Architecture Health Level Seven Org. (Accessed March 2018, 16, at http://wiki.hl7.org/index.php?title=CDA_R3_Project_Editing).

5. Internasional N. Nursing Diagnosis Definition and Classification 2012-2014. Herdman TH, editor. Jakarta: EGC, 2012.

6. Moorhead S, Johnson M, Maas ML, Swanson E. Nursing Outcomes Classification (NOC)-E-Book: Measurement of Health Outcomes: Elsevier Health Sciences, 2018.

7. Danko A, Kennedy R, Haskell R, Androwich IM, Button P, Correia CM, et al. Modeling nursing interventions in the act class of HL7 RIM Version 3. J Biomed Inform 2003;36:294-303.

8. Kim HS, Cho H Health level 7 development framework for medication administration. Comput Inform Nurs 2009;27:307-17.

9. Vittorini P, Tarquinio A, di Orio F. XML technologies for the Omaha System: A data model, a Java tool and several case studies supporting home healthcare. Comp Methods Programs Biomed 2009;93:297-312.

10. Ioanna P, Stiliani K, Vasliki B. Nursing documentation and recording systems of nursing care. Health Sci J 2007;1.

11. Goossen W, editor. Sending electronic nursing discharge messages using the HL7 v3 Care Provision standard. Nursing Informatics, 2009.

12. Hübner U, Flemming D, Heitmann KU, Oemig F, Thun S, Dickerson A, et al., eds. The need for standardised documents in continuity of care: results of standardising the eNursing summary. MedInfo, 2010.

13. Helleman J, Goossen WT. Modeling nursing care in health level 7 reference information model. Comp Inform Nurs 2003;21:37-45.

14. Goossen WT, Ozbolt JG, Coenen A, Park H-A, Mead C, Ehnfors M, et al. Development of a provisional domain model for the nursing process for use within the Health Level 7 reference information model. J Am Med Informa Assoc 2004;11:186-94.

15. The Omaha System (Accessed March 2018, 16, at Available from: http://www.omahasystem.org/.).

16. The North American Nursing Diagnosis Association (Accessed March 2018, 16, at http://www.nanda.org/.).

17. International Classification for Nursing Practice (Accessed March 2018, 16, at http://www.icn.ch/what-we-do/international-classification-for-nursing-practice-icnpr/.).

18. Refined Message Information Model Designer Current (Accessed March 2018, 16, at https://gforge.hl7.org/gf/project/visio-rmim-desi/frs/.).

19. RoseTree (Accessed March 2018, 16, at https://gforge.hl7.org/gf/project/rose-tree/frs/.).

20. Whittenburg L, Meetim A. Electronic Nursing Documentation: Patient Care Continuity Using the Clinical Care Classification System (CCC). Stud Health Technol Inform 2016;225:13-7.

21. Corbin JM. A nursing model for chronic illness management based upon the Trajectory Framework. Sch Inq Nurs Pract.1991;5:155-74.