Discovering Diabetes Complications: an Ontology Based Model

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ABSTRACT

Background: Diabetes is a serious disease that spread in the world dramatically. The diabetes patient has an average of risk to experience complications. Take advantage of recorded information to build ontology as information technology solution will help to predict patients who have average of risk level with certain complication. It is helpful to search and present patient’s history regarding different risk factors. Discovering diabetes complications could be useful to prevent or delay the complications.

Method: We designed ontology based model, using adult diabetes patients’ data, to discover the rules of diabetes with its complications in disease to disease relationship.

Result: Various rules between different risk factors of diabetes Patients and certain complications generated. Furthermore, new complications (diseases) might be discovered as new finding of this study, discovering diabetes complications could be useful to prevent or delay the complications.

Conclusion: The system can identify the patients who are suffering from certain risk factors such as high body mass index (obesity) and starting controlling and maintaining plan.

Key words: Protégé, ontology, SPARQL, rules, diabetes, complications.

1. INTRODUCTION

One of the serious diseases that spread in the world dramatically is Diabetes. The diabetes patient has high average of risk to experience complications such as cardiovascular disease, kidney disease and end-stage renal failure. Without continuous monitoring and take the appropriate action in the timely manner, the death rate will be high. Currently, the diagnosis depends on various test and factors that have relationships and relevance lead to understand the overall status of each patient (1). Monitoring blood glucose is important but is not enough to decrease the development of long term complications. There are different variables interact with each other and play important role in setting a high expectation of the disease progress, which are lab tests, primary and secondary diagnosis, blood pressure, blood glucose and Body Mass index (BMI) (2). Based on the patient’s data, we can find relationships and get interpretation that unpredictable by the normal observation. Extracted information from patient history with appropriate treatment and monitoring could limit the complications occurrence. As a result, the decision is taken about the patient will be based on context and the extracted information rather than long term plan so-called personalized service (1). In other word, due to the large amount of data that generate from diabetes patients, there is huge interest in extracting useful information and finding out hidden patterns. Information technology provides the ontology solution in healthcare domain (2-13). We would like to take advantage of the huge amount of data that generated by such diseases, reuse the others’ knowledge to identify current needs in order to improve the outcome in the future (1). We need a formal representation of diabetes terminology, vocabulary and relationships to discover and extract, share, retrieve and reuse knowledge. Ontology is a technique to store semantic information and facilitate manipulating with data by applying different methods such as analysis and algorithms (3).
This paper described the process of developing ontology to organize the data in order to represent, manage, share, reuse and discover knowledge in diabetes domain. In addition, it provides semantic interoperability among different domains and sub-domains. The concepts with its hierarchy will be defined and the relationships between them will be created. The diabetes data will be translated into Resource Description Framework (RDF) language to increase the capability of detecting problems and automate the interpretation process. In this way, we reduce the semantic gap between existing data and interpretation that followed by healthcare providers. This will ensure patient safety and improve the quality of care (4). Tracking patient and retrieve semantic information will improve care provided, support decision making and enhance disease management. The different stakeholders will access and share the most recent medical knowledge due to the scalability of the ontology and the frequent updates that will deliver. More advance queries could be applied by using Simple Protocol and RDF Query Language (SPARQL) (2, 5) and intelligent algorithms for clustering, classifications and generate association rules in many applications (3).

In most of the cases, the problem with chronic disease such as diabetes, heart condition or asthma etc. is not a so much disease but complications peoples can experience if it is not controlled properly (13). The objective of this study is to build model, using adult diabetes patients data, to discover the rules of diabetes with its complications in disease to disease relationship. Also, to determine and understand the risk level which could be useful to prevent or delay the complications. Finally, to conduct further discovering of new disease associated with diabetes as new finding.

The rest of the study is organized as following: Section 2 presents related work of relative ontologies. Section 3 describes ontology development process. In Section 4 presents result and discussion of developed ontology included DL and SPARQL queries. Finally, section 5 concludes the study.

2. LITERATURE REVIEW

In parallel with increasing the number of people who suffering from diabetes, there is increasing in the associated complications as a development of diabetes.

More understanding of the disease will reduce risk factors, study the different variables that shared by the diabetes patient, interact with each other and have relationships will lead to predict the level of the risk level of particular complication that each patient might experience it then take a prevention action. We would like to take advantage of the huge amount of data that generated by such diseases, reuse the others knowledge to identify current needs in order to improve the outcome in the future (1). We need a formal representation of diabetes terminology, vocabulary and relationships to discover and extract, share, retrieve and reuse knowledge. Ontology is a technique to store semantic information and facilitate manipulating with data by applying different methods such as analysis and algorithms (3).

Last years, there are a lot of attempts to build ontology in the chronic disease domain. Verma et al. (3) describe a basic model build based on genetic and clinical variables. The basic model will be used to with different methods for predict diabetes 2 risk. It is better to update the ontology automatically rather than add the information manually which could cause duplication or loose the current knowledge. As mentioned by Verma et al. (3), the success of the ontology that used in the personalized medicine is depending on the platform that used for the ontology and machine learning methods dynamic integration. In this way, the accuracy and the chance to discover new finding will be high. The ontology that build based on fixed number of variables is difficult to modify if we need to a new variable unlike the personalized model which ease accommodate the new variables. Frequent update and expand of the ontology become a requirement to achieve goal of building such ontology with highest accuracy (3). In attempt to control the glucose level, the ontology that developed by Chalortham et al. (4) by mapped database which included different processes for diabetes patients include assessment, diagnosis, treatment, complication and follow up. It was work with the reminder system to suggest activates, thus reduce the progress of the diabetes complications such as retinopathy and foot diabetes. The result of Cantais et al. (8) research shows the system can provide a recommendation of the appropriate food type for diabetes patient daily and it determine the with minimum and maximum amount.

Furthermore, Lasierra et al. (7) developed ontology to monitor the patient suffering from chronic disease at home (Tele-monitoring), and it has the capability to provide personalized care dynamically through three stages. Build the model started from create ontology of patient profile using vital measurements and information such as qualitative, quantitative and environmental. The information included in the patient profile will use in the monitoring task and will used to generate reminders. The ontology perform analyzing task based on IF\THEN rules using SPARQL. Finally a planning and execution tasks are performed to select appropriate action to the patient. In the third stage, the model will be ready to monitor any patient. The data will be presented by Lasierra et al. (7) ontology; furthermore the ontology has the capability to represent the procedures and workflows which lead to automate the task of the patient care. Keep glucose in the normal level, the diabetes patient, the ontology presented by Pramono et al. (2) is provide recommendation about the best physical activity based on patient situation and the history of the medication. The ontology was developed based on patient’s data such as age, Wight, high and complications as tree. Any new patient will define the similarity by SPARCL to suggest the appropriate activity. More improvement could be applied by gathering more data such food intake so the system will be more accurate in propose the physical activity. The ontology could be used to provide information with high precision and recall rate for diabetes patients for education purpose. Although there is health information available through the Internet, there is a risk to retrieve low quality information. The main challenge was face such ontology is it should be updated and provide knowledge that meet the patients need (10). Case-based reasoning (CBR) is a technology used by Jha et al. (1) to utilize the historical information of the diabetes patients problems and solutions stored in database. The similar cases will be retrieved to provide a solution of current problem. If there is no match between the new case and cases stored in the database, the queries will be applied to the diabetes ontology to provide support. The
learning ability of CBR will store non-matched case in the database for the future use. Therefore, it needs an adjustment for the effective use in different conditions. Yu et al. (1) had discussed using ontology to automate search in Electronic Health Record (EHR) to retrieve diabetes patient either for clinical trial or research purposes. Integration between databases, link between ontology and data base and data quality should be ensured for efficient use.

One of various benefits from developing ontology is the ability to reuse it to build other ontology on the same domain or use in computer systems. The diabetes ontology is useful to develop Adverse Drug Event ADE system for diabetes patients (9). It is contain all terms and relationships as base knowledge, aid the extraction of helpful information to use in ADE system. By this way, the medical error will be decrease, on the other hand, the quality and safety of the patients will be increased. Moreover, the ontology that presented by Liaw et al. (12) for data quality could be used in build any future ontology. Ensuring the quality of the data in terms of completeness, correctness etc. will lead to accurate outcomes. In addition, such ontology will enhance the quality of data that collected in the hospital information system (HIS), consequently any ontology aim to use HIS data will ensure a high quality inputs.

A lot of future works are planned in the different studies (1) expand Verma’s et al. (3) ontology by add more variable and cover more chronic diseases (2), the Jha et al. (1) ontology could be available publicly through the Internet (3). Consider the feedback from different care providers such as physician, nurse and pharmacists to build feedback framework based on acquired knowledge (4). Adapt Boulos et al. (10) ontology that used to educate diabetes patients to cover other topics.

We will develop ontology for adult diabetes patient in Saudi Arabia to predict patient that have average of risk level with certain complication. None of the previous studied talked about ontology for further discovering of diabetes complications.

3. ONTOLOGY DEVELOPMENT

The ontology developed to conceptualize the concept, relations and properties in the diabetes domain. The main objective of the ontology is to predict patients who have average of risk level with certain complication. Discovering diabetes complications could be useful to prevent or delay the complications. The scope is limited to adult diabetes patient who are more than 14 years old according to Ministry of National Guard Health Affair (MNGHA). Protégé 4.1 used to build the diabetes ontology using top-down approach. FaCT++ and HermiT reasoners used to check the consistency of the ontology.

Figure 1 shows the classes and subclasses hierarchy of the ontology. Each Patient (diabetes and non-diabetes) has PatientRecord contains the diabetes information from the Hospital Information system (HIS) to discover the complications and its risk degree. It contains Age (Adult and Child), Gender (Male, Female), Blood pressure, Body Mass Index (BMI) and Lab tests (Appendix A). In addition to diagnosis class that stores the first and second diagnosis results of the diabetes patients visits; all diagnosis will be created as individual which contains more than 200 diagnoses (Appendix B). The class complication risk level shows the risk level that could be experienced by the patient based on his/her data, it contains two subclasses: HighRisk and LowRisk. It is specified by the relation hasComplicationRisk to identify the risk degree to the Patient class. Complication class consists of diseases associated with diabetes, they are: Cardiovascular, kidney Disease, Diabetic Neuropathy, Retinopathy and Hypertension. Finally, if there is a new patient the relations will be fined between different risk factors and complications.

The main object properties that mapped classes are hasRecord, hasAge, hasGender, hasBloodPressure, hasBMI, hasComplication, hasComplicationRisk, diagnosis1-Is and diagnosis2-Is.

The data properties will have the classes’ value in the ontology which is Age, BMI, ComplicationRisk, Complication and various properties to add the result of different kind of lab test. According to the values or results, the risk level of certain complication will be identified.

There are many constrains applied to some values of data properties coupled with some classes. As mentioned before the scope of the ontology is the diabetes adult patients which classified under DiabetesPatient and Adult classes. Moreover, BodyMassIndex class has restriction on the value of MBIValue to classify the patients in the subclasses; they are NormalWeight, Obesity, OverWeight and UnderWeight. For instance, the restriction statement for the Obesity sub class is (BMIValue some integer[> = 30]). Also, BloodPressure class has three subclasses, the patients assigned to one of them based on the value of the two variables, systolic, diastolic.

For the patient class, individuals defined which take account of object and data properties to fill all information included in the PatientRecord class. Run reasoner will classify the patients in the different classes based on record information and predefined constrains. Finally, the ontology consists of 68 classes, 19 object properties, 39 data properties and 312 individuals.

4. RESULTS AND DISCUSSION

In the first step after develop the diabetes ontology, the data mapped from the hospital information system to the model. The reasoner runs to check the consistency of the ontology. Accordingly, the individuals classified in the ontology based on several factors, including age, gender, BMI, etc. we can search of patient’s history; and present patient’s individual information. Extracted information from model will help to identify patients who have abnormalities then take the appropriate decision. By using the model, we can identify the patients who are suffering from certain risk factors such as high
body mass index (obesity) and starting controlling and maintaining plan. Also, retrieve patients who already suffering from diabetes complications based on the second diagnosis. The non-diabetes and children patients are not covered in this model. Secondly, create instances (new patients) to present PatientRecord and the information of each instance mapped from real diabetes data in the hospital information system to the ontology model. Patient1, Patient2 and Patient3 are instances of class PatientRecord to illustrate how this ontology can be used; the classification of Patients in the ontology will be according to risk factors.

Several queries applied using DL Query in protégé to retrieve matched patients based on a set of factors as following:

- **Patient and HighBloodPressure**
- This query is allowing the retrieval of patients who suffering from High Blood Pressure.
- **HighBloodPressure and Obesity**
- This query is allowing the retrieval of patients who suffering from High Blood Pressure and Obesity.
- **HemoglobinA1c_Result some integer**
- This query is allowing the retrieval of patients who did HemoglobinA1c test.
- **genderIs value Male and CholesterolTest**
- This query is allowing the retrieval of male patients who did Cholesterol test.
- **Patient and diagnosis1-Is value Type_1_diabetes_mellitus_with_poor_control_CMC**
- This query is allowing the retrieval of patients suffering of “Type 1 diabetes mellitus with poor control CMC” as the first diagnosis.

As an outcome, the abnormal values detected for patients suffering from obesity. Patient1 will be retrieved.

| IF/THEN Rules | Description |
|---------------|-------------|
| Adult(?P), DiabetesPatient(?P), diagnosis2-Is(?P, Heart_failure_unspecified) -> hasComplication(?P, CardiovascularDisease), hasComplicationRisk(?P, Suffering_from_complication) | IF adult diabetes patient has “Heart_failure_unspecified” as the second diagnosis THEN he/she suffering from Cardiovascular complication. |
| Adult(?P), DiabetesPatient(?P), diagnosis2-Is(?P, End-stage_renal_disease) -> hasComplication(?P, KidneyDiseases), hasComplicationRisk(?P, Suffering_from_complication) | IF adult diabetes patient has “End-stage_renal_disease” as the second diagnosis THEN he/she suffering from KidneyDiseases complication. |
| Adult(?P), DiabetesPatient(?P), greaterThan(?UrineAlbumin-Microalbum_Result, 30), lessThan(?eGFR_Result, 160) -> hasComplication(?P, KidneyDiseases), hasComplicationRisk(?P, High) | IF adult diabetes patient has abnormal result of two types of test related (eGFR < 160 and UrineAlbumin-Microalbum > 30) THEN there is a high risk of Kidney disease as complication. |
| Adult(?P), DiabetesPatient(?P), Obesity(?P) -> hasComplicationRisk(?P, High) | IF adult diabetes patient has obesity THEN there is a high risk of diabetes complication. |
| Adult(?P), DiabetesPatient(?P), Obesity(?P), HighBloodPressure(?P) -> hasComplicationRisk(?P, High) | IF adult diabetes patient has obesity and high blood pressure THEN there is a high risk of diabetes complication. |
| Adult(?P), DiabetesPatient(?P), HighBloodPressure(?P), greaterThan(?Age, 70) -> hasComplication(?P, Hypertension), hasComplicationRisk(?P, High) | IF adult diabetes patient has high blood pressure AND the age is more than 70 years old THEN there is a high risk of Hypertension as complication. |
| Adult(?P), DiabetesPatient(?P), HighBloodPressure(?P), Obesity(?P), labTestIs(?P, ?HemoglobinA1cTest), greaterThan(?HemoglobinA1c_Result, 183) -> hasComplication(?P, CardiovascularDisease), hasComplicationRisk(?P, High) | IF Patient has high blood pressure AND obesity AND abnormal result of hemoglobinA1c test (>183) THEN there is a high risk of cardiovascular disease as complication. |
| Adult(?P), DiabetesPatient(?P), NormalBloodPressure(?P), NormalWeight_(?P) -> hasComplicationRisk(?P, Low). | IF adult diabetes patient has normal blood pressure AND normal weight THEN there is a low risk of diabetes complication. |

Table 1. Examples of Protégé rules

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NonDiabetesPatient(?P) -> hasComplicationRisk(?P, Non-Diabetes_patient_are_not_Covered) | IF patient is not diabetes patient based on the primary diagnosis THEN he/she not covered by this model. |

Child(?P) -> hasComplicationRisk(?P, Children_are_not_covered) | IF patient is child patient THEN he/she not covered by this model.

PatientRecord and the information of each instance mapped from real diabetes data in the hospital information system to the ontology model. Patient1, Patient2 and Patient3 are instances of class PatientRecord to illustrate how this ontology can be used; the classification of Patients in the ontology will be according to risk factors.

Several queries applied using DL Query in protégé to retrieve matched patients based on a set of factors as following:

- **(Patient1)**
- This query to retrieve information related to Patient1 individual.
- **Patient and hasComplicationRisk value High**
- This query is allowing the retrieval of all patients who have a high risks level of diabetes complications.
- **Patient and Obesity**
- This query is allowing the retrieval of patients who without classification in the ComplicationRisk and Complication class. To fill gap between some classes which shows in

![Figure 2. Diagram for part of classes used in defines rules.](image)

![Figure 3. SPARQL query for diabetes complications](image)
Figure 2, several rules added related to complication risk degree and certain diseases as complication. Rules (defined in Table 1) are suitable to define patients (individuals) who are have a high complication risk to certain diseases based on information related to the results of the lab test and diagnosis. Also, define patient who are under control and the degree of the risk is low. A high level corresponds to the abnormal result of the lab test, obesity, high blood pressure and age more than 70 years old. In addition to exclude uncovered patient who classified in NonDiabetes and Child classes.

SPARQL queries are supported by Protégé for semantic searching in the ontology. It retrieves the information that satisfies the condition for discovering purpose. The example of rules and queries results is shown in Figure 3.

For future work, we can use the developed ontology to apply advanced algorithm to generate association rules. More information might be added to expand the ontology and provide more discovering.

5. CONCLUSION

Ontology as information technology solution contributes in providing care to the chronic disease patients such as diabetics. We develop ontology for adult diabetes patient in Saudi Arabia to predict patient that have average of risk level with certain complication. It is helpful to search and present patient’s history regarding to blood glucose level, blood pressure, diagnosis and lab test. The key risk factors of diabetes patients introduced for monitoring purpose in order to minimize the prevalence of associated diseases. Various rules between different risk factors of diabetes Patients and certain complications generated. Furthermore, new complications (diseases) might be discovered as new finding of this study, discovering diabetes complications could be useful to prevent or delay the complications.

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CONFLICT OF INTEREST: NONE DECLARED.

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Appendix A: Lab test List

- Antinuclear antibody
- Anti-SSA and SSB antibodies
- Blood Glucose – SMBG
- Complete blood count
- Complete metabolic panel
- C-reactive protein
- Creatinine level
- Cystatin C
- eAG
- eGFR
- Erythrocyte sedimentation rate
- Fasting Lipid Profile
- Fasting plasma glucose
- Fasting plasma glycogen
- Genetic screens
- Gestational diabetes
- Glycated Hemoglobin Blood Glucose Test (G-Hgb)
- GlycoMark Test
- Hematology screen
- Liver function panel
- Oral glucose tolerance test (OGTT)
- Paraneoplastic antibodies
- Proteinuria
- Rheumatoid factor
- Sequential multiple analysis-7
- Serum protein electrophoresis with immunofixation electrophoresis
- Thyroid function tests
- Thyroid-stimulating hormone (TSH) blood test
- Urine albumin \ Microalbumin
- Vitamin B-12 and Folate levels level
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Appendix B: Diagnosis List

- Aortic_(valve)_stenosis
- 'Essential_(primary)_hypertension'
- 'Hypertensive_heart_disease_with_(congestive)_heart_failure'
- 'Intracranial_haemorrhage_(nontraumatic),_unspecified'
- 'Mitral_(valve)_insufficiency'
- 'Pericardial_effusion_(noninflammatory)'
- 'Prolonged_second_stage_(of_labour)'
- 'Ulcereative_(chronic)_rectsigmoiditis'
- Acquired_absence_of_foot_and_ankle
- Acquired_absence_of_leg_at_or_below_knee
- Acute_appendicitis_unspecified
- Acute_cholecystitis
- Acute_miliary_tuberculosis_of_multiple_sites
- Acute_myocardial_infarction_unspecified
- Acute_nephritic_syndrome_Diffuse_membranousglomerulonephritis
- Acute_nephritic_syndrome_Unspecified
- Acute_pancreatitis_unspecified
- Acute_peritonitis
- Acute_renal_failure_unspecified
- Acute_subendocardial_myocardial_infarction
- Acute_transmural_myocardial_infarction_of_anterior_wall
- Acute_transmural_myocardial_infarction_of_inferior_wall
- Acute_upper_respiratory_infection_unspecified
- Agranulocytosis
- Anaemia_unspecified
- Angina_pectoris_unspecified
- Arteriovenous_fistula_acquired
- Arteritis_unspecified
- Asthma_unspecified
- Atherosclerosis_of_arteries_of_extremities_unspecified
- Atherosclerosis_of_arteries_of_extremities_with_gangrene
- Atherosclerosis_of_arteries_of_extremities_with_rest_pain
- Atherosclerosis_of_arteries_of_extremities_with_ulceration
- Atherosclerotic_heart_disease_of_native_coronary_artery
- Atherosclerotic_heart_disease_of_unspecified_vessel
- Atrial_fibrillation_and_flutter
- Atrioventricular_block_complete
- Atrioventricular_block_second_degree
- Benign_paroxysmalvertigo
- Bifascicular_block
- Bronchiectasis
- Bronchopneumonia_unspecified
- Brucellosis_unspecified
- Calculus_of_bile_duct_with_cholecystitis_without_mention_of_obstruction
- Calculus_of_bile_duct_without_cholangitis_or_cholecystitis
- Calculus_of_bile_duct_without_cholangitis_or_cholecystitis_with_obstruction
- Calculus_of_bile_duct_without_cholangitis_or_cholecystitis_without_mention_of_obstruction
- Calculus_of_gallbladder_with_acute_cholecystitis_without_mention_of_obstruction
- Calculus_of_gallbladder_with_other_cholecystitis
- Calculus_of_gallbladder_with_other_cholecystitis_with_obstruction
- Calculus_of_kidney
- Calculus_of_ureter
- Cardiac_septal_defect_unspecified
- Cardiomyopathy_unspecified
- Carpal_tunnel_syndrome
- Cataract_unspecified
- Cellulitis_unspecified
- Cellulitis_of_face
- Cellulitis_of_lower_limbs
- Cellulitis_of_toe
- Cellulitis_of_trunk
- Cerebral_atherosclerosis
- Cerebral_infarction_unspecified
- Cerebral_infarction_due_to_embolism_of_cerebralarteries
- Cerebral_infarction_due_to_embolism_of_prearteries
- Cerebral_infarction_due_to_unspecified_occlusion_or_stenosis_of_cerebralarteries
- Chest_pain_unspecified
- Cholangitis
- Chronic_ischaemic_heart_disease_unspecified
- Chronic_nephritic_syndrome_Unspecified
- Chronic_obstructive_pulmonary_disease_unspecific
- Chronic_obstructive_pulmonary_disease_with_acute_exacerbation_unspecific
- Chronic_obstructive_pulmonary_disease_with_acute_lower_respiratory_infection
- Chronic_osteomyelitis_with_draining_sinuses_Ankle_and_foot
- Chronic_renal_failure_unspecified
- Congestive_heart_failure
- Cutaneous_abscess_furuncle_and_carbuncle_of_buttock
- Cutaneous_abscess_furuncle_and_carbuncle_of_limbs
- Cutaneous_abscess_furuncle_and_carbuncle_of_trunk
- Cystic_fibrosis_unspecified
- Cystocele
- Diabetes_insipidus
- Diarrhoea_and_gastroenteritis_of_presumed_infectious_origin
- Dietary_counselling_and_surveillance
- Dilated_cardiomyopathy
- Disorder_ofarteries_and_arterioles_unspecified
- Disorder_of_lipoprotein_metabolism_unspecified
- Disorientation_unspecified
- Dysuria
- End-stage_renal_disease
- Endocrine_nutritional_and_metabolic_diseases_complicating_pregnancy_childbirth_and_the_puerperium
- Endometrial_glandular_hyperplasias
- Endometrium
- Enterocolitis_due_to_Clostridium_difficile
- Epidermal_cyst
- Epilepsy_unspecified_without_mention_of_intractable_epilepsy
- Escherichia_coli_E_coli_as_the_cause_of_diseases_classified_to_other_chapters
- Family_history_of_diabetes_mellitus
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- Fever, unspecified
- First-degree perineal laceration during delivery
- Fitting and adjustment of urinary device
- Fluid overload
- Fourth [trochlear] nerve palsy
- Gangrene, not elsewhere classified
- Gas gangrene
- Gastritis, unspecified
- Gestational [pregnancy-induced] hypertension without significant proteinuria, CMC
- Gonarthrosis, unspecified
- Heart failure, unspecified
- Hepatitis A without hepatic coma
- Hyperplasia of prostate, CMC
- Hypertensive renal disease with renal failure
- Hypo-osmolality and hyponatraemia
- Hypoglycaemia, unspecified
- Infection of amputation stump
- Inflammatory disorders of breast
- Insulin
- Insulin and oral hypoglycaemic [antidiabetic] drugs
- Interstitial pulmonary disease, unspecified
- Intracerebral haemorrhage, intraventricular
- Intracerebral haemorrhage, unspecified
- Ischaemic cardiomyopathy
- Kidney transplant status
- Labour and delivery complicated by cord around neck, with compression
- Labour and delivery complicated by fetal heart rate anomaly
- Labour and delivery complicated by meconium in amniotic fluid
- Labour and delivery complicated by other cord entanglement
- Labour and delivery complicated by other evidence of fetal stress
- Left ventricular failure
- Maternal care due to uterine scar from previous surgery
- Maternal care for disproportion due to unusually large fetus
- Maternal care for excessive fetal growth
- Meningitis, unspecified
- Migraine with aura, [classical migraine]
- Mitral stenosis
- Mitral stenosis with insufficiency
- Mitral valve disease, unspecified
- Neglect or abandonment
- Nephrotic syndrome, Focal and segmental glomerular lesions
- Nephrotic syndrome, Unspecified
- Noninfective gastroenteritis and colitis, unspecified
- Nonunion of fracture, [pseudarthrosis, Forearm
- Obstruction of bile duct
- Obstructive and reflux uropathy, unspecified
- Oligohydramnios
- Osteomyelitis, unspecified, Ankle and foot
- Osteomyelitis, unspecified, Lower leg
- Other and unspecified abdominal pain
- Other and unspecified cirrhosis of liver
- Other and unspecified convulsions
- Other and unspecified intestinal obstruction
- Other and unspecified renal failure
- Other chest pain
- Other chronic osteomyelitis, Ankle and foot
- Other chronic pancreatitis
- Other chronic renal failure
- Other cystitis
- Other disorders of lipoprotein metabolism
- Other giant cell arteritis
- Other ill-defined heart diseases
- Other interstitial pulmonary diseases with fibrosis
- Other intracerebral haemorrhage
- Other maltreatment syndromes
- Other osteomyelitis, Ankle and foot
- Other peripheral vertigo
- Other primary gonarthrosis
- Other primary thrombocytopenia
- Other specified abnormal uterine and vaginal bleeding
- Other specified cataract
- Other specified chronic obstructive pulmonary disease
- Other specified counselling
- Other specified diabetes mellitus
- Other specified diabetes mellitus with foot ulcer due to multiple causes
- Other specified diabetes mellitus with other specified ophthalmic complication
- Other specified disorders of white blood cells
- Other specified heart block
- Other specified intervertebral disc displacement
- Other specified mononeuropathies
- Other specified special examinations
- Pathological fracture, not elsewhere classified, Upper arm
- Peritonitis, unspecified
- Personal history of allergy to analgesic agent
- Personal history of noncompliance with medical treatment and regimen
- Phlebitis and thrombophlebitis of other deep vessels of lower extremities, CMC
- Pituitary-dependent Cushing’s disease
- Pleural effusion, not elsewhere classified
- Pneumonia, unspecified
- Pneumonitis due to food and vomit
- Polymyalgias
- Polymyositis
- Polyph of corpus uteri
- Postmenopausal bleeding, CMC
- Postphlebitic syndrome
- Pre-excitation syndrome
- Pre-existing diabetes mellitus, other specified type, in pregnancy, non-insulin treated
- Pre-existing diabetes mellitus, Type_1, in pregnancy
- Pre-existing diabetes mellitus, Type_2, in pregnancy, insulin treated
