PS4: Final Project Proposal (Project Sprint 4)

Group Name: **ICD – 5**

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Use Case B: **Clinician to lab - orders from EHR to be generated as a lab worklist item**

Introduction

A collection of terminology used in patient assessment, patient management, and treatment is referred to as "health care standards and terminologies." The terminology used in healthcare is coded differently in several standard coding systems. Some of the several coding systems are SNOMED-CT, ICD-10, CPT, and LOINC. Standard terms and structured reporting are required for any medical information to be used properly in public health and research. Medical terminology has been standardized to store medical information in electronic medical records, retrieve it when needed, reuse it, and enable efficient communication between users (Awaysheh et al., 2018). By reducing the frequency of adverse events and misdiagnosis, medical standards and terminologies are used to improve healthcare. This standardization of medical information directly impacts patient care and coordination. The selected use case study has been carefully examined for this project to identify the many signs, symptoms, lab tests, and diagnosis.

We have used four standard terminologies, namely ICD-10-CM, CPT, LOINC, and SNOMED CT, to associate and compare each of these. These terminologies enable us to construct systems for ensuring patient safety and supporting advancements in the healthcare industry.

A standard coding system called the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD10-CM) enables clinicians to assign diagnosis codes to a variety of diseases and associated health issues. It classifies diseases according to a unique alphabetical coding system. The World Health Organization (WHO) provided ICD 10-CM coding, which is used in clinical and outpatient settings in the US (Holman & DelVecchio, 2018).

CPT stands for Current Procedural Terminology, and "CPT codes offer doctors and health care professionals a uniform language for coding medical services and procedures to streamline reporting, increase accuracy, and increase efficiency." (CPT Overview and Code Approval. American Medical Association, n.d.). Clinical procedural reporting (CPT) is a standard method for

describing clinical operations like "surgical, radiological, laboratory, anesthesia, genetic sequencing, evaluation, and treatment." (CPT Overview and Code Approval. American Medical Association, n.d.).

Clem McDonald founded the logical observation identifiers names and codes, or LOINC, in 1994, which is a global nomenclature for laboratory and clinical observations. Information about patients' outcomes, therapies, and lab findings is shared between different healthcare facilities using LOINC. LOINC upkeep is the responsibility of Regenstrief, an entity affiliated with Indiana University. This non-profit organization was created by the LOINC Committee. It was developed in response to the expanding trend of electronic health records (EHR)-based information sharing and is used to transport data to hospitals and clinical offices, where it is used to manage clinical treatment (McDonald et al., 2003).

Systematized Nomenclature of Medicine - Clinical Terms is known as SNOMED CT. In healthcare contexts, SNOMED-CT is a comprehensive, multidisciplinary medical terminology standard. It is a source with extensive clinical information that has been endorsed by experts. It is compatible with various international standards like HL7, CPT, and ICD-10. SNOMED-CT is crucial for health records because it allows for the preprocessed display of complex clinical data. SNOMED-CT nomenclature is substantially different from ICD-10. SNOMED-CT is intended for use by medical professionals throughout the course of treatment, whereas ICD-10 is meant for coding specialists to use after the episode of care is over. SNOMED-CT terminology can enhance data quality and patient safety by recording clinical data in a standard, clear, and detailed manner (Dennis et al., 2014).

UML and BPMN have been developed for the use-case scenario "B" in this project. UML stands for Unified Modeling Language. Class architecture, interpretations, and their relationships are shown using UML. UML has several features that most semantic data languages lack, such as profiles, global configurability, and adaptation methods (Baclawski et al., 2002). Business (institutional) systems are prototyped using the user-friendly language BPMN (Business Process

Modeling Notation). In a broader sense, it refers to a piece of software that makes it possible to characterize and analyze complicated interactions through the comparatively straightforward use of visual images (Scheuerlein et al., 2012).

Use Case & Terminologies

Clinical elements in the use case:

After carefully reviewing the selected use case study, the following clinical elements have been noted down. These clinical elements consist of signs, symptoms, diagnosis, and laboratory tests mentioned in the use case study.

1. **Lethargy:**

   ICD-10-CM: The ICD10-CM code is R53.83 and it is being used since October 1, 2021. This sign is most commonly applicable to tiredness, lack of energy, fatigue. It also means lack of energy and sluggishness to do basic activities. [Link]

   SNOMED-CT: The SNOMED-CT code for Lethargy is 2142264003. [Link]

   LOINC: The LOINC code 45495-9 is applicable to periods of lethargy. [Link]

2. **Generalized weakness:**

   ICD-10-CM: The ICD10-CM suggests the code M62.81 for generalized weakness in a patient. The code covers symptoms like muscle weakness in general and trunk muscle weakness. [Link]

   SNOMED-CT: The SNOMED-CT code for generalized weakness is 260407003. [Link]

   LOINC: The LOINC code 66669-3 refers to weakness and muscle weakness. This sign shows a lack of energy in the body that causes weakness. [Link]

3. **Inability to do routine work:**

   ICD-10-CM: The ICD-10 code for decreased activity is Z73.6. This sign shows that there has been decreases activities due to life management and tasks.[Link]

   SNOMED-CT: The SNOMED-CT code for alteration in daily living activities is 129818000. [Link]

4. **Excessive bleeding during menstruation:**

   ICD-10-CM: ICD10-CM suggests the billable code N92.0 for heavy bleeding during menstrual cycle. This is applicable to excessive and frequent menstruation which is also called Menorrhagia. [Link]

   SNOMED-CT: The SNOMED-CT code for excessive bleeding during menstruation is 386692008. [Link]

   LOINC: Menstrual history is denoted by the LOINC codes 62668-9, and menstrual status is denoted by 3146-8. Menorrhagia, often known as heavy menstrual bleeding, is sometimes common and other times lasts more than seven days.[Link][Link]

5. **Breathlessness:**

   ICD-10-CM: ICD- R06 is the code used to denote shortness of breath, although it lacks specificity other billable codes include more information depending on the type of breathlessness being discussed—such is shortness of breath, acute respiratory distress syndrome, respiratory arrest, or respiratory failure.[Link]

   SNOMED-CT: The SNOMED-CT code for 267036007. Another name for this ailment is Dyspnea. [Link]

LOINC: The LOINC code for breathlessness is 82950-7. Chest discomfort can cause breathing difficulties occasionally. [Link]

6. **Palpitations:**

ICD-10-CM: The ICD10-CM code for palpitations is R00.2 and it is a billable code. It explains the clinical situation when an unpleasant sensation and irregular heartbeats are experienced by a person. [Link]

SNOMED-CT: The SNOMED-CT code for palpitations is 80313002. [Link]

LOINC: LOINC code 76281-5 is assigned to palpitation. Stress is the main reason of palpitations, exercise that is difficult or depression could also be contributing factors. [Link]

7. **Light-headedness:**

ICD-10-CM: The ICD10-CM's R42 code was created to represent lightheadedness. The code is used for giddiness and dizziness, but it can also be used for lightheadedness and a condition called vertigo.[Link]

SNOMED-CT: The SNOMED-CT code for 386705008. [Link]

LOINC: Dizziness or vertigo is covered under the LOINC code 45699-6. Lightheadedness is caused by a number of reasons, such as hypotension and abrupt changes in posture. [Link]

8. **Cramping in legs:**

   ICD-10-CM: The ICD10-CM system recommends using the code R25.2 for cramping legs. It is commonly used for cramps and spasms, but it may also be used to discuss muscle cramps, bilateral leg cramps, benign cramp syndrome, etc. [Link]

   SNOMED-CT: The SNOMED-CT code for cramps in legs is 449918009. [Link]

   LOINC: Leg cramps are classified as LOINC code 66093-6. It can result from standing in one place for a long time or from a strained muscle. Dehydration can lead to this occasionally.[Link]

9. **Desire to crunch on ice:** This is a condition that is associated with compulsive eating disorders. It is also known as Pica.

   ICD-10-CM: The ICD-10 code for Pica is F50.89. [Link]

   SNOMED-CT: The SNOMED-CT code for Pica is 423790006. [Link]

10. **No history of fear:**

    ICD-10-CM: The ICD-10 code there was no specific code indicating no history of fear. However, fear of any specific kind is F40.2. [Link]

    SNOMED-CT: The SNOMED-CT code for fear of any specific kind is 1402001.[Link]

11. **No history of abdominal pain:**

    SNOMED-CT: The SNOMED-CT code for no history of abdominal pain situation is 162037008. [Link]

12. No history of drug intake:

SNOMED-CT: There is no code for no history of drug abuse. However, the SNOMED-CT code for nondependent substance or drug abuse disorder is 66214007.[Link]

13. Appetite has also decreased:

ICD-10-CM: R63.0 is the code for appetite loss. It mainly covers lack of appetite due to cancer, mental disorder, or other diseases.[Link]

SNOMED-CT: The SNOMED-CT code for this is 64379006.[Link]

LOINC: Decreased appetite in LOINC is represented by the code 65961-5.[Link]

14. Taking meals once a day:

ICD-10-CM: Z72.4 is the code for inappropriate eating habits as suggested by ICD10-CM. This code covers eating disorders, lack of adequate food, and malnutrition and other nutritional deficiencies. [Link]

15. Had tachycardia:

ICD-10-CM: ICD10-CM gives R00.0 as the code for Tachycardia. This covers inappropriate heart rate, sinus tachycardia, and rapid heartbeat.[Link]

SNOMED-CT: The SNOMED-CT code for this is 3424008. Tachycardia is a condition where heart rate is increased rapidly.[Link]

LOINC: Rhythmic or arrhythmic heart rate in LOINC is represented by 88104-5 code. [Link]

16. **Pale gums:**

ICD-10-CM: The code is K06.8 and covers signs and symptoms like giant cell epulis, flabby alveolar ridge. [Link]

SNOMED-CT: The SNOMED-CT code for pale gums is 274134003. This condition is also known as “Leukoplakia”. [Link]

LOINC: 34013-3 is the LOINC code for the Gingiva periodontal assessment.[Link]

17. **Nail beds:**

ICD-10-CM: L60.9 is the code for nail beds. This basically covers all types of nail disorders and nail diseases along with discoloration of nails and fungal or bacterial infections in nails.[Link]

SNOMED-CT: The SNOMED-CT code for nail beds is 719193000. [Link]

18. **Swollen tongue:**

SNOMED-CT: The SNOMED-CT code for Swollen tongue is 45534005. This condition is also known as Glossitis. [Link]

LOINC: The LOINC code for physical findings of the tongue is 32483-0.[Link]

19. **Anemic:**

ICD-10-CM: D64.9 is the code for anemia. The code covers many types of anemia like anemia due to pregnancy, due to medication, due to radiation or other diseases.[Link]

SNOMED-CT: The SNOMED-CT code for anemic condition is 271737000.[Link]

LOINC: The LOINC code for anemia is 45676-4.[Link]

20. Blood sample ordered:

SNOMED-CT: The SNOMED-CT code for blood sample is 119297000.[Link]

LOINC: 58410-2 is the LOINC code for Blood by Automated count.[Link]

Terms

Sr. No.	Term Description	Terminology codes	Rationales
1.	Lethargy	**ICD-10-CM:** R53.83 **SNOMED-CT:** 214264003 **LOINC:** 45495-9	• The term "lethargy" has a parent-child relationship with the term "lack of lethargy" as the parent with parent ID as "248274002" and this matches the exact symptom of our patient in our use case (American Hospital Association, 2020). • The LOINC code system describes the word lethargy as sluggishness and little body movement which is matching the description of our patient's signs and symptoms (Eilers & Harrington, 2017).
2.	Generalized weakness	**ICD-10-CM:** M62.81 **SNOMED-CT:** 260407003 **LOINC:** 66669-3	• Generalized weakness is often referred to as muscle weakness which causes reduction in strength of muscles in multiple anatomic sites (Bhimani et al., 2021). • ICD-10 code system also states that generalized weakness is synonymous with trunk muscle weakness and relates to various muscle diseases as well.
3.	Inability to do routine work	**ICD-10-CM:** Z73.6 **SNOMED-CT:** 129818000	• ICD-10 provides code for this condition and relates it to the condition where people don't feel like standing up for their daily chores as well like cooking, bathing, washing which is exactly what our patient also complaints about. • In ICD-10 code system, this also has relationships with terms like "limited activity", ''disability to do work".
4.	Excessive bleeding during menstruation	**ICD-10-CM:** N92.0 **SNOMED-CT:** 386692008	• In ICD-10, this is termed as Dysmenorrhea which covers complaints about menses that are painful or irregular (Ryan, 2017). • In SNOMED, this is termed as Menorrhagia which includes profuse menstrual flow and heavy bleeding.

5.	Breathlessness	**ICD-10-CM:** R06.02 **SNOMED-CT:** 267036007 **LOINC:** 82950-7	• A condition where chest feels tight or heavy and the pains gradually spreads to arms, neck, and jaw which is related to palpitations as told by our patient. • This has been related to terminology "shortness of breath" in some coding systems where the patient struggles to breathe (Kupchik & Green, 2021).
6	Palpitation	**ICD-10-CM:** R00.2 **SNOMED-CT:** 80313002 **LOINC:** 76281-5	• It is subclass of 'Finding related to awareness of heartbeat in SNOMED coding (SNOMED CT - Palpitations – Classes, n.d.) • In ICD-10 coding, it is specific to arrhythmias.
7	Light-headedness	**ICD-10-CM:** R42 **SNOMED-CT:** 386705008 **LOINC:** 45699-6	• The sensation of the external world revolving around the patient in this disorder. (2023 ICD-10-CM diagnosis code R42. 10, n.d.) • Interprets consciousness and general wellbeing. (SNOMED CT - Lightheadedness – Classes, n.d.)
8	Cramping in legs	**ICD-10-CM:** R25.2 **SNOMED-CT:** 449918009 **LOINC:** 66093-6	• Any kind of anomaly moment such as spasm or cramps use this code. (2023 ICD-10-CM diagnosis code R25.2. 10, n.d.) • SNOMED can be used to identify restless leg syndrome in anemia. (SNOMED CT, n.d.)
9	Desire to crunch on ice	**ICD-10-CM:** F50.89 **SNOMED-CT:** 423790006	• The ICD-10-CM for Desire to crunch on ice is F50.89, it is also known as Pica. This is applicable to Pica in adults and Psychogenic loss of appetite. • The SNOMED-CT code for Pica is 423790006. The compulsive consumption of foods with no nutritional value is a symptom of pica. The cause of pica is not solitary.
10	No history of fear	**ICD-10-CM:** No specific code. **SNOMED-CT:** No specific code.	• ICD-10-CM: No specific code indicating no history of fear. However, fear of any specific kind is F40.2. • SNOMED-CT: Code for fear of any specific kind is 1402001.
11	No history of abdominal pain	**ICD-10-CM:** No specific code. **SNOMED-CT:** 162037008	• ICD-10-CM: No specific code indicating no history of abdominal pain. • SNOMED-CT: Code for no history of abdominal pain situation is 162037008.

12	No history of drug intake	**ICD-10-CM:** No specific code **SNOMED-CT:** No specific code	• ICD-10-CM: No specific code indicating no history of drug intake. • SNOMED-CT: No specific code indicating no history of drug intake. The SNOMED- CT code for nondependent substance or drug abuse disorder is 66214007
13	Appetite has also decreased	**ICD-10-CM:** R63.0 **SNOMED-CT:** 64379006 **LOINC:** 65961-5	• The ICD-10-CM for this was selected because it indicates loss of appetite(ICD10Data.com, 2019) • An inability to eat, accompanied by an aversion to food, along with a physio pathological loss of appetite(ICD10Data.com, 2019)
14	Taking meals once a day	**ICD-10-CM:** Z72.4	• This code indicates eating disorders, lack of proper food and other nutritional deficiencies(ICD10Data.com, 2019) • It also deals with improper eating habits and diet(ICD10Data.com, 2019)
15	Had tachycardia	**ICD-10-CM:** R00.0 **SNOMED-CT:** 3424008 **LOINC:** 88104-5	• The term Tachycardia describes rapid heartbeat and inappropriate heart rate(ICD10Data.com, 2019) • As per the LOINC code, it is an arrhythmic heart rate.
16	Pale gums	**ICD-10-CM:** K06.8 **SNOMED-CT:** 274134003 **LOINC:** 34013-3	• As per the SNOMED-CT coding system, the condition defined for pale gums is “Leukoplakia” that covers symptoms like oral mucosa. • The LOINC class attribute for pale gums falls under the “Dental” umbrella and the component is “Periodontal evaluation”
17.	Nail Beds	**ICD-10-CM:** L60.9 **SNOMED-CT:** 719193000	• The ICD-10 for nail beds code is represented as L60.9 which is indicated as diagnosis for reimbursement purposes. This concept is limited to primates • The SNOMED-CT code for nail beds is 719193000. Different standards have various codes, but the description will be the same as it in turn maps to the whole concept.
18.	Swollen Tongue	**SNOMED-CT:** 45534005 **LOINC:** 32483-0	• Inflammation of tongue in SNOMED-CT is represented as 45534005. It is also known as glossitis. This matches to the patient symptoms which is related to tachycardia. • The LOINC system represented a code for the swollen tongue which is 32483-0. This

			standard is taken to know the code for the swollen tongue. Overall, it maps to the common findings related to the same.
19.	Anemic	**ICD-10-CM**: D64.9 **SNOMED-CT:** 271737000 **LOINC:** 45676-4	• The code ICD-10-CM: D64.9 has covered many common findings related to anemia. Which include anemia due to pregnancy, due to medication, due to radiation or other diseases. The mentioned conditions maps to a single code. • The SNOMED-CT code is represented as 271737000. It also covers some common conditions related to Anemia. • The LOINC code for anemic condition is 45676-4. It also represents various anemic conditions.
20.	Blood sample ordered	**SNOMED-CT:** 119297000 **LOINC:** 58410-2	• The blood sample ordered diagnosis is represented as a code in SNOMEDCT. Which is 119297000. It represents the diagnosis of patients by which defects can be known through results. • The LOINC code for the diagnosis called blood sample order is represented as 58410-2. It links to the diagnosis of an individual.

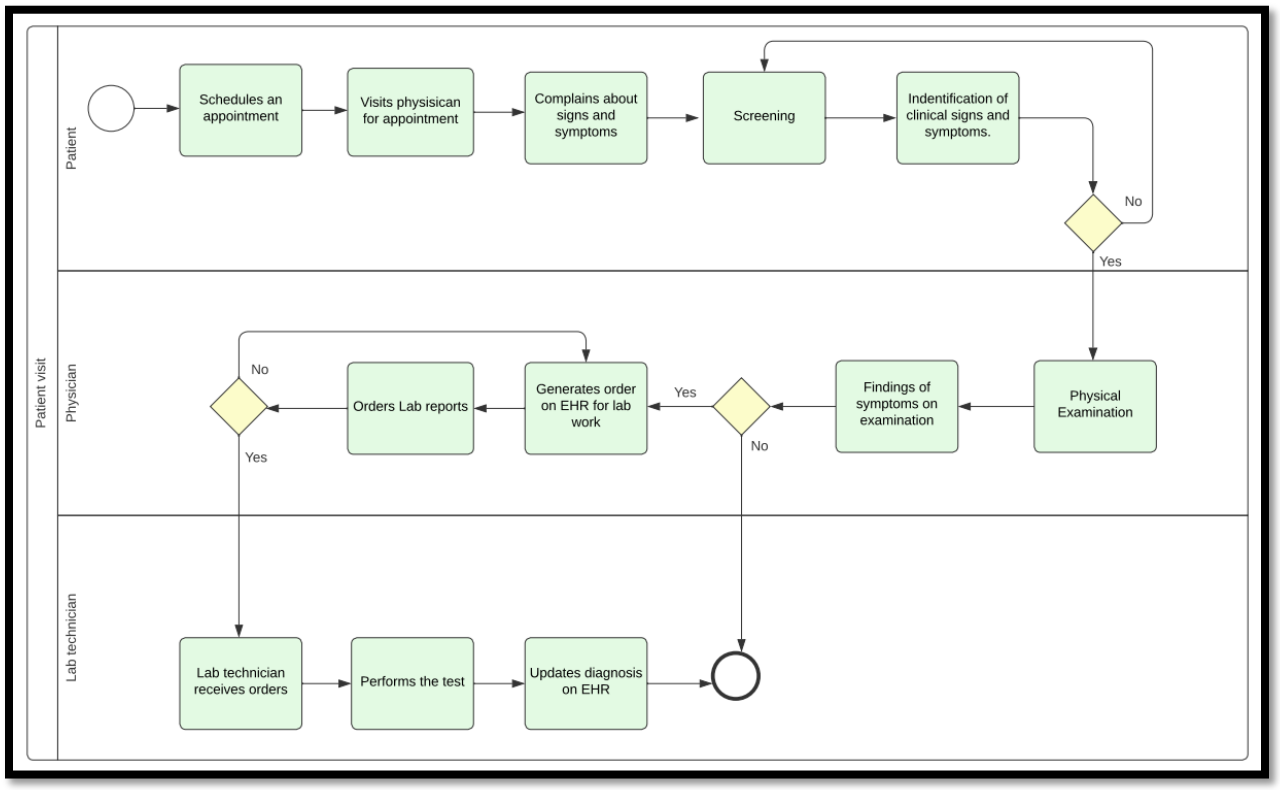
Business Process Modeling Notation(BPMN) steps

A semantic workflow model of interoperability is included in the Business Process Modeling Notation (BPMN). A working system's workflow can be represented by it. This diagram uses a variety of symbols, including circles for events, diamonds for gateways, rectangles for activities, and lines for connections. For the given example, the workflow includes the patient visiting a physician and receiving laboratory orders from the physician. A chain of events is represented as a collection of events dependent on one another. We chose a use case that consists of three swim lanes representing interoperability between patients, physicians, and laboratory technicians. Human interoperability is defined by the first layer. Schedule an appointment with a physician, visit the physician, communicate signs and symptoms, conduct a screening, and identify clinical symptoms

in this lane. In addition, this opens a door towards physician's lanes. A clinical diagnosis involves identifying signs, generating a workflow, and ordering lab reports in the physician's lane, which further results in the patient facing a physician's lane. Lab technicians' lane is again reached through a gateway. Receiving lanes, performing tests, and updating diagnoses on the EHR. The interoperability system reaches its conclusion here.

In the given used case, we had to use a single pod, three laned diagram. There was a single point of initiation leading to activities. In the selected case, it was ‘to schedule an appointment’. It further leads to multiple activities. Consequently, when conditions come up, we had to create gateways.

According to the given used case, there are three lanes, representing three actors. Each actor has corresponding workflows, and gateways are required to navigate through the lanes. However, there is exactly only one start event and one end event in this case.



Model 1: BPMN diagram illustrating the Patient-Physician Examination flow

Workflow for the BPMN model

The event starts with the patient scheduling an appointment, in the patient lane. Later she visits the physician for her appointment. She complains about the signs and symptoms. Screening is conducted. Later the identification of clinical signs and symptoms is validated.

A gateway is opened over here to see if the signs and symptoms have been observed or not, and the event navigates to the 2nd lane. If not, the patient must undergo screening again, in the 1st lane. If yes, the patient must undergo a physical examination. During the physical examination the physician observes more signs and symptoms. This opens to another gateway. If the physician does not find any signs and symptoms, the BPMN will reach the end point. If the physician finds signs and symptoms, he will generate an order on the EHR for lab work. This generates another gateway to the 3rd lane, if or not the lab technician receives the order. If not, the order should be generated again. If yes, the lab technician receives the order, performs the test, and updates it on the EHR. After updating, the event ends.

UML Relations

Unified Modelling Language (UML) for Patient-Physician workflow

Data Elements:

In the below UML diagram, we demonstrate an appointment encounter between a patient

and her physician. Our use case describes a situation where we have an 18-year-old female who wants to go for an appointment with a physician. The patient observed some signs and symptoms like

generalized weakness, lethargy and was not feeling good about it. On being questioned further by the physician, she explained other changes that she noticed in her body like decreased appetite, breathlessness, and palpitations while climbing stairs. She further told the physician that she observed a few more symptoms like instant desire to crunch on ice, cramping in legs. We use an UML diagram to depict the encounter between the patient and the physician. The UML diagram explains the associations of the classes and the objects in a system.

From the diagram all the signs/symptoms and the changes she told the physician were the information that was passed on from one actor (patient) to another actor (physician) in the system. We have two actors in our case one is the patient and the other is the physician.

The signs/symptoms in the use case act as the attributes of the patient.

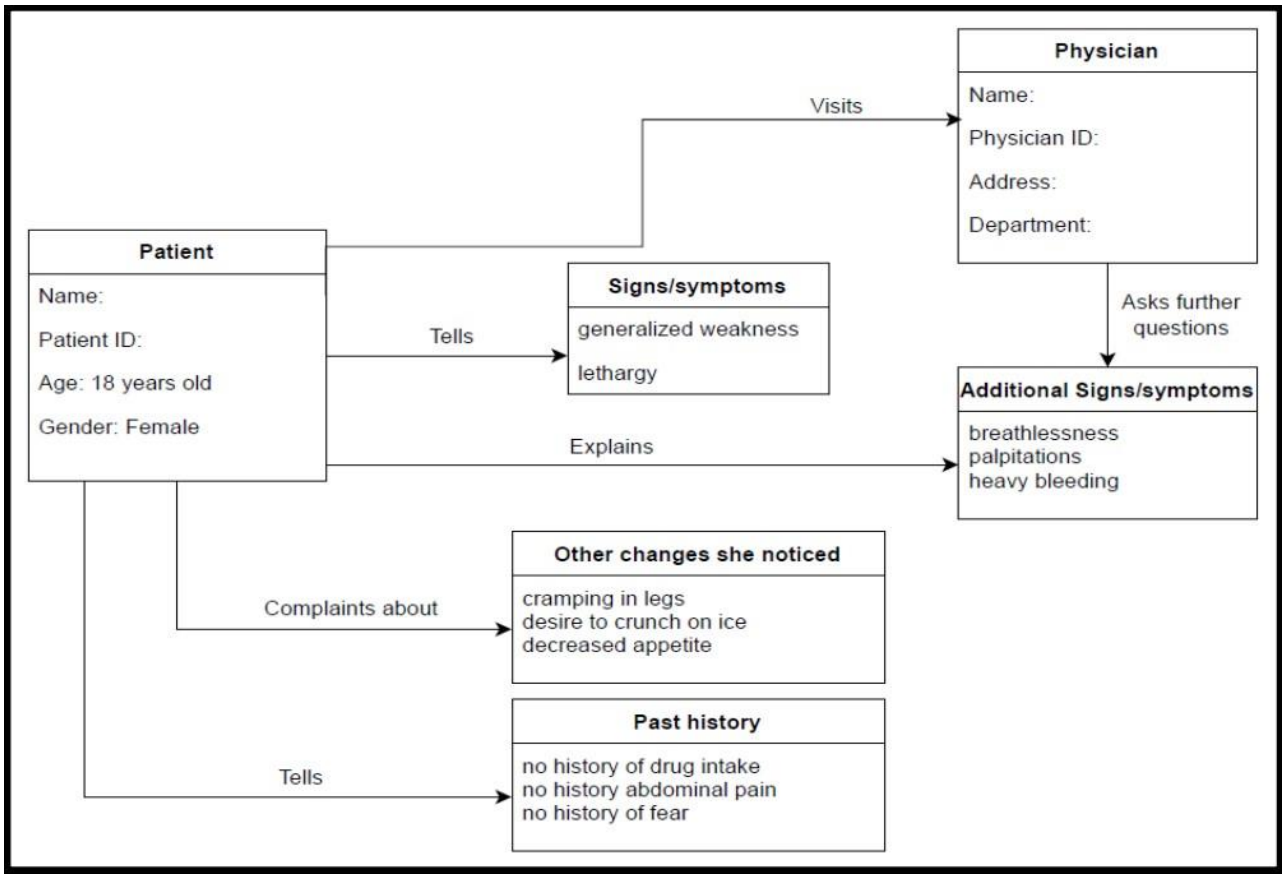
Footnotes:

•The unique ID attribute for the patient as well as the physician will prevent from confusing between two patients or two physicians with same names at the same time and will allow to identify them distinctly.

•The signs/symptoms and the health-related changes that the patient listed out to the physician will allow the physician to examine her properly and figure out the appropriate treatment plan for her accordingly.

Types of Interoperability:

Semantic: This scenario addresses the semantic interoperability. Semantic interoperability is where two or more systems communicate with each other for exchange of information in such a way that both can interpret it. The passing of the information is very crucial as it forms the base for the functioning of the framework. In this UML diagram, we depict the scenario where the patient in our use-case meets up for an appointment with the physician and shares some information regarding her condition. In our use-case, the patient gave details about the signs and the symptoms that she was experiencing and this information that was passed on from the patient to the physician and then eventually it was recorded in the patient Electronic Health Record (EHR) which was further taken as the input by the examination tool which yields out her final diagnosis. It is necessary for the framework to be semantically interoperable as this will allow the physician to interpret the details given by the patient correctly for understanding her condition.



Model 2: UML diagram illustrating the Patient-Physician workflow

Steps for Unified Modelling Language (UML) for Patient-Physician encounter:

Actors: Patient, Physician

Steps:

Step 1: The first step in our UML diagram is that the patient visits the physician's clinic. For consultation.

Step 2: The second step explains the conversation between our patient and the doctor where she explains out the problems she had been suffering from for the past few months like generalized weakness, lethargy, and inability to do the routine work.

Step 3: The next step covers the scenario where after listening to the patient, the physician wants to know more details and questions the patient further where she tells the doctor about the signs and symptoms that she has been observing for quite some time, like heavy menstruation cycle, periods of palpitations, shortness of breath, fainting while climbing stairs and many more.

Step 4: Next, the physician is interested in knowing a few details about the patient's history and finds out that she does not have any drug intake history, no abdominal pain history, and no history of fear as well.

Step 5: To be sure of the patient's condition and to provide her with the best treatment, the physician asks a few more questions where she reveals additional information like cramping in legs, her desire of crunching on ice and her decreased appetite.

Unified Modelling Language (UML) for Physician-Lab Technician workflow

Data Elements:

The physician examined the patient and found out that she had tachycardia, pale gums, nail beds, and a swollen tongue. The physician suspected that the woman was anemic based on her history and the findings of her physical examination and asked for a blood sample for testing. The lab information system's worklist item should be generated using the lab orders from the EHR. The clinician gave instructions to the lab technician, who then performed the test. The test findings need to be updated in the EHR.

Definitions: The terms "diagnosis code" and "procedure code" denote the terminology's code for the diagnosis or procedure that was carried out, respectively. Depending on the clinic, this could change. For the doctor, it might be SNOMED-CT, but for the lab technician, it might be LOINC.

The Physician attribute contains three fields: physician_name, physician_id, and conducts_examination, which describe the activity the physician will perform on the patient. The physician_name field contains the name of the physician who will conduct the examination.

For the Physical Examination attribute, patient_signs_symptoms, patient_history, and patient_findings are the clinical findings that the physician assessed during the consultation that are related to the patient in the use case study.

For the Diagnosis and Procedures attribute, the diagnosis_name, and procedure_name, include details about the conditions the patient was diagnosed with and the treatments the physician prescribed following a checkup.

For the Lab Technician attribute, the lab_technician_name and conducts_test is the name and activity of the technician who will perform the requested test respectively, lab_technician_id indicates the unique value associated with each lab technician.

For the EHR attribute, lab_orders are added to the worklist item by the physician for the technician to perform and lab_results are the test results updated by the technician back to the EHR.

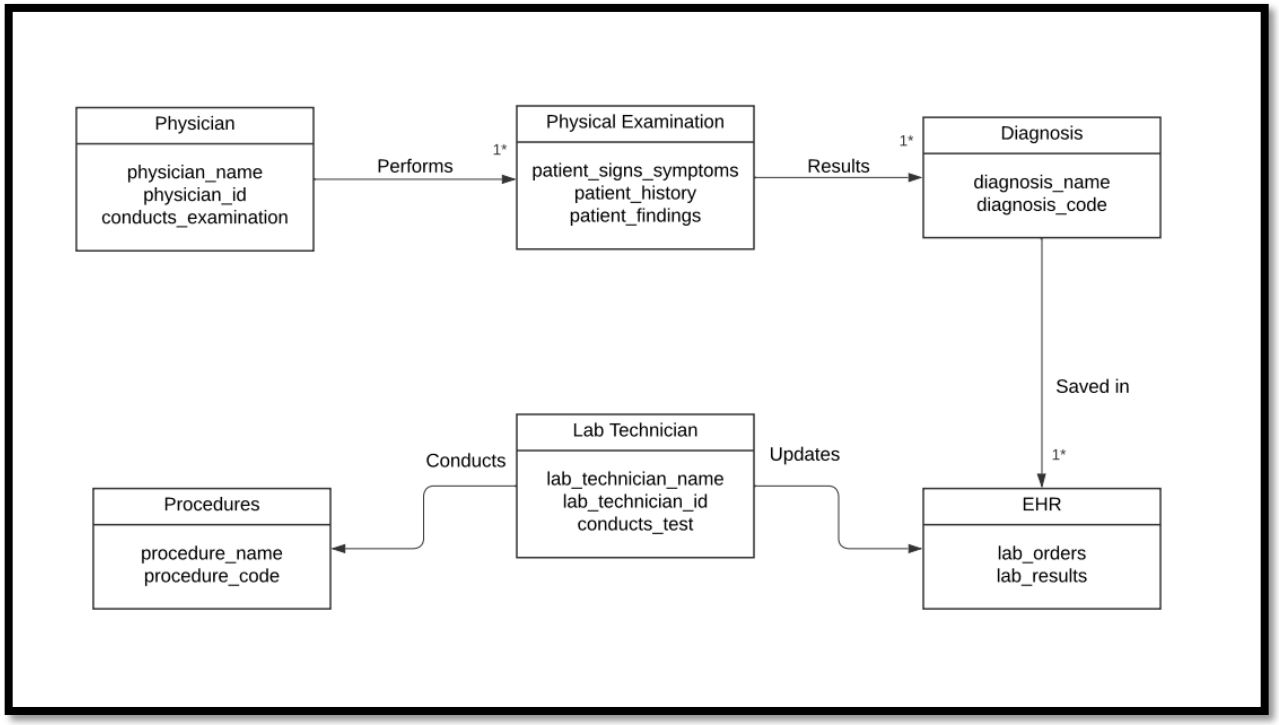
Footnotes:

patient_signs_symptoms have a major effect on the diagnosis provided.

Types of interoperability:

Process: This can be observed at attribute levels Diagnosis and EHR. The lab orders from EHR should be generated and added to the lab information systems worklist item.

Human: This can be observed at attribute levels Physician and Physical Examination. Given the patients history and the findings on her physical examination, the physician conducted the diagnosis.



Model 3: UML diagram illustrating the Physician-Lab Technician workflow

Steps for Unified Modelling Language (UML) for Physician-Lab Technician encounter:

Actors: Physician, Lab Technician

Steps:

Step 1: The first step in this UML diagram is that the physician performs a physical examination on the patient.

Step 2: During this process, the physician identifies the patient's signs and symptoms, her history, and findings. Upon examining, her physician found that she had tachycardia, pale gums and nail beds, and her tongue was swollen.

Step 3: The results produced at the end of the physical examination, and given her history and the findings, the physician suspected that the patient was anemic and ordered a sample of her blood for further diagnosis and examination.

Step 4: The results were saved in the EHR system by the physician to generate the lab orders for the lab technician. The lab orders from EHR should be generated and added to the lab information systems worklist item.

Step 5: The lab technician received orders from the physician and performed the test. These test results were updated in the EHR.

Situation not modelled in the diagram:

The patient's prior test results, in our opinion, are the condition that is not being modelled here. Her earlier reports would have provided a clearer picture of her blood sugar levels and other necessary components in her body. These reports may aid the physician in developing a better understanding of her condition and ultimately aid in creating a more precise treatment strategy for her.

Conclusion

Clinical medicine receives more attention than clinical research when it comes to standards for representing, managing, and sharing data, despite the fact that the necessity for data standards and terminologies in clinical research is becoming increasingly apparent. (Richesson et al., 2006). We have used a variety of terminologies and done research on their application in the medical field for

our project proposal. We used SNOMED-CT, ICD-10, LOINC, and CPT explored and discovered standard codes. As our studies progressed, we discovered that CPT is used as a standard vocabulary for surgical procedures, including small surgeries carried out by doctors. Additionally, we were able to locate the ICD-10 and SNOMED-CT codes for the majority of the signs and symptoms. There were a few circumstances, though, in which the term did not have a direct code but instead fell under a broader category. We found that SNOMED-CT appears to be appropriate for representing a range of clinical healthcare concepts. (Richesson et al., 2006). It and can be used to represent medical information that provides high specificity (Awaysheh et al., 2018). It is very useful to report diagnostic information with SNOMED-CT codes (Awaysheh et al., 2018). A mechanism for filtering set value definitions and searching for operators is also built into the FHIR mechanism, making SNOMED-CT an HL7- FHIR standard (Richesson et al., 2006). ICD-10-CM on the other hand provides more data about the severity of a patient's signs, symptoms, and medical conditions (Holman & DelVecchio, 2018). Furthermore, LOINC codes were also used as this provides a universal code system for reporting laboratory and clinical observations in the case study (McDonald et al., 2003). The performance of a complex system can be more easily understood through modeling. A simple, well-structured graphic makes the concept easier to understand. In the healthcare sector, Unified Modeling Language modeling can be used to graphically represent events, the people involved, treatments received, prescriptions written, and all other inconsequential activities completed in between appointments that are simple to understand and record. However, the healthcare sector is increasingly using Business Process Model Notation (BPMN). Health outcomes for people and the efficiency of the healthcare system are both enhanced. It also supports the provision of interprofessional analysis. The most important part of HL7 is CDA. Various XML elements and attributes are used in our project to encrypt syntactically interoperable messages assisting in semantic interoperability.

References

A-code - ICD 10 codes, CPT codes, HCPCS codes, ICD 9 codes - online encoder - medical billing and coding. Find. (n.d.). Retrieved September 21, 2021

American Hospital Association. (2020, May 10). *ICD-10-CM code for other fatigue R53.83*. ICD-10 Code for Other fatigue- R53.83- Codify by AAPC. Retrieved December 4, 2022, from https://www.aapc.com/codes/icd-10-codes/R53.83

Awaysheh, A., Wilcke, J., Elvinger, F., Rees, L., Fan, W., & Zimmerman, K. (2018). A review of medical terminology standards and structured reporting. *Journal of veterinary diagnostic investigation : official publication of the American Association of Veterinary Laboratory Diagnosticians, Inc*, *30*(1), 17–25. https://doi.org/10.1177/1040638717738276

Bhimani, R., Punjani, B., & Peden-McAlpine, C. (2021). Understanding clinical characteristics of muscle weakness. *Journal of Neuroscience Nursing, Publish Ahead of Print*. https://doi.org/10.1097/jnn.0000000000000574

Classification of Diseases and Related Health Problems, Tenth Revision Codes With Electronic Medical Records Among Patients With Symptoms of Coronavirus Disease 2019. JAMA

network open, 3(8), e2017703-e2017703.s

Dennis, L., Nicolette. K., Francis, L., Ronald, C. (2014). Literature review of SNOMED CT use, *Journal of the American Medical Informatics Association*, Volume 21, Issue e1, Pages e11–e19. https://doi.org/10.1136/amiajnl-2013-001636

Eilers, L., & Harrington, J. W. (2017). Neonatal lethargy, seizures, and asphyxiation. *Pediatrics In Review*, *38*(6), 290–291. https://doi.org/10.1542/pir.2016-0004

Holman, T., & DelVecchio, A. (2018, October 29). What is ICD-10-CM (clinical modification)? - definition from whatis.com. SearchHealthIT. Retrieved September 19, 2022, from https://www.techtarget.com/searchhealthit/definition/ICD-10-CM https://doi.org/10.1001/jamanetworkopen.2020.17703

https://www.findacode.com/index.html.

ICD10Data.com. (2019). The Web's Free 2019 ICD-10-CM/PCS Medical Coding Reference. Icd10data.com. https://www.icd10data.com/

K., DeMoor, G., Hook, J., Williams, W., Case, J., Maloney, P., & Developers, f. t. L. L. (2003). LOINC, a Universal Standard for Identifying Laboratory Observations: A 5-Year Update. *Clinical Chemistry*, *49*(4), 624-633. https://doi.org/10.1373/49.4.624

Kupchik, N., & Green, J. (2021). A case of heart palpitations and shortness of breath. *AJN, American Journal of Nursing*, *121*(6), 61–64. https://doi.org/10.1097/01.naj.0000753672.64281.f3

McDonald, C. J., Huff, S. M., Suico, J. G., Hill, G., Leavelle, D., Aller, R., Forrey, A., Mercer,

Peacock, J. B., Leung, D. T., & Shah, R. U. (2020). Comparison of International

Periodontal evaluation Gingiva PSR scale. (n.d.). LOINC. Retrieved December 6, 2022, from https://loinc.org/34013-3/

SNOMED CT - palpitations - classes: NCBO bioportal. SNOMED CT - Palpitations - Classes | NCBO BioPortal. (n.d.), from https://bioportal.bioontology.org/ontologies/SNOMEDCT?p=classes&conceptid=80313002

2023 ICD-10-CM diagnosis code R42. 10. (n.d.), from https://www.icd10data.com/ICD10CM/Codes/R00-R99/R40-R46/R42-/R42

SNOMED CT - lightheadedness - classes: NCBO bioportal. SNOMED CT - Lightheadedness - Classes | NCBO BioPortal. (n.d.), from https://bioportal.bioontology.org/ontologies/SNOMEDCT?p=classes&conceptid=386705008

2023 ICD-10-CM diagnosis code R25.2. 10. (n.d.), from https://www.icd10data.com/ICD10CM/Codes/R00-R99/R25-R29/R25-/R25.2

SNOMED CT: NCBO Bioportal. SNOMED CT | NCBO BioPortal. (n.d.), from https://bioportal.bioontology.org/ontologies/SNOMEDCT

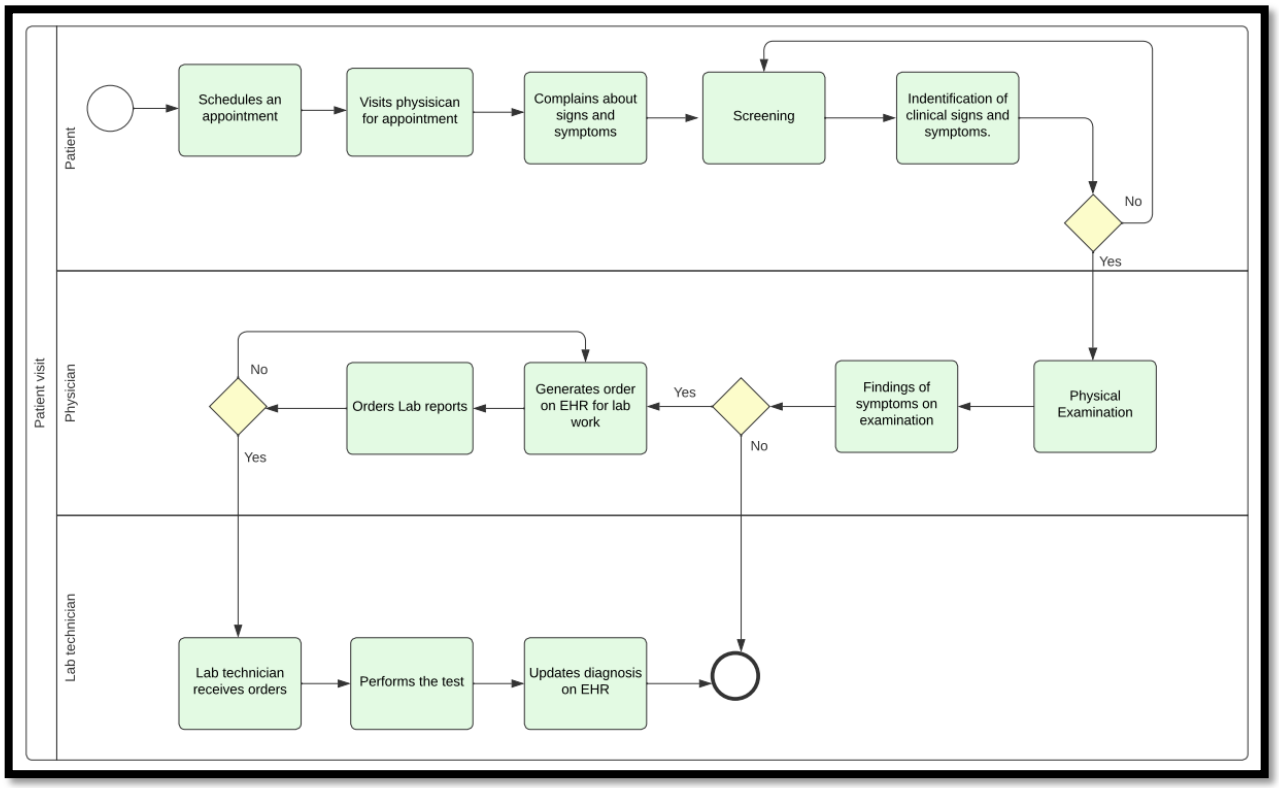
Richesson, R. L., Andrews, J. E., & Krischer, J. P. (2006). Use of SNOMED CT to represent clinical research data: a semantic characterization of data items on case report forms in vasculitis research. *Journal of the American Medical Informatics Association : JAMIA*, *13*(5), 536–546. https://doi.org/10.1197/jamia.M2093

Ryan, S. A. (2017). The treatment of dysmenorrhea. *Pediatric Clinics of North America*, *64*(2), 331–342. https://doi.org/10.1016/j.pcl.2016.11.004

The web's free 2021 ICD-10-CM/PCS Medical Coding Reference. 10. (n.d.). Retrieved September 21, 2021, from https://www.icd10data.com/

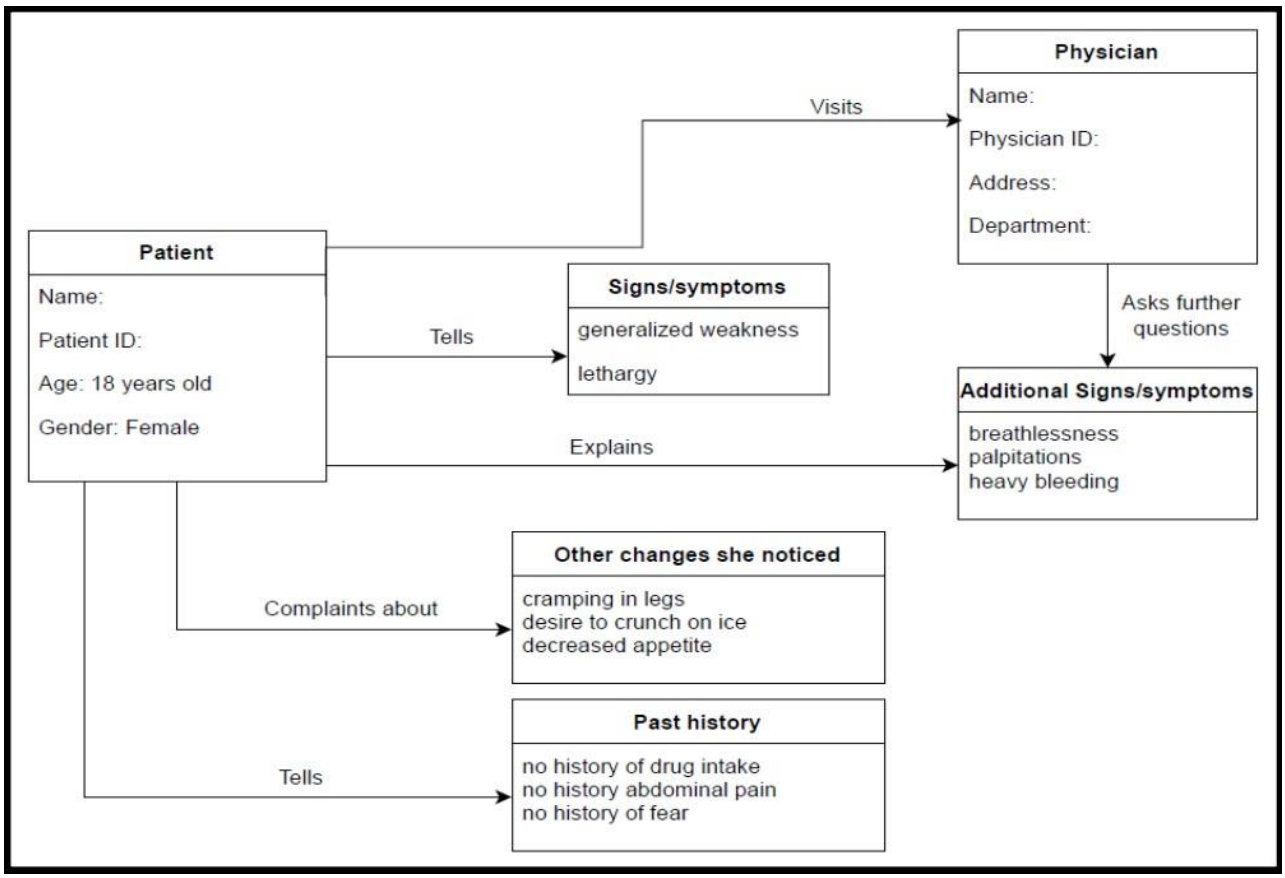
APPENDIX 1

BPMN diagram illustrating the use case workflow



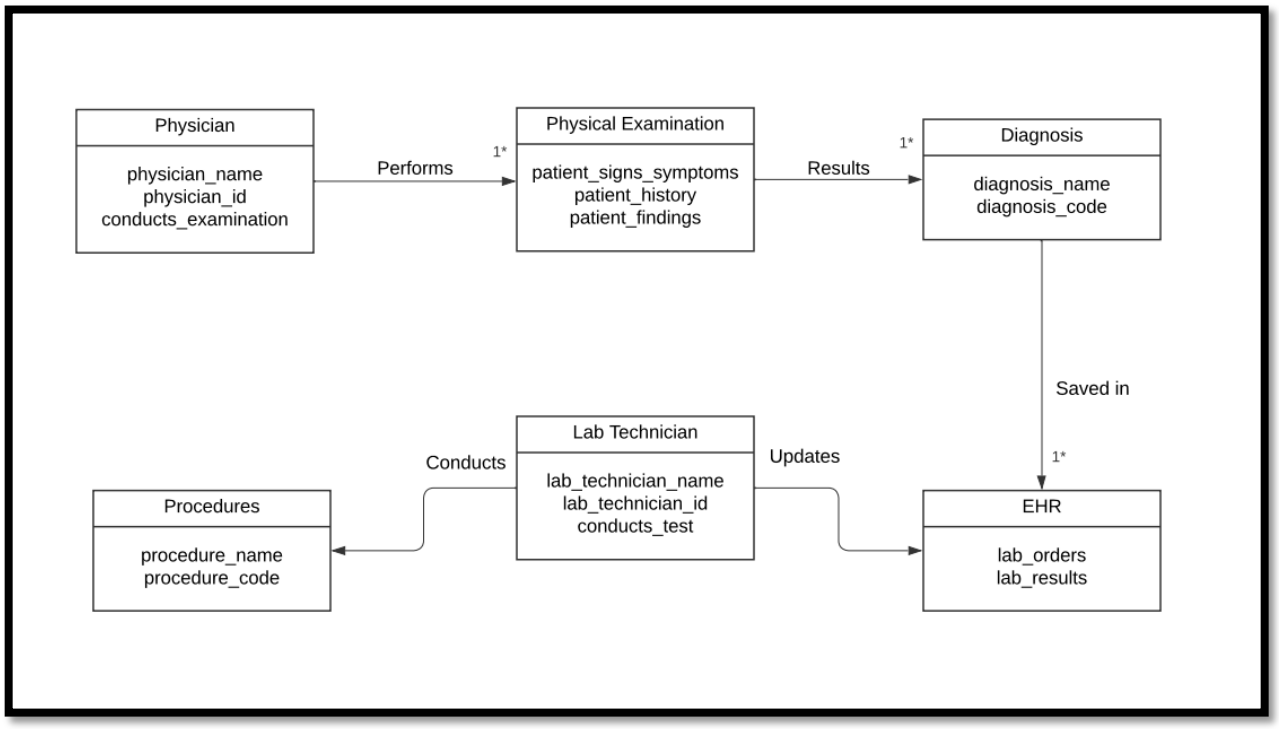
Model 1: BPMN diagram illustrating the Patient-Physician Examination flow

UML diagram illustrating the Patient-Physician workflow



Model 2: UML diagram illustrating the Patient-Physician workflow

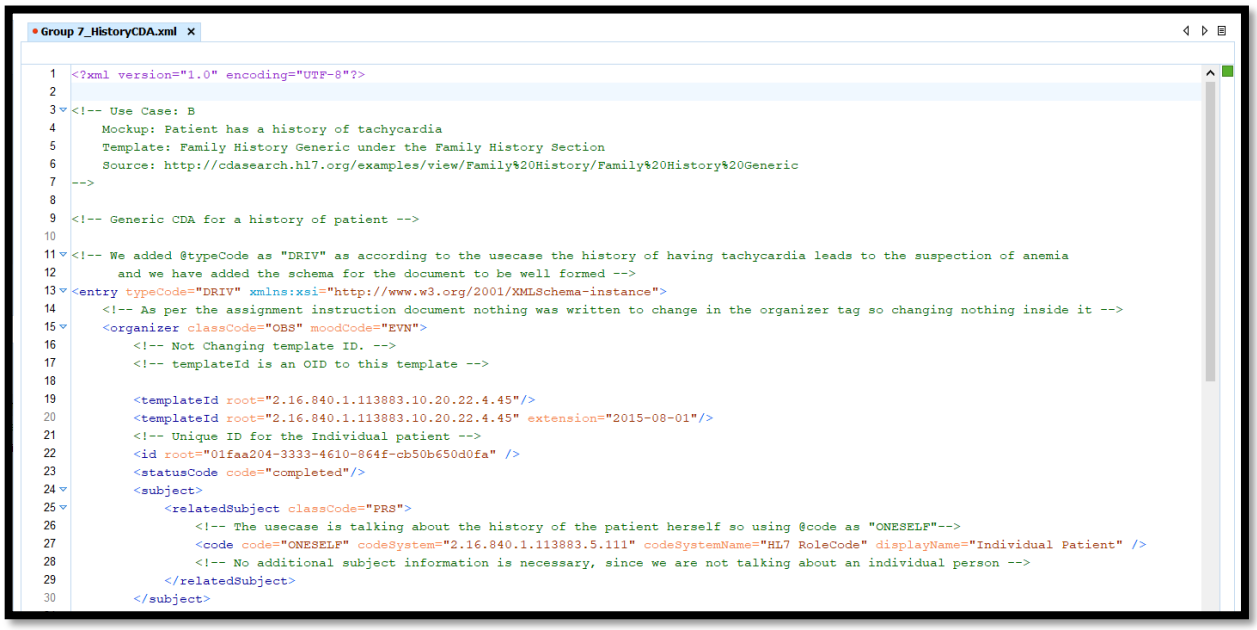
Unified Modelling Language (UML) for Physician-Lab Technician workflow



Model 3: UML diagram illustrating the Physician-Lab Technician workflow

APPENDIX 2

Mockup for Patient has a history of Tachycardia:



```
<?xml version="1.0" encoding="UTF-8"?>

<!-- Use Case: B
    Mockup: Patient has a history of tachycardia
    Template: Family History Generic under the Family History Section
    Source: http://cdasearch.hl7.org/examples/view/Family%20History/Family%20History%20Generic
-->

<!-- Generic CDA for a history of patient -->

<!-- We added @typeCode as "DRIV" as according to the usecase the history of having tachycardia leads to the suspection of anemia
     and we have added the schema for the document to be well formed -->
<entry typeCode="DRIV" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
    <!-- As per the assignment instruction document nothing was written to change in the organizer tag so changing nothing inside it -->
    <organizer classCode="OBS" moodCode="EVN">
        <!-- Not Changing template ID. -->
        <!-- templateId is an OID to this template -->

        <templateId root="2.16.840.1.113883.10.20.22.4.45"/>
        <templateId root="2.16.840.1.113883.10.20.22.4.45" extension="2015-08-01"/>
        <!-- Unique ID for the Individual patient -->
        <id root="01faa204-3333-4610-864f-cb50b650d0fa" />
        <statusCode code="completed"/>
        <subject>
            <relatedSubject classCode="PRS">
                <!-- The usecase is talking about the history of the patient herself so using @code as "ONESELF"-->
                <code code="ONESELF" codeSystem="2.16.840.1.113883.5.111" codeSystemName="HL7 RoleCode" displayName="Individual Patient" />
                <!-- No additional subject information is necessary, since we are not talking about an individual person -->
            </relatedSubject>
        </subject>
```

Figure 1: CDA Mockup for Patient has a history of Tachycardia

```
            </relatedSubject>
        </subject>
        <!-- Tachycardia observation -->
        <component>
            <!-- Class code should be OBS as it was observed in the examination results that the patient had history of tachycardia -->
            <!-- Mood Code is EVN as the event of examination occured that showed that the patient had history of tachycardia -->
            <observation classCode="OBS" moodCode="EVN">
                <!-- Not Changing template ID. -->
                <templateId root="2.16.840.1.113883.10.20.22.4.46"/>
                <templateId root="2.16.840.1.113883.10.20.22.4.46" extension="2015-08-01"/>
                <!-- Unique ID for this individual observation -->
                <id root="02faa204-3333-4610-864f-cb50b650d0fa" />
                <!-- Code. Changing this to reflect SNOMED CT code for the observation tachycardia -->

                <!-- /entry/organizer/component/observation says what this document is about.
            code=document term code, SNOMED-CT code for tachycardia,
            displayName = history name
            codeSystem = document terminology OID,
            codeSystemName = document terminology name -->

                <code code="3424008" codeSystem="2.16.840.1.113883.6.96" displayName="Tachycardia" codeSystemName="SNOMED-CT" >
                </code>
                <!-- The code attribute of <statusCode> for all severity observations in our case tachycardia is changed to be completed as it has
                <statusCode code="completed"/>
                <!-- Since no date is given in our usecase so, changing effectiveTime to current date in format yyyymmdd -->
                <effectiveTime value="20221106"/>
                <!-- As tachycardia is an observation in our usecase so the value tag records relevant findings-->
                <!-- The <value> element contains the clinical status and it is always represented using the CE datatype (xsi:type='CE') and
                    we use the code here "255227004" as the clinical status is recurrent for tachycardia -->
                <value xsi:type="CE" code="255227004" codeSystem="2.16.840.1.113883.6.96" displayName="Tachycardia (disorder)">
                </value>
            </observation>
        </component>
    </organizer>
</entry>
```

Figure 1a: CDA Mockup for Patient has a history of Tachycardia

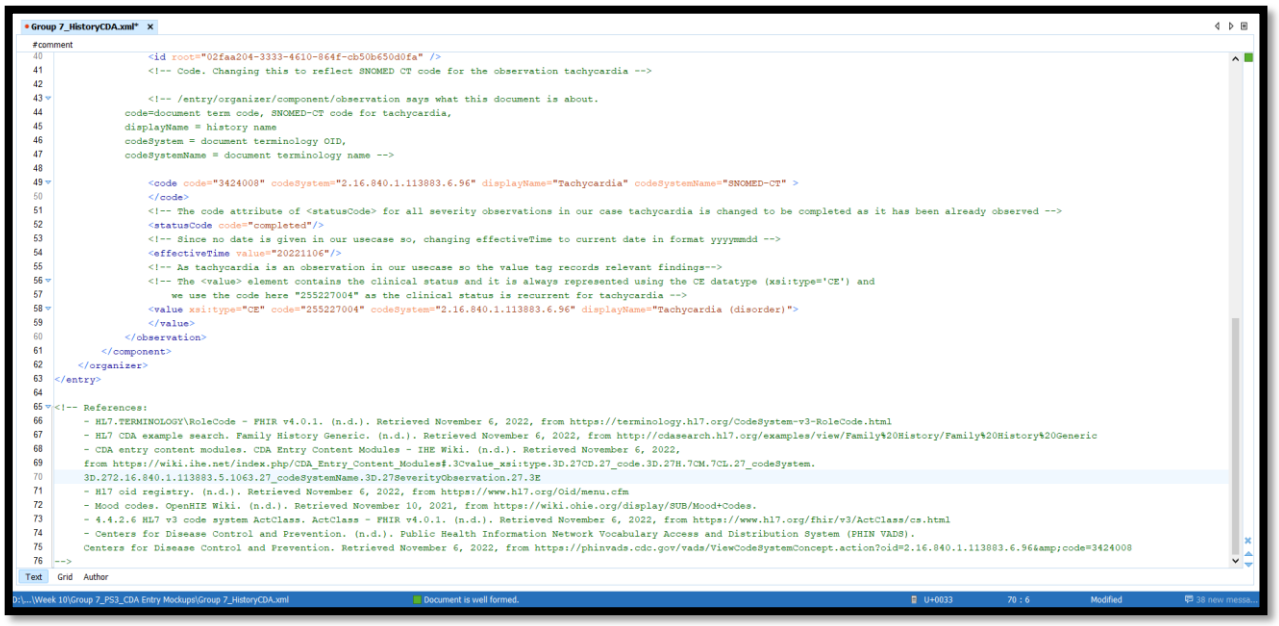


Figure 1b: CDA Mockup for Patient has a history of Tachycardia

Mockup for After conducting the examination, the physician ordered a sample of the patient's blood for examination for procedure

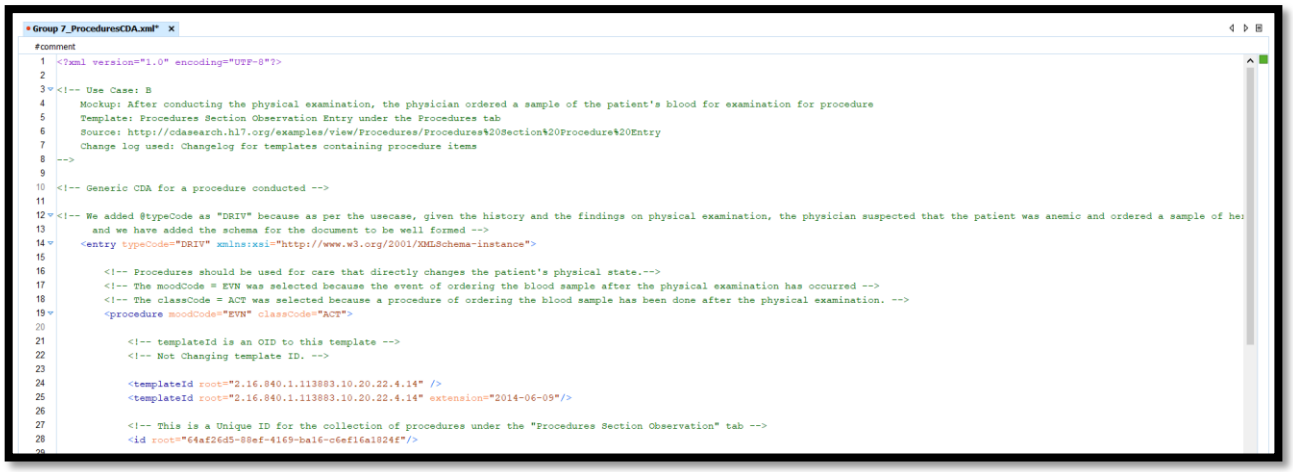


Figure 2: CDA Mockup for Physical examination procedure

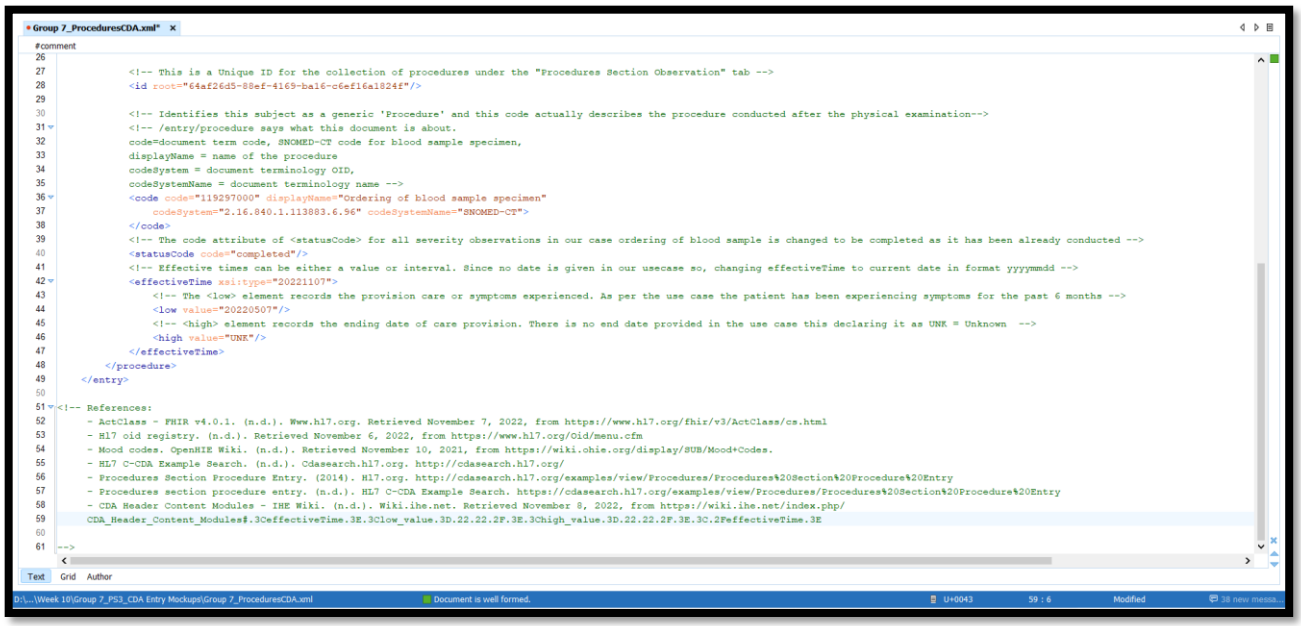


Figure 2a: CDA Mockup for Physical examination procedure

Mockup for A vital signs panel with 2 vital signs (Palpitations and Breathlessness):

Part_1:

```
<?xml version="1.0" encoding="UTF-8"?>

<!-- Use Case: B
    Mockup: A vital signs panel with 2 vital signs(Palpitations and Breathlessness)
    Template: Heart Rate Rhythm under the Vital Signs Section
    Source: Heart Rate Rhythm. (2018). Hl7.org. http://cdasearch.hl7.org/examples/view/Vital%20Signs/Heart%20Rate%20Rhythm

-->
<!-- Generic CDA for a vital signs -->
<!-- We have added the schema for the document to be well formed -->
<entry typeCode="COMP" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
    <!--  The type code is COMP, which implies it has one or more observations in the study -->
    <!-- When a set of vital signs are recorded together, include them in single clustered organizer-->
    <!-- As per the assignment instruction document nothing was written to change in the organizer tag so changing nothing inside it -->
    <organizer classCode="CLUSTER" moodCode="EVN">
        <!--  CLUSTER classscode is given because of two vital signs which are palpitations and breathlesness and moddcode is EVN as the event has already occured -->
        <!-- templateId is an OID to this template -->
        <!-- Not Changing template ID. -->
        <templateId root="2.16.840.1.113883.10.20.22.4.26"/>
        <templateId root="2.16.840.1.113883.10.20.22.4.26" extension="2015-08-01"/>
        <!-- Unique ID for the Individual patient -->
        <id extension="21688133041015158234"
            root="2.16.840.1.113883.3.42.126.100001.19"/>
        <code code="46680005" displayName="Vital Signs" codeSystem="2.16.840.1.113883.6.96"
            codeSystemName="SNOMED CT">
            <!-- 4668005 is the SNOMED CT code for vital signs -->
            <!-- /entry/organizer/component/observation says what this document is about.
            code=document term code, SNOMED-CT code for tachycardia,
            displayName = history name
            codeSystem = document terminology OID,
            codeSystemName = document terminology name -->
        </code>
        <!-- The code attribute of <statusCode> for all severity observations in our case vital signs is changed to be completed as it has been already been reported -->
        <statusCode code="completed"/>
        <!-- Since no date is given in our usecase so, changing effectiveTime to current date in format yyyymmdd -->
        <effectiveTime value="20221108"/>
        <!-- Each vital sign should be its own component. -->
        <component>
            <!-- The first vital sign observation is Palpitations -->
            <observation classCode="OBS" moodCode="EVN">
                <!-- OBS is an observation of an event and the observed event is Palpitations in this use case and EVN is event  -->
                <!-- templateId is an OID to this template -->
                <!-- Not Changing template ID. -->
                <templateId root="2.16.840.1.113883.10.20.22.4.27"/>
                <templateId root="2.16.840.1.113883.10.20.22.4.27" extension="2022-11-06"/>
                <!-- Unique ID for the Individual patient -->
                <id extension="216881330410151584"
                    root="2.16.840.1.113883.3.42.126.100001.19"/>
                <!-- 88104-5 is the LOINC code for palpitations -->
                <!-- /entry/organizer/component/observation says what this document is about.
            code=document term code, LOINC code for tachycardia,
            displayName = first vital sign name
            codeSystem = document terminology OID,
            codeSystemName = document terminology name -->
                <code code="88104-5" codeSysteem="2.16.840.1.113883.6.1" codeSystemName="LOINC"
                    displayName="Palpitations"/>
                <statusCode code="completed"/>
                <!-- Effective times can be either a value or interval. As per the use case the patient has been experiencing symptoms for the past 6 months thus keeping in the format yyyymmdd -->
                <effectiveTime value="20220507"/>
                <!-- Here IVL is interval of Palpitations and the value is 12 as it occurs 12 times of heart flutters a day -->
               <value xsi:type="IVL" value="12" unit="/day" >
               </value>
            </observation>
        </component>
```

Figure 3: CDA Mockup for Vital signs(Palpitations)

Part_2:

```
        <!-- Each vital sign should be its own component. -->
        <component>
            <!-- The second vital sign observation is Breathlessness -->
            <!-- OBS is an observation of an event and the observed event is Breathlessness in this use case and EVN is event  -->
            <observation classCode="OBS" moodCode="EVN">
                <!-- templateId is an OID to this template -->
                <!-- Not Changing template ID. -->
                <templateId root="2.16.840.1.113883.10.20.22.4.2"/>
                <templateId root="2.16.840.1.113883.10.20.22.4.2" extension="2022-11-06"/>
                <!-- Unique ID for the Individual patient -->
                <id extension="216881330410151"
                    root="2.16.840.1.113883.3.42.126.100001.19"/>
                <!-- /entry/organizer/component/observation says what this document is about.
            code=document term code, LOINC code for tachycardia,
            displayName = second vital sign name
            codeSystem = document terminology OID,
            codeSystemName = document terminology name -->
                <code xsi:type="CE" codeSystem="2.16.840.1.113883.6.1"
                    codeSystemName="LOINC"
                    code="64113-4" displayName="Breathlessness"/>
                <!-- 64113-4 is the LOINC code for Breathlessness -->
                <statusCode code="completed" />
                <effectiveTime value="20220507" />
                <value xsi:type="CE" codeSystem="2.16.840.1.113883.6.96"
                    codeSystemName="SNOMED CT" code="267036007"
                    displayName="Breatlessness"/>
                <!-- 267036007 is the SNOMED CT code for Breathlessness -->
            </observation>
        </component>
    </organizer>
</entry>

<!-- References -->
<!-- HL7 FHIR: HL7 v3 code system actClass. (2019, November 1). HL7.org. https://www.hl7.org/fhir/v3/ActClass/cs.html -->
<!-- HL7 OID Registry. (n.d.). https://www.hl7.org/Oid/menu.cfm -->
<!-- Marquard, B. (2018, July 12). Vital signs section: Heart rate rhythm. cdasearch.hl7.org. http://cdasearch.hl7.org/examples/view/Vital%20Signs/Heart%20Rate%20Rhythm -->
<!-- Mood Codes - Communities - OpenHIE Wiki. (n.d.). https://wiki.ohie.org/display/SUB/Mood+Codes -->
<!-- Heart Rate Rhythm. (2018). Hl7.org. http://cdasearch.hl7.org/examples/view/Vital%20Signs/Heart%20Rate%20Rhythm -->
```

Figure 3a: CDA Mockup for Vital signs(Breathlessness)s