
MEDLINEPLUS CONNECT: MAPPING DIETARY SUPPLEMENTS TO MEDICATION CODES

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ABSTRACT

Background: MedlinePlus Connect is a service that allows electronic health record (EHR) systems to link patients and providers to relevant information on MedlinePlus.gov. A curated mapping file specifies connections between certain medical codes and MedlinePlus resources. The focus has been on diagnoses, lab tests, and over-the-counter and prescription drugs, with dietary supplements being excluded from the mapping file. However, dietary supplements are frequently requested through MedlinePlus Connect. In FY13, 2,193 queries were supplements, which accounted for 14% of the queries without a match.

Objective: The purpose of this project was to enhance MedlinePlus Connect responses by creating an additional mapping file to include relationships between RXCUIs (RxNorm codes) and dietary supplement information from MedlinePlus.

Methods: The project began with review of MedlinePlus Connect and RxNorm documentation. This was followed by analysis of MedlinePlus and MedlinePlus Connect queries to understand the need for dietary supplement information. Additional research was required in exploring available tools for searching the RxNorm database, ultimately selecting RxMix as the optimal tool. After reviewing the content on the dietary supplement webpages, a list of common and scientific names for the supplements was compiled for use in the RxMix searches.

Results: After analyzing the results of ten RxMix searches, the Associate selected 484 RXCUIs relevant to the supplements on MedlinePlus. For the supplements that didn't retrieve results through RxMix, the Associate consulted with NLM staff that had access to the full RxNorm database to find additional RXCUIs.

Outcomes: The manually-selected RXCUIs went through an automatic expansion process, and the final mapping has 3,739 RXCUIs for dietary supplements. The mapping file is currently undergoing testing for accuracy. After testing is completed and the mapping file is implemented into the system, then MedlinePlus Connect will provide improved responses and allow clinicians and patients to have quick and easy access to targeted information on dietary supplements through their EHRs.

BACKGROUND

MEDLINEPLUS CONNECT

MedlinePlus Connect is a service provided by the National Library of Medicine. It allows electronic health records (EHRs), patient health portals, and other health IT systems to link to consumer health information. The information comes from MedlinePlus.gov, Genetics Home Reference, and other NIH resources. One of the federal standards for EHRs is the ability to use them to identify patient-specific education resources. Through MedlinePlus Connect, patients, families, and health care providers can use their EHRs to easily access authoritative, up-to-date health information at the point of need.

An EHR is able to access this information by submitting a code-based request to MedlinePlus Connect. The medical codes provide a standard terminology, enable interoperability between different health IT systems, and permit accurate communication among the health professionals using the EHRs. MedlinePlus Connect responds to the request from the EHR with consumer health information targeted to the specific medical code used in the request. Then patients or clinicians can click a link in their EHR and read the information provided. Currently, MedlinePlus Connect successfully responds to requests for information on diagnoses, prescription & OTC drugs, and lab tests.

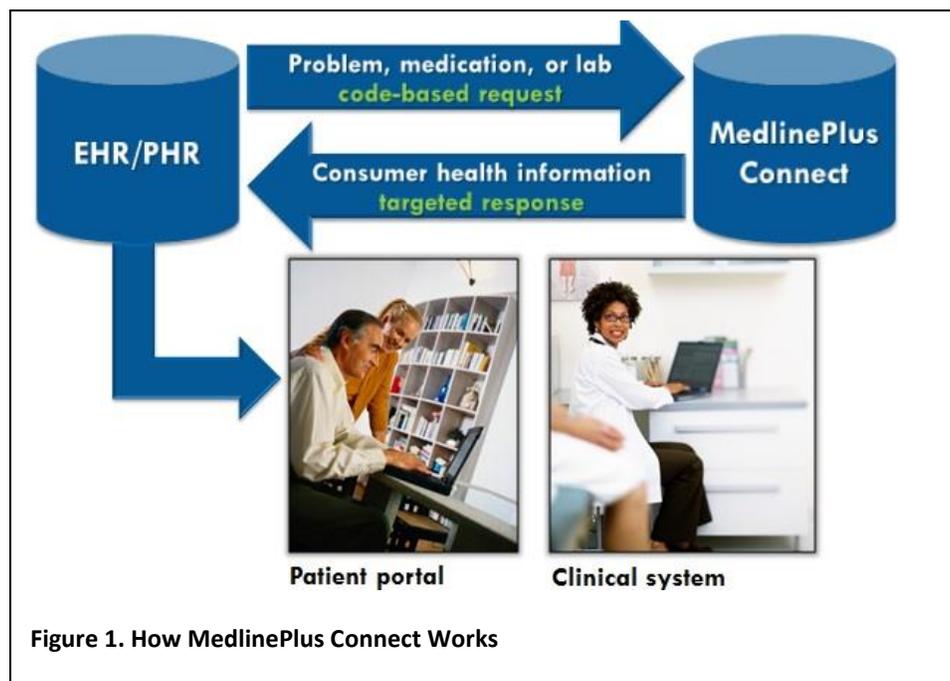


Figure 1. How MedlinePlus Connect Works

MAPPING FILE

On the backend of MedlinePlus Connect, one of the features that enables the connection between the medical code and the health information to happen is the mapping file. There are many other parts to the system, but this project focused on the mapping file. A mapping file lists all of the resources in a particular category and then establishes a relationship between those resources and relevant medical codes. Figure 2 shows a simplified image of how a mapping file works.

When a medical code is submitted to the MedlinePlus Connect system it is processed against the mapping file. When the appropriate resource related to that code is identified, then the URL is sent back to the EHR and the user can click through and read the resource.



Figure 2. How a mapping file works

Figure 3 shows an example of a drug code request. In this image, a code for an Acetaminophen tablet is submitted to MedlinePlus Connect. When the related resource is identified, then the URL is returned to the EHR and the user can click through and read the information on MedlinePlus.gov.

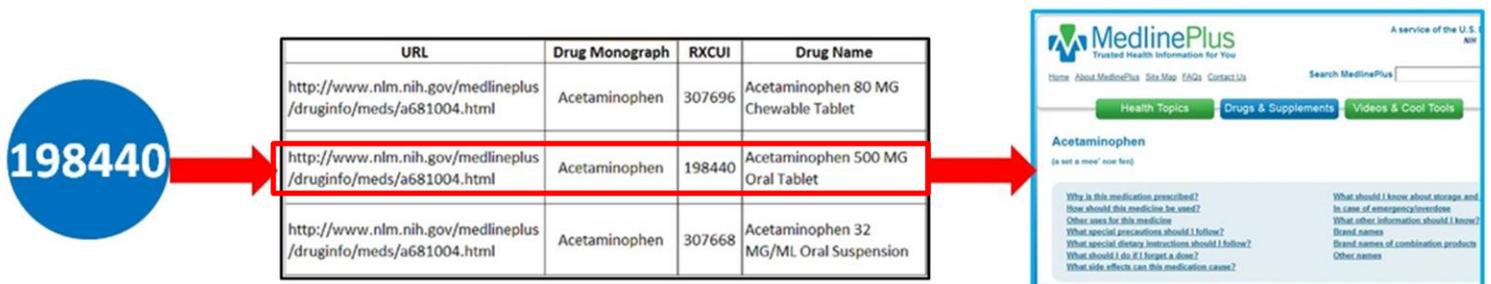


Figure 3. How a mapping file works: drug code request

DIETARY SUPPLEMENTS

WHY FOCUS ON DIETARY SUPPLEMENTS

Previous work with mapping drug codes has focused on the highest-demand content. There are 1,247 English-language drug information resources on MedlinePlus.gov. Those have all been successfully linked in a mapping file, using RxNorm drug codes. In FY2013, MedlinePlus Connect received 180,549 RxNorm code requests for information. Over 90% of those requests were successfully mapped to drug resources on MedlinePlus.gov and received a response. Now there is an opportunity to address the small percentage of RxNorm code requests that are not recognized by the system and therefore not receiving responses. There are three categories for those unmapped codes. Seven percent include drugs that are not approved by the FDA, unavailable in the US, or otherwise not able to be mapped at this time. One percent is invalid codes, and one percent is dietary supplements.

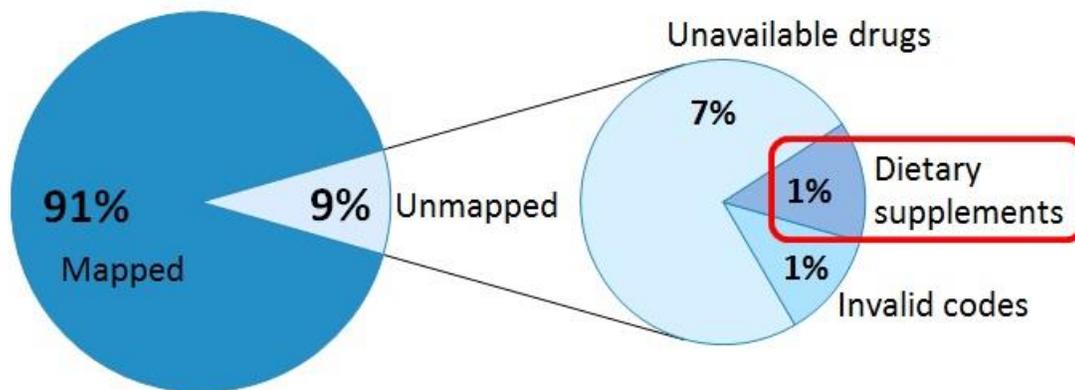


Figure 4. 180,549 RxNorm Code Queries FY13

When looking at how to reduce the percentage of unmapped RxNorm codes, dietary supplements are the most logical starting point. This is a category of codes that already has a collection of information to map to, and as evidenced by the requests, there are providers and patients already expecting to have access to this information through their EHR.

DIETARY SUPPLEMENT RESOURCES

There is a lot of hype in the United States about dietary supplements. Dietary supplements are vitamins, herbs, or other substances used to supplement the diet, such as calcium or St. John's

Wort.¹ Americans are spending over 32 billion dollars a year on supplements.² However there is not a lot of solid information available. Finding reliable and authoritative information to combat the personal anecdotes and fraudulent claims is important to consumers. MedlinePlus.gov currently has 176 English language resource pages available on dietary supplements. They provide evidence-based information on effectiveness, side effects, and interactions with other drugs and supplements. The resources include licensed content from the Natural Medicines Comprehensive Database. In addition there is content from NIH agencies and programs, such as the National Center for Complementary and Alternative Medicine, NIH Office of Dietary Supplements, National Toxicology Program, and National Cancer Institute.

DIETARY SUPPLEMENT CHALLENGES

As important as dietary supplement information is, it does present some challenges when it comes to mapping this information to drug codes. Dietary supplements are not as well regulated as drugs. There are fewer research studies and standards related to the quality and effectiveness of the products. Because of this, dietary supplements are not as well represented in drug terminologies, and there is a wider range of concepts used. So it can be harder to know if a mapping has captured all of the relevant codes available. However, it's worth the effort, and important for patients and their providers to have easy access to this dietary supplement information through their EHR. With all the potential benefits of supplements, there can be harmful side effects or interactions with other medications. Having this information at the point of need helps patients make an informed decision about how to implement dietary supplements into their health care.

RxNORM

From the beginning of the project, it was decided to use RxNorm codes for the mapping file. RxNorm is a clinical drug terminology produced by NLM, and it is the national standard for drug codes in electronic health record systems. The RxNorm database also includes many dietary supplements. There are multiple other drug terminologies available, but they sometimes have different ways of describing the same drug or dietary supplement. RxNorm pulls from those other terminologies, groups the similar concepts together, and applies a standardized name and a unique identifier. This unique identifier is called a RxCUI. In addition to successfully using

¹ Office of Dietary Supplements, "What is a Dietary Supplement?"
<http://ods.od.nih.gov/factsheets/DietarySupplements-HealthProfessional/>

² Forbes Magazine, "Nutritional Supplements Flexing Muscles as Growth Industry"
<http://www.forbes.com/sites/davidlariviere/2013/04/18/nutritional-supplements-flexing-their-muscles-as-growth-industry/>

RxCUIs for drug information requests, MedlinePlus Connect also implements the RxNorm API into the system to help validate incoming code requests.

RxNORM TERM TYPES

RxNorm uses term types to provide many levels of description of the RxCUIs and their concept names. There are two term types that were used in manually selecting RxCUIs for the dietary supplement mapping file. The first is the Semantic Clinical Drug Form (SCDF). SCDF is a concept that includes the ingredient plus the dose form. For example, with the concept “chamomile flowers oral capsule,” “chamomile flowers” is the ingredient and “oral capsule” is the dose form. If a dietary supplement did not have any SCDF term types available, then the Ingredient (IN) term type was used instead. IN is a concept that only includes the name of the ingredient. For example “calcium carbonate” or “bitter orange oil.”

METHODS

BACKGROUND READING

The project began with reviewing technical information about MedlinePlus Connect and RxNorm. The review of MedlinePlus Connect provided details on how the Connect system works, how users interact with the system, how code-based requests are processed, the need for dietary supplement information, and what type of dietary supplement information is included on MedlinePlus.gov. The review of RxNorm provided information on how RxNorm data is organized and used. The sources for the information included the MedlinePlus Connect and RxNorm websites, staff who are responsible for developing and maintaining MedlinePlus Connect and RxNorm, recorded webcasts of past conference presentations or technical updates, and MedlinePlus.gov.

ASSESSING THE NEED

To assess the need for dietary supplement information, data was analyzed from the log of unmapped RxNorm code queries in FY13. MedlinePlus Connect received 180,549 RxNorm queries last year. There were 16,061 unmapped queries that did not receive a response. Of those unmapped queries, 2,193 (or 14%) were requests for dietary supplement information.

Usage statistics from MedlinePlus.gov were also analyzed to see how popular dietary supplements are in those searches. Out of the 1,000 search words used most often in FY13, 49 were dietary supplements. This is 5% of those 1,000 terms. Even though this is a small percentage of the search words, it still represents over 152,773 searches on the site. The MedlinePlus.gov searches are not a direct reflection of MedlinePlus Connect requests; however

it still provides another mechanism to understand the need for users to locate supplement information.

RxMix

There are a few tools available for searching the RxNorm database. The UMLS Metathesaurus Browser provides very detailed information on each concept in many different vocabularies. The Lister Hill National Center for Biomedical Communications (LHC) has developed two other applications: RxNav and RxMix. They are built using the RxNorm API and enable browsing and searching specifically of RxNorm data. RxMix was chosen because it allows batch input. After a file is created with a list of supplement names, it is uploaded to the RxMix website.³ The user then selects a simple sequence of RxNorm functions to process this file. Within minutes the user receives an email with the results of the search. The results from RxMix can be transferred to a spreadsheet file, which enables easy sorting and manipulation of the results.

Three RxMix search functions in particular were utilized during this project.

- **findRxcuiByString:** This function searches for a name in the RxNorm data set and retrieves RxCUIs for the concepts that contain that name, or have that name identified in the database as a synonym.
- **getApproximateMatch:** This function retrieves concepts that most closely match the search string.
- **getAllRelatedInfo:** This function retrieves all related concepts for a specified RxCUI. For example, if submitting the RxCUI for “Vitamin B6 injectable solution,” it will retrieve codes for all the other variations of Vitamin B6 products, such as “Vitamin B6 oral capsule,” the brand name product “B-Natal,” and “Melatonin 5 MG/ Vitamin B6 1 MG oral tablet.”

SEARCH AND SELECTION PROCESS

For the first RxMix search, supplement names were taken from the titles of the dietary supplement resources on MedlinePlus.gov. After de-duplicating the list, there were 149 supplement names. The names were put into a text file and uploaded to the RxMix website. Although most of the supplement names were matched to RxCUIs, there were 12 names with no related RxCUIs. There were also 23 names with RxCUIs that did not include a concept name assigned by the RxNorm database. The RxNorm concept name helps with making a positive

³ RxMix website: <http://mor.nlm.nih.gov/RxMix/>

identification that the RxCUI is in fact a correct match to the supplement name from MedlinePlus.gov. The number by itself without RxNorm's description is not as helpful. For example, when searching for the supplement name "oral probiotics," RxMix returned just the RxCUI "813233" by itself without any accompanying concept description. After consulting with staff who work with RxNorm, it was discovered that this RxCUI is for the general term "probiotic." So the RxCUI was for the general category of all probiotics, whereas the MedlinePlus.gov page was specifically targeting oral probiotics.

The concept name provides important information on RxNorm's level of detail in describing the supplement. The supplement names as listed on MedlinePlus.gov may not match the normalized name in RxNorm or other source terminologies. The drug terminologies also have many levels of detail in the supplement concept names. In order to retrieve and identify all of the relevant RxCUIs, it would be imperative to recognize any synonyms or additional terms. The goal was to carefully select RXCUIs that matched the exact content of each resource.

After the preliminary search, the contents of the dietary supplement resources on MedlinePlus.gov were reviewed in detail to learn more about all the possible terms to include in the search. There were five categories of information that were considered.

- **Alternative names:** This is especially relevant for plants, because they have a scientific name and one or more common names. For example, *Panax ginseng* is the scientific name for one supplement with additional common names including Asian Ginseng, Korean Ginseng and Chinese Ginseng. Some of the RxCUIs and concepts for this supplement include "1370774 Asian Ginseng extract" and "375547 Korean Ginseng root capsule."
- **Parts of the plant:** It was also important to identify which parts of a plant are used for medicinal purposes, since there can be RxCUIs with concept names specific to the parts of a plant. For example, the supplement Noni (or *Morinda citrifolia*) is a tree that has six parts used for medicine: leaves, flowers, fruit, stems, bark, and root. Some of the relevant RxCUIs include "1311642 Morinda citrifolia fruit juice," and "1307858 Morinda citrifolia leaf extract." The RxNorm database also included a RxCUI for "Morinda citrifolia seed oil," however this RxCUI was not included in the mapping file because MedlinePlus.gov did not address the use of the seed for medicine.
- **Additional forms:** Vitamins and minerals often have multiple forms and different forms have separate names and RxCUIs. For example, Vitamin D comes in two forms: ergocalciferol and cholecalciferol. Some of the RxCUIs for these different forms include

“374313 Vitamin D oral tablet,” “372040 Ergocalciferol oral tablet,” and “371481 Cholecalciferol oral tablet.”

- **Route of Administration:** The RxCUIs that are a SCDF term type always include the drug form. This information tells how a supplement is administered, whether oral, topical, suppository, etc. It was important to know which route(s) of administration were addressed by information resources, and only select the RxCUIs that matched the information.
- **Combination of supplements:** There are many RxCUIs that have multiple ingredients for products that combine two or more supplements. However, a multiple-ingredient RxCUI would only be selected if a resource addressed how that specific combination of supplements affects the human body. If a resource simply mentioned that supplements can be combined, then the multiple-ingredient RxCUI would not be selected.

After discovering additional terms to include in the search, nine more searches were completed using different combinations of supplement names and RxMix functions. The process was cyclical in nature. RxMix search results sometimes led to further examination of the dietary supplement resources, which would result in adjusting the list of terms and then conducting another RxMix search. The resource content was also consulted to assist in the selection of RxCUIs to ensure that the selected RXCUIs were an accurate representation of the content. The goal was to carefully select RXCUIs that matched the exact content of each resource.

There are fourteen dietary supplement resources on MedlinePlus.gov that are not represented in the mapping file. For five of those resources, there were no RXCUIs found in the RxNorm database. For the other nine supplements, one or more relevant RXCUIs were identified in the RxNorm database, but they have not been assigned any standardized names. Due to the behavior of the RxNorm API that is used in MedlinePlus Connect to validate incoming codes, MedlinePlus Connect does not recognize RXCUIs that do not have a standardized name. It is possible that this group of supplements is less commonly used in the United States. Also, there are several in this group that have been banned by the FDA, or there are no high-quality products available in the U.S. at this time. MedlinePlus includes these riskier supplements in order to provide consumers with reliable information on dangerous side effects and any current legal restrictions. For example, the ephedra plant has been used in for weight loss and athletic performance. However, the risks of heart problems and stroke outweigh any benefits, and in 2004, the FDA banned the sale of any products containing ephedra.

RESULTS

The Associate created a new dietary supplement mapping file by manually selecting 484 RxCUIs that are relevant to the specific supplement resources on MedlinePlus.gov. The format of the mapping file is a spreadsheet file, with columns for the resource URL, supplement name as used on MedlinePlus.gov, RxCUI, and supplement concept name as used in the RxNorm database. All of the manually-selected RxCUIs have term types of either SCDF or IN. However, the mapping file will go through an automated expansion, which will enable the addition of more RxCUIs with additional term types. The term types included in the automatic expansion are: IN, BN, BPCK, GPCK, SBD, SBDC, SBDF, SCD, SCDC, and SCDF.⁴ After automatic expansion, the mapping file will have over 3,700 RxCUIs.

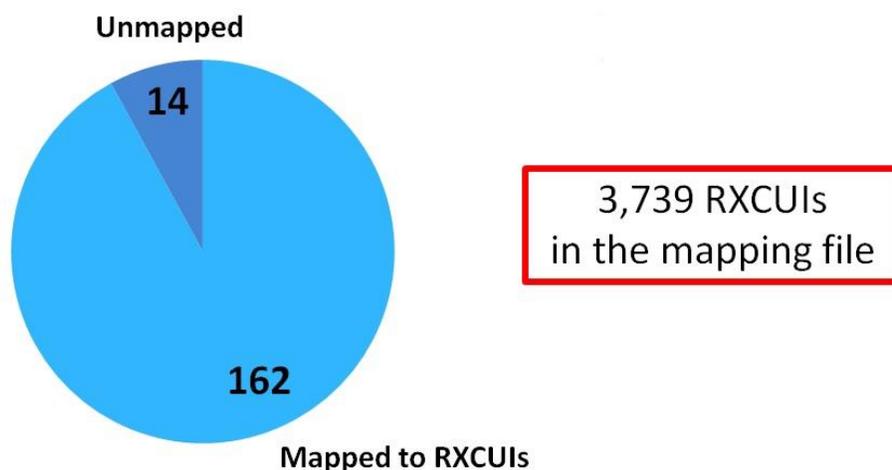


Figure 5. 176 Dietary Supplement Resources on MedlinePlus.gov

DISCUSSION

IMPACT OF PROJECT

The new mapping file will improve the MedlinePlus Connect user experience. Before the mapping file, an EHR request for dietary supplement information would result in a message stating that there is not an exact match, and the user would be provided with a search box for the MedlinePlus.gov website. This presents the users with an extra step, and may discourage them from looking further.

⁴ For more details on the RxNorm's term types, see "Where Does RxNorm Get Its Data?" (<http://www.nlm.nih.gov/research/umls/rxnorm/overview.html>)

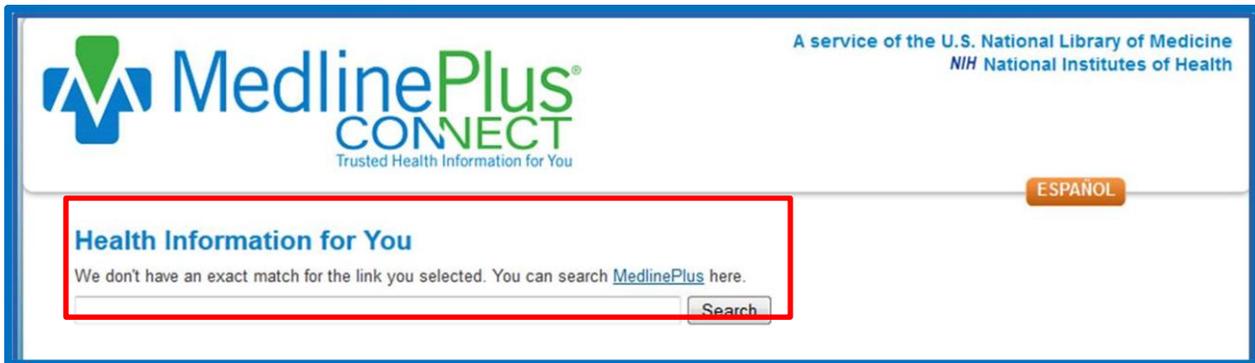


Figure 6. Before the Mapping File

After the mapping file is implemented, the user will receive a page with one or more links to resources specific to the code-based request. This will present an instant response to the request without any additional searching required. Clicking the link will take the user directly to the webpage specific to the code submitted in the request. The new mapping file is expected to not only decrease the number of unmapped queries, but also to increase the number of dietary supplement queries.

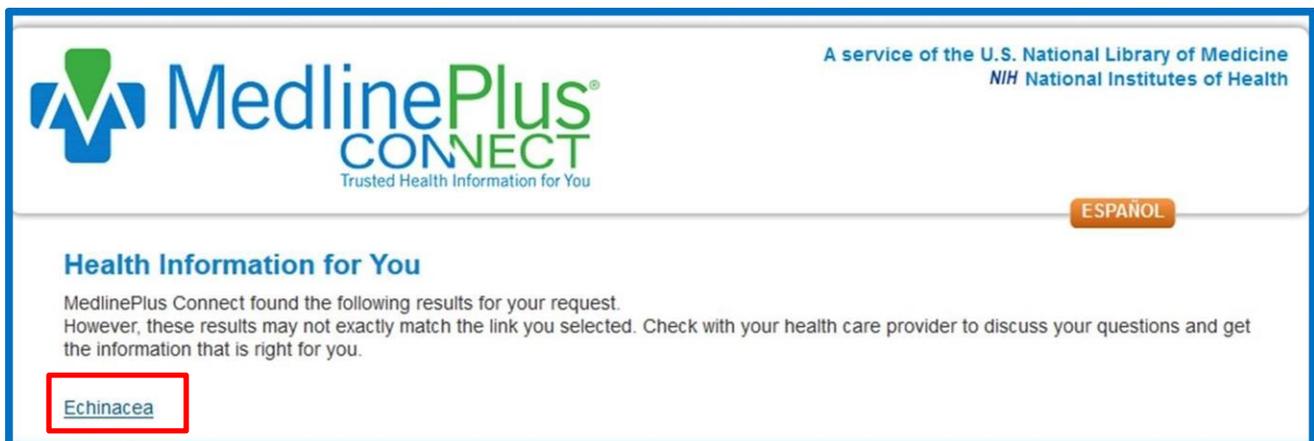


Figure 7. After the Mapping File

LESSONS LEARNED

This project provided the Associate with an opportunity to learn more about dietary supplements, MedlinePlus Connect, and RxNorm terminology. It has also provided her with a greater appreciation for standardized vocabularies and consumer health informatics. Her focus with consumer health information has always been on face-to-face delivery, and because of this project she has a better understanding of the need for tools and services that assist patients and providers in accessing patient-centered health information at the point of need through their electronic health records.

NEXT STEPS

- **Test:** The mapping file is being tested on the QA system to make sure that MedlinePlus Connect will send the correct responses to the dietary supplement queries. See Appendix II for the most recent test report.
- **Implement:** After the testing is completed, then the mapping file will be implemented into the MedlinePlus Connect system by staff from the Office of Computer and Communication Systems (OCCS).
- **Promote:** After implementation, the new enhancement will be announced to users through the MedlinePlus Connect listserv.
- **Evaluate:** The performance of the mapping file will be monitored in order to evaluate the dietary supplement information requests that are received and how MedlinePlus Connect responds. There is the expectation that once users become aware of the new mapping file, that there will be an increase of supplement queries.

ACKNOWLEDGEMENTS

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APPENDIX I – MAPPING FILES

A copy of the files containing the RxCUIs that were manually selected during the project has been posted to the NLM SharePoint site. The URLs are below:

Licensed Content Mapping File

[https://sharepoint.nlm.nih.gov/Projects/nlmassociates/Associate%20Fellow%20Report/Mapping%20File Licensed%20Content.xlsx](https://sharepoint.nlm.nih.gov/Projects/nlmassociates/Associate%20Fellow%20Report/Mapping%20File%20Licensed%20Content.xlsx)

NIH Content Mapping File

[https://sharepoint.nlm.nih.gov/Projects/nlmassociates/Associate%20Fellow%20Report/Mapping%20File NIH%20Content.xlsx](https://sharepoint.nlm.nih.gov/Projects/nlmassociates/Associate%20Fellow%20Report/Mapping%20File%20NIH%20Content.xlsx)

APPENDIX II – MAPPING FILE TEST REPORT

Dietary Supplement Mapping File Test

8/13/14

The purpose of the test is to make sure the MedlinePlus Connect system responds correctly to the RxNorm codes contained in the dietary supplement mapping file, and to check the accuracy of the automatic expansion. The mapping file contains manually selected single-ingredient RXCUIs with the term type (TTY) of semantic clinical drug form (SCDF) and ingredient (IN). Using SCDF was the first choice, but when that is not available then IN is used. The SCDFs and INs go through an automatic expansion to add other term types, including BN, BPCCK, GPCK, IN, SBD, SBDC, SBDF, SCD, SCDC, and SDCF. The test sample included RXCUIs, NDC codes, and text strings.

RXCUIs

Seventeen dietary supplement names were selected and tested for all of the RXCUI term types that would be included either by manual selection or expansion. This resulted in 104 RXCUIs being included in the test sample. Not every dietary supplement had RXCUIs available for every term type included by expansion, but the sample still provided a good representation of how well the system is mapping dietary supplement codes.

Findings:

- All of the manually selected RXCUIs were matched to the correct resource.
- The automatic expansion only expands SCDFs to other TTYs with the same drug form.
 - Ex: calcium citrate has drug forms oral solution, oral tablet, oral capsule, chewable tablet, and granules. Effervescent oral tablet drug form had not been included in the mapping file for this particular supplement. So the system could not map the SCDF for effervescent oral tablet or expand to capture other RXCUI term types for the drug form effervescent oral tablet.
- Since the mapping file only includes single-ingredient RXCUIs, the expansion only includes other term types with the same single ingredient. Multiple ingredient RXCUIs are not included in this mapping file at all, and MedlinePlus Connect will not be able to respond to dietary supplement code requests for multiple-ingredient products.
- Supplements that are included in both the drug mapping file and dietary supplement mapping file:
 - All term types except IN map to both drug and supplement monographs
 - IN term type is only mapping to the drug monograph
- Inconsistent mapping of SCDC term type. Some supplements mapped correctly, and for a couple there was no match found. At this time, it is not known why this happens.

NDCs

Eleven NDC codes were selected for the test sample. All single ingredient NDCs mapped correctly. Multiple ingredient NDC codes are not able to be mapped at this time.

Text Strings

Nineteen dietary supplement names were selected for the text string sample.

Findings:

- The text search does not operate as a key word search. The full ingredient name as listed in the mapping file has to be entered in order to map correctly. For example, if entering “calendula” or “acai” there is no match found. If entering “calendula officinalis extract” or “acai berry extract” then the correct resource is found.
- For supplements that are included in both the drug mapping file and the dietary supplement mapping file, only the drug monograph is retrieved by a text search (Ex. Vitamin B6, Vitamin K).

Conclusions:

- The manually selected RXCUIs are mapping correctly for code-based requests.
- Text based requests have to include the full ingredient name.
- Only single-ingredient codes are mapped, which is correct. Multiple ingredient SCDFs would have to be added to the file for expansion to capture other multiple ingredient codes.
- There is inconsistent mapping for the semantic clinical drug component (SCDC) term type. For some RxCUIs, the system maps this term type, for others it does not.
- There may need to be adjustments to the expansion algorithm for to allow mapping to both drug and supplement resources for those supplements that are included in both the drug and dietary supplement mapping files.

The test results can be viewed here:

https://sharepoint.nlm.nih.gov/Projects/nlmassociates/Associate%20Fellow%20Report/MappingFileTest_8-2014.xlsx