| I. Use Case Description | |
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| Use Case Name | Patient Guideline Recommender |
| Use Case Identifier | OE2020-PGR |
| Source | Ontology Engineering- Ishita Padhiar |
| Point of Contact | Shruthi Chari, charis@rpi.edu<br>Liam Feehery, feehew@rpi.edu<br>Ishita Padhiar, padhii@rpi.edu<br>Travis Peterson, petert6@rpi.edu<br>Bolun "Namir" Xia, xiab3@rpi.edu |
| Creation / Revision Date | 09/11/2020 |
| Associated Documents | |

| II. Use Case Summary | |
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| Goal | The goal of this project is to provide the tools to assess the nutritional/lifestyle needs of a diebetic patient. We would do this by developing an ontology that could answer their questions based on the recommendations provided by the ADA guidelines. The ontology should also match them to the guidelines that are relevant to them. |

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| Requirements | For this project we want to enable individuals to understand and interpret their nutritional needs in relation to their pre-existing conditions and other restrictions. Currently this information is scattered in a variety of locations. In a best case scenario, diligent patients have to hunt through over 200 pages of the ADA guidelines to find the answers relevant to them. In many other situations, the patient might instead resort to quick google searches with often unverified information and possibly incorrect information.<br><br>For this use case to be successful we require a complete dissection of the guidelines and would also want basic health and body information as well as access to certain parts of the patient's medical history. |
| Scope | For the sake of this project in the Ontology Engineering class, I am bounding the problem to answer questions and recommend guidelines based on nutritional and lifestyle requirements coming from the American Diabetes Association. In the future you could open this project to all guidelines including drug and exercise, as well as truths that originate from outside the ADA guidelines.<br><br>Consequently, the target population for the project is individuals that have diabetes and/or individuals that want to know more about nutritional requirements and restrictions for diabetic populations. |
| Priority | The priority use case is to correctly map patients to recommendations from guidelines that are relevant to them |
| Stakeholders | Stakeholders for this ontology include patients that want verified answers relevant to their specific conditions and attributes. Other stakeholders might be doctors who want qualified answers for their patients and researchers trying to understand relationships between patients and guidelines. |

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| Description | The current use case aims to create a clean and consistent site from which users can view their health information and learn more about the guidelines that pertain to them, essentially empowering the user with facts and supported recommendations regarding their health. This can be in the form of a website or application. The biggest aim of this project is to accurately answer questions from patients based on their personal needs and pre-existing conditions. The principal actor in this case is the patient or their family and the interface we will be using is a website or phone application.<br><br>There are two main objectives for this that can also be split into multiple sub-categories:<br><br>· First, we need to create a schema for mapping patients to their recommendations relevant to them. This first filtering is the crux of this project. In order to properly complete this task we will need to:<br>o Create a structure to store natural language recommendations and their implications. We will need to extract limiting details that will be used for filtering. For instance, if a recommendation only applies to type 1 diabetes it is important that this information is explicitly stored.<br>o Map patient characteristics to guideline filter queries. This can be done by checking if they fall in the same ontological classes.<br><br>· Next we want to allow questions from our users. This means that we will be filtering by not only the patient's details but also by the filters in their question. For instance, if a user asks a question about nutrition, we do not want to show them guidelines about exercise and lifestyle.<br><br>· Last, if possible we want to extend the range of the questions, allowing broader questions by leveraging other ontologies such as FoodKG and GProv. In these cases we would use the inference tools in either of the habove ontologies as well as our ontology so that users have a smooth usage experience. |

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| Actors / Interfaces | The primary actor for this use case is the patient or their family that would be interested in finding the guidelines that would best serve the patient's health. Other actors/ interfaces would be:<br><br>· The patient's profile. This page would store all important information about the patient's health and medical history.<br><br>· ADA guidelines<br><br>· HEALS existing ontologies.<br>o FoodKG- A patient might enter a food that they had and ask if it meets or breaks nutritional requirements provided in the ADA guidelines<br>o GProv- A patient might want to better understand why a a guideline exists and was recommended to them<br><br>· Oshani's Guideline Encoding- https://github.com/oshanis/misc/blob/master/guidelines.owl |
| Pre-conditions | First and foremost, since we are restricting ourselves to the American Diabetes Association Guidelines, a requirement on the user side is that the patient has diabetes or other conditions that would qualify results from the ADA guidelines. If the patient doesn't have any of these preconditions, the recommendations from the ADA would not apply to them, which means that every search to the ontology would return zero qualifying recommendations.<br><br>Next to initiate the use cases we would also need certain basic information about the patients and their medical history. In order to provide the user with the best data for them, we need more information about them. Some basic mandatory characteristics might include gender, age, weight, pre-existing conditions. If we have no information about the user, we will simply return all guidelines.<br><br>Another requirement is that at least one guideline exists in the system and can be searched for, otherwise every search will be empty.<br><br>Because of HIPPA, if we connect this service to healthcare providers/ get information from them, it will be important to password protect and secure all user information. |
| Post-conditions | If a user decides to update any of their personal information we should save it for future uses. |

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| Triggers | The main trigger for this use case is if a user logs in or signs up |
| Performance Requirements | Since our guideline set is currently pretty small there aren't many issues with the timing and sizing portions. However since we are dealing with health data (ADA guidelines) maintainability is key. It will be important to update that information every year, or risk providing inaccurate, or worse, incorrect answers and guidelines. |
| Assumptions | |
| Open Issues | · Application or Website?<br>· Best way to create a mapping from the patient to the guideline<br>· A more extensible way to add different guidelines to our ontology<br>o For the sake of this class and the scope of the project, we can probably get away with manually inputting the guidelines, however if we pursue this for the long term we might want an automated solution. This seems like more of a NLP task though, so I think we should ignore it for the sake of this project. |
| Notes | This is the very paired down version of this ontology. In the future we may want to expand it, to include guidelines from other sources, provide other kinds of recommendations (drug, exercise, etc), and appeal to a broader range of users. |

## III. Usage Scenarios

1. For our first usage scenario we consider a young man in his early-20s that has recently been diagnosed as diabetic. He is young and wants to mitigate symptoms and maintain his health as much as possible so that the chronic condition does not become a bigger issue in future years. He has tried to find information online but since the majority of cases are with older adults he has had difficulty finding information that might work for him. He has also noticed that some other websites have given him contradictory recommendations and is unsure which site to trust and why. His primary goals are to make lifestyle and dietary changes that are sustainable for the rest of his life and are backed by reputable organizations.

2. Our second usage scenario is a middle school child with type 2 diabetes. Her mother is concerned about her health and wants to ensure she receives the best day to day care, to prevent the worsening of symptoms. Being a single mom, however, she doesn't have the time to read through the 200-page American Diabetes Association guidelines to figure out exactly which recommendations apply to her daughter and which ones do not. She has searched online but has found that the information is often not very scientifically informed and is concerned with the evidence behind empty statements found on google.

## IV. Basic Flow of Events

Narrative: *Often referred to as the primary scenario or course of events, the basic flow defines the process/data/workflow that would be followed if the use case were to follow its main plot from start to end. Error states or alternate states that might occur as a matter of course in fulfilling the use case should be included under Alternate Flow of Events, below. The basic flow should provide any reviewer a quick overview of how an implementation is intended to work. A summary paragraph should be included that provides such an overview (which can include lists, conversational analysis that captures stakeholder interview information, etc.), followed by more detail expressed via the table structure.*

*In cases where the user scenarios are sufficiently different from one another, it may be helpful to describe the flow for each scenario independently, and then merge them together in a composite flow.*

This case highlights the most normal flow for this application. In this case a user would go to the site, update any required information and then ask a couple questions relating to their health and the guidelines recommended for them.

| **Basic / Normal Flow of Events** | | | |
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| **Step** | **Actor (Person)** | **Actor (System)** | **Description** |
| 1 | Patient | | Launches the application or goes to the website and logs in. |

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| 2 | | Patient Guideline site, (app or website) | Retrieves all the information on the patient and their characteristics. |
| 3 | Patient | | If there is only one associated user with the account skip this step. Else if this is the account of a parent, for example, it may give you the option to pick between the different profiles, or multiple profiles to be loaded in at once. |
| 4 | | Patient Guideline Site | Display a summary of the user's profile and other details including their health concerns. Highlight any fields that might be old or out of date so that the user knows to update them. Also show charts and graphs any information that can be consistently logged by the user, for example, weight and progress towards goals. |
| 5 | Patient | | Reviews all the given information and updates anything that needs to be updated. |
| 6 | Patient | | Asks a question if a guideline is applicable to them. |
| 7 | | Patient Guideline Site | Displays an answer breaking down the guideline and dissecting which parts apply to our use and which ones do not |
| 8 | Patient | | Asks whether their current meal plan fits with their goals |
| 9 | | Patient Guideline Site | Display information and charts showing the difference between their current meal plan, and their dietary goals and what is recommended by the ADA guidelines |
| 10 | Patient | | Logs out. |

## V. Alternate Flow of Events

*The first alternative flow of events is when a user creates an account for the first time and all the associated sign up steps.*

| V.a Alternate Flow of Events- Initial Account Set-Up | | | |
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| **Step** | **Actor (Person)** | **Actor (System)** | **Description** |
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| 1 | Patient | | Clicks the sign up button rather than the login option |
| 2 | | Patient Guideline Site | Prompts the new user to enter basic login information, for example a username and password. Next it asks for any relevant health information that the user can choose to fill in. These questions include, but are not limited to:<br>· Age<br>· Gender<br>· Weight<br>· Conditions<br>o Type of Diabetes<br>o Family history |
| 3 | Patient | | Fills in the fields they are comfortable with providing |
| 4 | | Patient Guideline Site | Does a preliminary search to the ontology to get *all* the guidelines relevant to the user and asks the user to fill in information for any goals they might have. This would be a closed set that would include, but is not limited to:<br>· Weight goals: ex) Weight loss. At this point the system would ask you to fill in your goal weight and and diets you might be following to make that happen<br>. |

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| 5 | Patient | | Fills in any goal information |
| 6 | | Patient Guideline Site | Loads in patient information, goal information, and conditions into the knowledge graph |
| 7 | | Patient Guideline Site | Displays the login screen home page, with the same fields as the Basic Flow in IV step. After this the user can follow all the subsequent steps from the Basic flow or log out and continue another time |

## VI. Use Case and Activity Diagram(s)

*Provide the primary use case diagram, including actors, and a high-level activity diagram to show the flow of primary events that include/surround the use case. Subordinate diagrams that map the flow for each usage scenario should be included as appropriate*

***Figure 1: High level diagram of the basic flow***

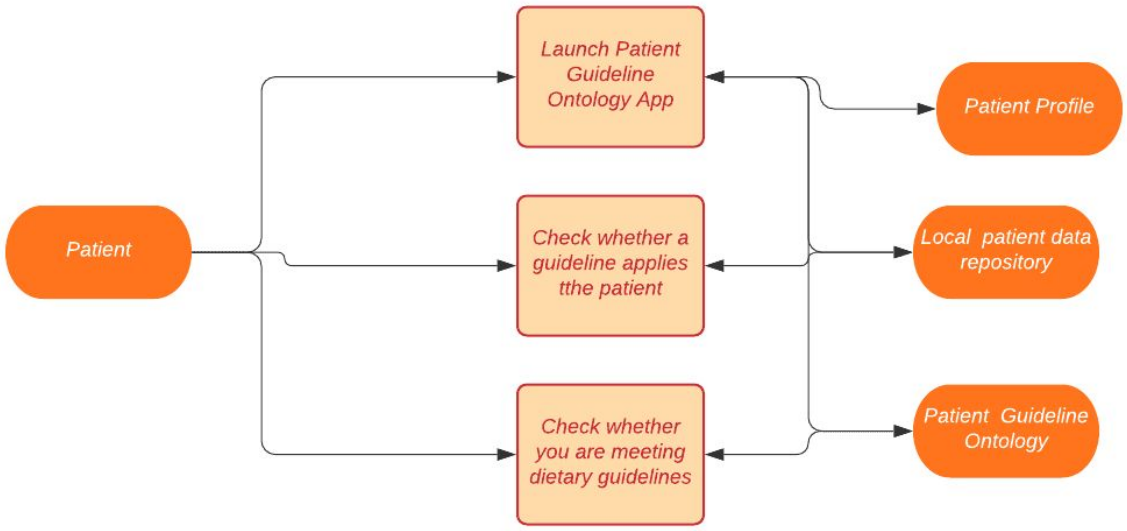


***Figure 2: Diagram of the launch of the App . The inputs here are the initiation of the system/opening of the app and the output is the user profile and app start page.***

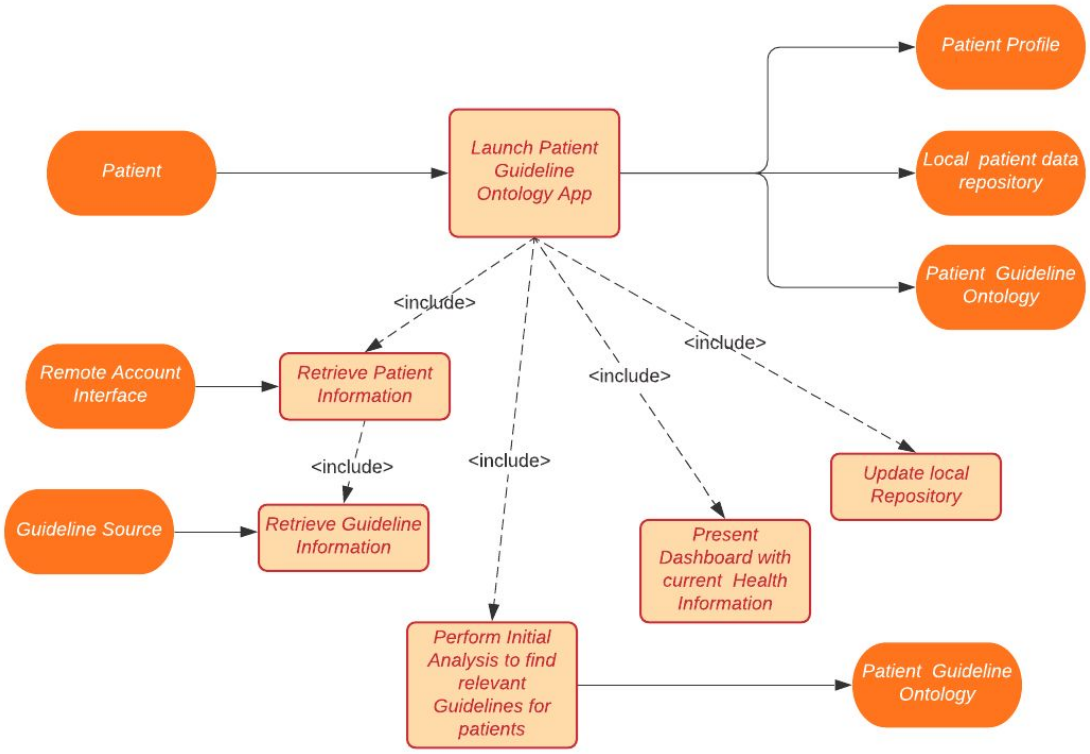


*Figure 3: Diagram of checking whether a patient matches the guideline. The inputs would be the patient asking whether a guideline would apply to them and the output is whether it does.*

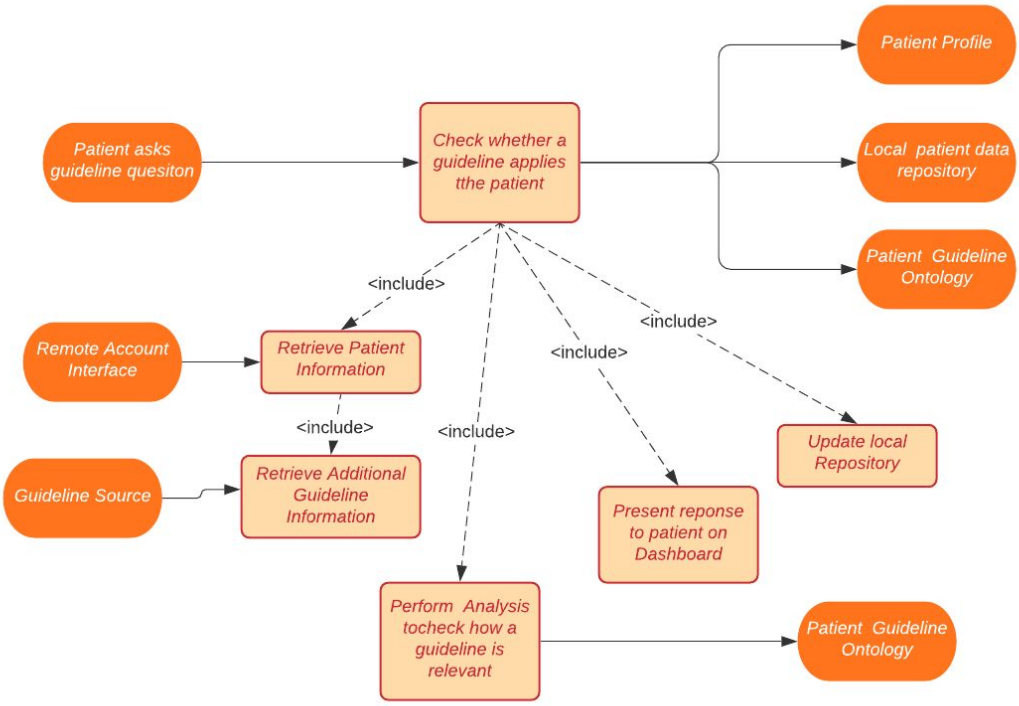
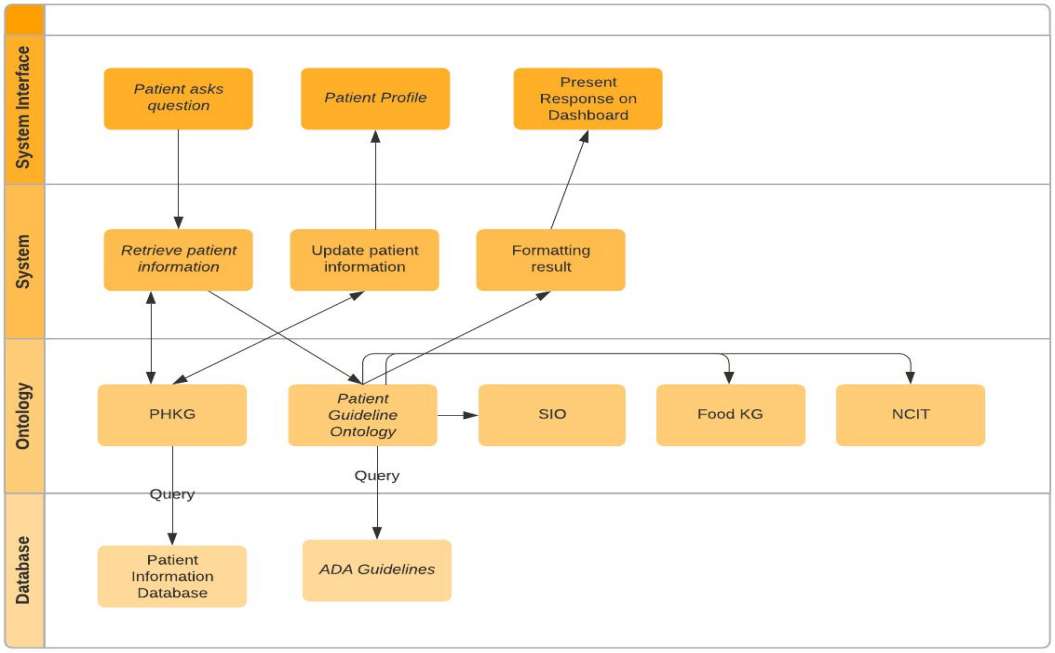



**Figure 4:Activity Diagram From the User Questions to Response, including full frontend to backend flow.**




## VII. Competency Questions

1. Does this guideline recommendation apply to me?
    a. Guideline 5.27 which states that "5.27 All adults, and particularly those with type 2 diabetes, should decrease the amount of time spent in daily sedentary behavior. B Prolonged sitting should be interrupted every 30 min for blood glucose benefits, particularly in adults with type 2 diabetes. C", does apply to you. This recommendation is primarily aimed towards adults with type 2 diabetes and sedentary habits. Modifying your lifestyle to better fit this guideline would have a positive impact on your life.
    b. Using our ontology we would search to find out if our user matched any of the key traits required by the guideline, in this case, an adult with type 2 diabetes and somewhat sedentary. For every case we would return the area where the guidelines did match and the areas where our user differed from the guideline's target. The most obvious solution to this problem is just having the user read the guideline and skip our tool altogether. However this may end up being more tedious for the patient. Also the patient may not have the medical background

required to properly understand the guideline and we present it in an easily digestible way. We will be identifying sedentary behavior using the NCIT ontology definitions of different types of physical activities, which states that sedentary behavior is “a type of lifestyle that lacks physical exercise, characterized by sitting, reading, watching television or using a computer for much of the day without vigorous physical exertion”. We define “much of the day” as less than 30 min of exercise a day.

2. If I ate a burrito, pad thai, and a slice of cheesecake today, with no exercise, am I working towards my dietary goal?

a. According to recommendation 8.7, in order to meet your dietary goals of weight loss you need to need to maintain a calorie deficit. With your current intake of 2000 calories and 1750 burned calories you are at a surplus of 250 calories. In order to meet your goal you must burn at least 251 calories. This is recommendation 8.7: “8.7 As all energy-deficit food intake will result in weight loss, eating plans should be individualized to meet the patient’s protein, fat, and carbohydrate needs while still promoting weight loss. A”

b. For this competency question we leverage both the HEALS FoodKG as well as our new PatientToGuideline ontology. First we must use FoodKG to find the calorie amount of the food we talked about. Alternatively if this is not an option we could also use other APIs (ex. https://developer.edamam.com/food-database-api-docs) to get/encode this information or have the user directly enter their caloric intake. Next we would look at the user’s profile to determine what their diet goals are. After this and with their profile information, we would query the parameters in the user’s question to find a guideline that might answer the user's question. This can be done using a Sparql query. This would return guideline 8.7, after which we can fill in the underlined sections to confirm or deny that they are meeting requirements. The benefits to using semantics in this situation is the mapping that we are doing. Other than humans reading the dense guidelines, it is difficult to represent the information present in an understandable way that clearly maps to what the patient wants and needs.

Additional Competency Questions

3. I like ice cream, chocolate cake, baklavas, halva, turkish delight, tomatoes and eggs, lamb tandoori, and chicken biryani, and I don’t like bitter melon, kale, spinach, fish, and beef. What combinations of food and exercise do you recommend so that I could be safe as a type 2 diabetic patient?

a. We recommended one plate of tomatoes and eggs, and one serving of lamb tandoori, along with 30 minutes of tennis;  one plate of chicken biryani, and a chocolate cake, along with 1 hour of running.
b. For this question, we would utilize the FoodKG ontology. First, we would put this query into the FoodKG ontology to see what kinds of combinations of food and exercise we can get, with due considerations to the likes and dislikes of the user. Again, we could also use other APIs (ex. https://developer.edamam.com/food-database-api-docs) to get/encode this information. Second, we would use our ontology to determine whether or not the user, with their specific medical information on file, can consume these types of food, and whether or not they would be good for them (this information, we would extract from the ADA guidelines). Finally, we would eliminate the options that would not be safe for our user, and recommend some combinations of food and exercise that could be safe for this specific patient with this specific type of diabetes.

4. I (65 year-old male with diabetes) have been maintaining an active lifestyle by walking for an hour every day. Are there other forms of physical activity that I should be incorporating?

a. According to guideline 5.28, you should be incorporating flexibility and balance training into your routine 2-3 times per week. You might consider yoga and Tais Chi as options. would both utilize our own ontology and the NCI Thesaurus Ontology on different types of physical activities. Our own ontology would first access the user's profile to obtain that the user is an older adult (65 year-old male)  with type 2 diabetes, then our Ontology would tell us that for an older adult, trainings like yoga and tai chi are recommended 2-3 times/week, per "5.28 Flexibility training and balance training are recommended 2–3 times/week for older adults with diabetes. Yoga and tai chi may be included based on individual preferences to increase flexibility, muscular strength, and balance. C". And both of these types of training, yoga and tai chi, can be found on the NCI Thesaurus, for further context.

5. I am type 2 diabetic and I want to smoke a cigarette to relieve my stress. But, I was advised heavily by my physician to avoid that. Could I smoke an e-cigarette instead?

a. No. As per Guideline 5.29, The use of e-cigarettes for a smoking alternative is no more effective than actually smoking a regular cigarette.

   Suggestions:

   - Per Guideline 5.30, to try and regulate smoking habit please consider attending smoking cessation counseling, This can be done through in person interaction or the use of telephone quit lines

- Alternative products to smoking include nicotine gum, nicotine patches, and nicotine lozenges which are all approved by the FDA.

b. First we explore our PatientToGuideline ontology to see if the question matches any of the guidelines in the ontology (in this case, smoking an e-cigarette). The ontology query would return ADA guidelines 5.29 and 5.30, which we would then display to the user. Then the ontology will look for any relative information in dealing with smoking and nicotine use which can be found in the ADA guidelines as well as through other sources of info such as FDA approved guidelines (Pharmacologic Product Guide: FDA-Approved Medications for Smoking Cessation) that contains information regarding safer alternatives to curve nicotine addiction. Recommending a specific alternative will require the system to look through the patient's profile and data in order to see any other health concerns that might trigger one of the substitute's precautions making it unsuitable for the patient to use.

## VIII. Resources

*In order to support the capabilities described in this Use Case, a set of resources must be available and/or configured. These resources include the set of actors listed above, with additional detail, and any other ancillary systems, sensors, or services that are relevant to the problem/use case.*

### Knowledge Bases, Repositories, or other Data Sources

| Data | Type | Characteristics | Description | Owner | Source | Access Policies & Usage |
|---|---|---|---|---|---|---|
| ***(dataset or repository name)*** | *(remote, local/in situ, etc.)* | *e.g. – no cloud cover* | *Short description of the dataset, possibly including rationale of the usage characteristics* | | *Source (possibly a system, or remote site) for discovery and access* | |

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| ADA Guidelines | local | | Contains all the guidelines we will be using in the scope of this project. We will need to create a semantic representation of these to use in our system. | ADA | https://care.diabetesjournals.org/content/diacare/suppl/2018/12/17/42.Supplement_1.DC1/DC_42_S1_2019_UPDATED.pdf | |

## External Ontologies, Vocabularies, or other Model Services

| Resource | Language | Description | Owner | Source | Describes/Uses | Access Policies & Usage |
|---|---|---|---|---|---|---|
| ***(ontology, vocabulary, or model name)*** | *(ontology language and syntactic form, e.g., RDFS - N3)* | *If the service is one that runs a given ontology or model-based application at a given frequency, state that in addition to the basic description* | | *Source (link to the registry or directly to the ontology, vocabulary, or model where that model is maintained, if available)* | *List of one or more data sources described by and/or used by the model* | |
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| **FoodKG** | OWL | Models food recipes | HEALS | | The user might provide a food they ate and we can break it down to its components to check if it fits guidelines. | |

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| **GProv** | OWL | Guideline Provenance-contains mappings from recommendations to their evidence | HEALS | https://tetherless-world.github.io/GProv/widoco/widocDocumentationo/index-en.html | A user may ask for the provenance information behind the guideline that was recommended to them | |
| **SIO** | OWL | The SemanticScience integrated ontology provides many different biological terms and their relationships | BioPortal | | Required for connecting different concepts in our ontology. | |

**Other Resources, Service, or Triggers** *(e.g., event notification services, application services, etc.)*

| Resource | Type | Description | Owner | Source | Access Policies & Usage | |
|---|---|---|---|---|---|---|
| ***(sensor or external service name)*** | | *Include a description of the resource as well as availability, if applicable* | *Primary owner of the service* | ***Application or service URL**; if subscription based, include subscription and any subscription owner* | | |
| NCI Thesaurus | remote | Large Ontology with a variety of biomedical terms. We will be using it to help define physical activity and lifestyle. | NCI (National Cancer Institute) | http://www.ontobee.org/ontology/NCIT | Public Domain | |

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| **FoodData Central** | remote | | This would be used to find nutritional breakdown of different types of foods for the system to later compare dietary thresholds against | U.S. Department of Agriculture | https://fdc.nal.usda.gov/ | Public domain but prefer to be notified of its use |

## IX. References and Bibliography


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American Diabetes Association, “Lifestyle Management: Standards of Medical Care in Diabetes-2019,” Diabetes Care, 01-Jan-2019. [Online]. Available: https://doi.org/10.2337/dc19-S005. [Accessed: 24-Sep-2020].


## X. Notes

*There is always some piece of information that is required that has no other place to go. This is the place for that information.*