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 pa-

tient 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 quires. 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 work-flows 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 quires 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 on-

Figure 1. class hierarchy of diabetes ontology

tology 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 experience 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 proprieties, 39 data proprieties 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

Figure 2. Diagram for part of classes used in defines rules.

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

suffering from obesity. Patient1 will be retrieved.

- 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 who suffering of “Type 1 diabetes mellitus with poor control CMC” as the first diagnosis.

As an outcome, the abnormal values detected for patients

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.
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.

Table 1. Examples of Protégé rules

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

Patient	ComplicationRisk	Complication
Patient1	High	Hypertension
Patient2	High	CardiovascularDisease
Patient3	High	KidneyDiseases
Patient4	Low	
Patient5	Children_are_not_covered	
Patient6	Non-Diabetes_patient_are_not_Covered	
Patient7	Suffering_from_complication	CardiovascularDisease
Patient8	Suffering_from_complication	KidneyDiseases

Figure 3. SPARQL query for diabetes complications

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 diabetes. 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 glucose
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 \ Microalbum
Vitamin B-12 and Folate levels level

Appendix B: Diagnosis List

'Aortic_(valve)_stenosis'	Calculus_of_gallbladder_with_other_cholecystitis
'Essential_(primary)_hypertension'	Calculus_of_gallbladder_with_other_cholecystitis_with_obstruction
'Hypertensive_heart_disease_with_(congestive)_heart_failure'	Calculus_of_kidney
'Intracranial_haemorrhage_(nontraumatic),_unspecified'	Calculus_of_ureter
'Mitral_(valve)_insufficiency'	Cardiac_septal_defect,_acquired
'Pericardial_effusion_(noninflammatory)'	Cardiomyopathy,_unspecified
'Prolonged_second_stage_(of_labour)'	Carpal_tunnel_syndrome
'Ulcerative_(chronic)_rectosigmoiditis'	Cataract,_unspecified
Acquired_absence_of_foot_and_ankle	Cellulitis,_unspecified
Acquired_absence_of_leg_at_or_below_knee	Cellulitis_of_face
Acute_appendicitis,_unspecified	Cellulitis_of_lower_limb
Acute_bronchitis,_unspecified	Cellulitis_of_toe
Acute_cholecystitis	Cellulitis_of_trunk
Acute_miliary_tuberculosis_of_multiple_sites	Cerebral_atherosclerosis
Acute_myocardial_infarction,_unspecified	Cerebral_infarction,_unspecified
Acute_nephritic_syndrome_Diffuse_membranous_glomerulonephritis	Cerebral_infarction_due_to_embolism_of_cerebral_arteries
Acute_nephritic_syndrome_Unspecified	Cerebral_infarction_due_to_embolism_of_precerebral_arteries
Acute_pancreatitis,_unspecified	Cerebral_infarction_due_to_unspecified_occlusion_or_stenosis_of_cerebral_arteries
Acute_peritonitis	Chest_pain,_unspecified
Acute_renal_failure,_unspecified	Cholangitis
Acute_subendocardial_myocardial_infarction	Chronic_ischaemic_heart_disease,_unspecified
Acute_transmural_myocardial_infarction_of_anterior_wall	Chronic_nephritic_syndrome_Unspecified
Acute_transmural_myocardial_infarction_of_inferior_wall	Chronic_obstructive_pulmonary_disease,_unspecified
Acute_upper_respiratory_infection,_unspecified	Chronic_obstructive_pulmonary_disease_with_acute_exacerbation,_unspecified
Agranulocytosis	Chronic_obstructive_pulmonary_disease_with_acute_lower_respiratory_infection
Anaemia,_unspecified	Chronic_osteomyelitis_with_draining_sinus_Ankle_and_foot
Angina_pectoris,_unspecified	Chronic_renal_failure,_unspecified
Arteriovenous_fistula,_acquired	Congestive_heart_failure
Arteritis,_unspecified	Cutaneous_abscess,_furuncle_and_carbuncle_of_buttock
Asthma,_unspecified	Cutaneous_abscess,_furuncle_and_carbuncle_of_limb
Atherosclerosis_of_arteries_of_extremities,_unspecified	Cutaneous_abscess,_furuncle_and_carbuncle_of_trunk
Atherosclerosis_of_arteries_of_extremities_with_gangrene	Cystic_fibrosis,_unspecified
Atherosclerosis_of_arteries_of_extremities_with_rest_pain	Cystocele
Atherosclerosis_of_arteries_of_extremities_with_ulceration	Diabetes_insipidus
Atherosclerotic_heart_disease_of_native_coronary_artery	Diarrhoea_and_gastroenteritis_of_presumed_infectious_origin
Atherosclerotic_heart_disease_of_unspecified_vessel	Dietary_counselling_and_surveillance
Atrial_fibrillation_and_flutter	Dilated_cardiomyopathy
Atrioventricular_block,_complete	Disorder_of_arteries_and_arterioles,_unspecified
Atrioventricular_block,_second_degree	Disorder_of_lipoprotein_metabolism,_unspecified
Benign_paroxysmal_vertigo	Disorientation,_unspecified
Bifascicular_block	Dysuria
Bronchiectasis	End-stage_renal_disease
Bronchopneumonia,_unspecified	Endocrine,_nutritional_and_metabolic_diseases_complicating_pregnancy,_childbirth_and_the_puerperium
Brucellosis,_unspecified	Endometrial_glandular_hyperplasia
Calculus_of_bile_duct_with_cholecystitis_without_mention_of_obstruction	Endometrium
Calculus_of_bile_duct_without_cholangitis_or_cholecystitis	Enterocolitis_due_to_Clostridium_difficile
Calculus_of_bile_duct_without_cholangitis_or_cholecystitis_with_obstruction	Epidermal_cyst
Calculus_of_bile_duct_without_cholangitis_or_cholecystitis_without_mention_of_obstruction	Epilepsy,_unspecified_without_mention_of_intractable_epilepsy
Calculus_of_gallbladder_with_acute_cholecystitis_without_mention_of_obstruction	Escherichia_coli_[E._coli]_as_the_cause_of_diseases_classified_to_other_chapters
	Family_history_of_diabetes_mellitus

Fever,_unspecified	Other_and_unspecified_cirrhosis_of_liver
First_degree_perineal_laceration_during_delivery	Other_and_unspecified_convulsions
Fitting_and_adjustment_of_urinary_device	Other_and_unspecified_intestinal_obstruction
Fluid_overload	Other_bacterial_infections_of_unspecified_site
Fourth_[trochlear]_nerve_palsy	Other_chest_pain
Gangrene,_not_elsewhere_classified	Other_chronic_osteomyelitis_Ankle_and_foot
Gas_gangrene	Other_chronic_pancreatitis
Gastritis,_unspecified	Other_chronic_renal_failure
Gestational_[pregnancy-induced]_hypertension_without_significant_proteinuriaCMC	Other_cystitis
Gonarthrosis,_unspecified	Other_disorders_of_lipoprotein_metabolism
Heart_failure,_unspecified	Other_giant_cell_arteritis
Hepatitis_A_without_hepatic_coma	Other_ill-defined_heart_diseases
Hyperosmolality_and_hypernatraemia	Other_interstitial_pulmonary_diseases_with_fibrosis
Hyperplasia_of_prostate_CMC	Other_intracerebral_haemorrhage
Hypertensive_renal_disease_with_renal_failure	Other_maltreatment_syndromes
Hypo-osmolality_and_hyponatraemia	Other_osteomyelitis_Ankle_and_foot
Hypoglycaemia,_unspecified	Other_peripheral_vertigo
Infection_of_amputation_stump	Other_primary_gonarthrosis
Inflammatory_disorders_of_breast	Other_primary_thrombocytopenia
Insulin	Other_specified_abnormal_uterine_and_vaginal_bleeding
Insulin_and_oral_hypoglycaemic_[antidiabetic]_drugs	Other_specified_cataract
Interstitial_pulmonary_disease,_unspecified	Other_specified_cerebrovascular_diseases
Intracerebral_haemorrhage,_intraventricular	Other_specified_chronic_obstructive_pulmonary_disease
Intracerebral_haemorrhage,_unspecified	Other_specified_counselling
Ischaemic_cardiomyopathy	Other_specified_diabetes_mellitus
Kidney_transplant_status	Other_specified_diabetes_mellitus_with_foot_ulcer_due_to_multiple_causes
Labour_and_delivery_complicated_by_cord_around_neck,_with_compression	Other_specified_diabetes_mellitus_with_other_specified_ophthalmic_complication
Labour_and_delivery_complicated_by_fetal_heart_rate_anomaly	Other_specified_disorders_of_white_blood_cells
Labour_and_delivery_complicated_by_meconium_in_amniotic_fluid	Other_specified_heart_block
Labour_and_delivery_complicated_by_other_cord_entanglement	Other_specified_intervertebral_disc_displacement
Labour_and_delivery_complicated_by_other_evidence_of_fetal_stress	Other_specified_mononeuropathies
Left_ventricular_failure	Other_specified_special_examinations
Maternal_care_due_to_uterine_scar_from_previous_surgery	Pathological_fracture,_not_elsewhere_classified_Upper_arm
Maternal_care_for_disproportion_due_to_unusually_large_fetus	Peritonitis,_unspecified
Maternal_care_for_excessive_fetal_growth	Personal_history_of_allergy_to_analgesic_agent
Meningitis,_unspecified	Personal_history_of_noncompliance_with_medical_treatment_and_regimen
Migraine_with_aura_[classical_migraine]	Phlebitis_and_thrombophlebitis_of_other_deep_vessels_of_lower_extremities_CMC
Mitral_stenosis	Pituitary-dependent_Cushing's_disease
Mitral_stenosis_with_insufficiency	Pleural_effusion,_not_elsewhere_classified
Mitral_valve_disease,_unspecified	Pneumonia,_unspecified
Neglect_or_abandonment	Pneumonitis_due_to_food_and_vomit
Nephrotic_syndrome_Focal_and_segmental_glomerular_lesions	Polyhydramnios
Nephrotic_syndrome_Unspecified	Polymyositis
Noninfective_gastroenteritis_and_colitis,_unspecified	Polyp_of_corpus_uteri
Nonunion_of_fracture_[pseudarthrosis]_Forearm	Postmenopausal_bleeding_CMC
Obstruction_of_bile_duct	Postphlebotic_syndrome
Obstructive_and_reflux_uropathy,_unspecified	Pre-excitation_syndrome
Oligohydramnios	Pre-existing_diabetes_mellitus,_other_specified_type,_in_pregnancy_non-insulin_treated
Osteomyelitis,_unspecified_Ankle_and_foot	Pre-existing_diabetes_mellitus,_Type_1,_in_pregnancy
Osteomyelitis,_unspecified_Lower_leg	Pre-existing_diabetes_mellitus,_Type_2,_in_pregnancy_insulin_treated
Other_and_unspecified_abdominal_pain	

Pre-existing_diabetes_mellitus,_Type_2,_in_pregnancy_non-in-sulin_treated	Type_2_diabetes_mellitus_with_diabetic_ischaemic_cardiomyopathy
Pre-existing_essential_hypertension_complicating_pregnancy,_childbirth_and_the_puerperium	Type_2_diabetes_mellitus_with_diabetic_polyneuropathy
Premature_rupture_of_membranes,_onset_of_labour_within_24_hours	Type_2_diabetes_mellitus_with_established_diabetic_nephropathy
Primary_gonarthrosis,_bilateral	Type_2_diabetes_mellitus_with_features_of_insulin_resistance
Primary_hyperparathyroidism	Type_2_diabetes_mellitus_with_foot_ulcer_due_to_multiple_causes
Primary_open-angle_glaucoma	Type_2_diabetes_mellitus_with_hyperosmolarity_with_coma
Procedure_not_carried_out_because_of_patient's_decision_for_other_and_unspecified_reasons	Type_2_diabetes_mellitus_with_hyperosmolarity_without_non-ketotic_hyperglycaemic-hyperosmolar_coma_NKHC
Procedure_not_carried_out_for_other_reasons	Type_2_diabetes_mellitus_with_hypoglycaemia
Progressive_supranuclear_ophthalmoplegia	Type_2_diabetes_mellitus_with_ketoacidosis,_without_coma
Pulmonary_embolism_without_mention_of_acute_cor_pulmonale	Type_2_diabetes_mellitus_with_multiple_microvascular_complications
Pulmonary_oedema	Type_2_diabetes_mellitus_with_other_retinopathy
Retinal_detachment_with_retinal_break	Type_2_diabetes_mellitus_with_other_specified_complication
Retropharyngeal_and_parapharyngeal_abscess	Type_2_diabetes_mellitus_with_other_specified_ophthalmic_complication
Rheumatic_mitral_insufficiency	Type_2_diabetes_mellitus_with_other_specified_renal_complication
Rotator_cuff_syndrome	Type_2_diabetes_mellitus_with_peripheral_angiopathy_with_gangrene
Salmonella_enteritis	Type_2_diabetes_mellitus_with_peripheral_angiopathy_without_gangrene
Second_degree_perineal_laceration_during_delivery	Type_2_diabetes_mellitus_with_poor_control_CMC
Senile_cataract,_unspecified	Type_2_diabetes_mellitus_with_unspecified_neuropathy
Sepsis_due_to_other_Gram-negative_organisms	Type_2_diabetes_mellitus_without_complication
Sick_sinus_syndrome	Ulcerative_colitis,_unspecified
Single_live_birth	Umbilical_hernia_without_obstruction_or_gangrene
Spinal_stenosis_Lumbar_region	Unilateral_or_unspecified_inguinal_hernia,_without_obstruction_or_gangrene_not_specified_as_recurrent
Streptococcus,_group_A,_as_the_cause_of_diseases_classified_to_other_chapters	Unspecified_atrial_septal_defect
Stricture_of_artery	Unspecified_chronic_renal_failure
Stroke,_not_specified_as_haemorrhage_or_infarction	Unspecified_diabetes_mellitus_with_acidosis
Supervision_of_pregnancy_with_grand_multiparity	Unspecified_diabetes_mellitus_with_advanced_renal_disease
Supraventricular_tachycardia	Unspecified_diabetes_mellitus_with_diabetic_ischaemic_cardiomyopathy
Syndrome_of_inappropriate_secretion_of_antidiuretic_hormone	Unspecified_diabetes_mellitus_with_established_diabetic_nephropathy
Traction_detachment_of_retina	Unspecified_diabetes_mellitus_with_features_of_insulin_resistance
Transient_cerebral_ischaemic_attack,_unspecified	Unspecified_diabetes_mellitus_with_foot_ulcer_due_to_multiple_causes
Tuberculosis_of_lung,_confirmed_by_sputum_microscopy_with_or_without_culture	Unspecified_diabetes_mellitus_with_hyperosmolarity,_without_nonketotic_hyperglycaemic-hyperosmolar_coma_NKHC
Tuberculous_peripheral_lymphadenopathy	Unspecified_diabetes_mellitus_with_multiple_microvascular_complications
Tubulo-interstitial_nephritis,_not_specified_as_acute_or_chronic	Unspecified_diabetes_mellitus_with_other_retinopathy
Type_1_diabetes_mellitus_with_advanced_ophthalmic_disease	Unspecified_diabetes_mellitus_with_other_specified_complication
Type_1_diabetes_mellitus_with_advanced_renal_disease	Unspecified_diabetes_mellitus_with_other_specified_ophthalmic_complication
Type_1_diabetes_mellitus_with_background_retinopathy	Unspecified_diabetes_mellitus_with_peripheral_angiopathy_with_gangrene
Type_1_diabetes_mellitus_with_diabetic_cataract	Unspecified_diabetes_mellitus_with_poor_control_CMC
Type_1_diabetes_mellitus_with_foot_ulcer_due_to_multiple_causes	Unspecified_diabetes_mellitus_with_proliferative_retinopathy
Type_1_diabetes_mellitus_with_hypoglycaemia	Unspecified_diabetes_mellitus_without_complication
Type_1_diabetes_mellitus_with_ketoacidosis_with_coma	Unstable_angina
Type_1_diabetes_mellitus_with_ketoacidosis_without_coma	Urinary_tract_infection,_site_not_specified
Type_1_diabetes_mellitus_with_multiple_microvascular_complications	Vitreous_haemorrhage
Type_1_diabetes_mellitus_with_other_retinopathy	Volume_depletion
Type_1_diabetes_mellitus_with_other_specified_complication	Wegener's_granulomatosis
Type_1_diabetes_mellitus_with_poor_control_CMC	Zoster_without_complication
Type_1_diabetes_mellitus_with_proliferative_retinopathy	
Type_1_diabetes_mellitus_without_complication	
Type_2_diabetes_mellitus_with_advanced_renal_disease	
Type_2_diabetes_mellitus_with_background_retinopathy	