Ideas

- A mathematical/computational model to capture evolution of recipes, so as to capture the statistics of contemporary cuisines.
- A ‘recipe data structure’ that captures practically all quantifiable nuances of cooking.
- An app (web/mobile) for crowdsourcing recipes from lay users.
- What other kind of known data mining algorithms could be used to analyse cuisines?
- Mining the bipartite graph ingredient-disease associations

Ideas

- **Collecting/scraping data (from websites/books) and making a structured data repository**:
- Preservatives used in processed food
- Food Additives
- Fermented food
- Cocktails/Mocktails
- Allergic foods and allergens
- Nutritional profile of (say) Indian food (NIN)
- Fortified food (list and statistics)
- *Think of other sources of culinary data.*

Ideas

- **Improvised models of culinary evolution**.
- What if the evolution happens by choosing ingredient pairs (as opposed to ingredients)?
- What if the flavor plays a major role?

- FlavorDB/FlavorDB2 data analytics and visuals
- Chemical Elements (Fe/Ca/Zn etc.): Flavor-wise/Food-wise
- **Services**: A.Recipe.A.Day/An.Ingredient.A.Day *See: A.Word.A.Day*
- **Artificial Flavors**: Recreating natural flavors by combining and mixing flavor molecules. Data?
- **Fragrance/Perfumes**: The art of juxtaposing molecules. Data?
- A simple model of transformation of flavor molecules, when boiled/fried/roasted/etc.?

Why spices? Broad-spectrum benevolence of culinary herbs and spices

"Data-driven analysis of biomedical literature suggests broad-spectrum benefits of culinary herbs and spices," Rakhi NK, Tuwani R, Mukherjee J, Bagler G, PLoS ONE 13(5): e0198030 (2018).

Why spices? Broad-spectrum benevolence of culinary herbs and spices

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THE QUARTERLY REVIEW of BIOLOGY

ANTIMICROBIAL FUNCTIONS OF SPICES:
WHY SOME LIKE IT HOT

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Ithaca, NY 14853 USA

Darwinian Gastronomy: Why We Use Spices

Spices taste good because they are good for us

Paul W. Sherman and Jennifer Billing

Humans have borrowed plants' chemical "recipes" for evolutionary survival for use in cuisine to combat foodborne microorganisms and to reduce food poisoning

Darwinian Gastronomy: Why We Use Spices

Spices taste good because they are good for us

Paul W. Sherman and Jennifer Billing

Spices are plant products used in flavoring foods and beverages. For thousands of years, aromatic plant materials have been used in food preparation and preservation, as well as for embalming, in areas where the plants are native, such as Hindustan and the Spice Islands (Govindarajan 1985, Dillon and Board 1994). During and after the Middle Ages, seafarers such as Marco Polo, Ferdinand Magellan, and Christopher Columbus undertook hazardous voyages to establish routes to trading ports in primary spice-growing regions (Parry 1953). The spice trade was so crucial to national economies that rulers repeatedly mounted costly expeditions

Humans have borrowed plants' chemical "recipes" for evolutionary survival for use in cuisine to combat foodborne microorganisms and to reduce food poisoning

restaurants, or preparing exotic recipes at home. Japanese dishes are often "delicate," Indonesian and Szechwan dishes "hot," and middle

fruits of herbaceous plants (Figure 1). Cookbooks generally distinguish between seasonings (spices used in food preparation) and condiments (spices added after food is served), but not between herbs and spices. However, herbs, which are defined botanically (as plants that do not develop woody, persistent tissue), usually are called for in their fresh state, whereas spices generally are dried (Figure 2). Salt is sometimes thought of as a spice, but it is a mineral.

Each spice has a unique aroma and flavor, which derive from compounds known as phytochemicals or "secondary compounds" (because they are secondary to the plant's

Table 1. Mean annual temperature, number of meat-based recipes analyzed (in 93 cookbooks), mean number of spices per recipe, and the four most frequently used spices (i.e., used in the highest proportion of recipes) for each of the 36 countries included in this study.

Country[a]	Mean annual temperature (°C)	Recipes analyzed	Spices per recipe	Frequently used spices[b]
Thailand	27.6	118	4.6	Garlic, onion, chilis[c], pepper[d]
Philippines	27.0	118	3.0	Pepper, onion, garlic, lemon/lime
India	26.9	91	9.3	Ginger, onion, chilis, coriander
Malaysia	26.9	60	5.4	Onion, garlic, chilis, ginger
Indonesia	26.8	120	6.9	Garlic, onion, chilis, coriander
Nigeria	26.5	82	2.6	Chilis, onion, pepper, nutmeg
Ghana	25.9	95	2.2	Onion, pepper, chilis, ginger
Vietnam	24.6	84	4.5	Pepper, garlic, onion, chilis
Brazil	23.9	132	4.2	Onion, pepper, parsley, garlic
Mexico	23.1	123	4.4	Onion, garlic, chilis, pepper
Kenya	22.1	73	5.4	Garlic, onion, pepper, chilis
Ethiopia	21.1	56	7.5	Onion, garlic, chilis, ginger
Lebanon	20.6	98	4.7	Pepper, onion, cinnamon, garlic
Israel	19.1	145	3.9	Pepper, onion, garlic, lemon/lime
Australia	18.6	64	3.4	Pepper, onion, parsley, lemon/lime
Morocco	18.3	104	5.8	Onion, pepper, parsley, saffron
South Africa	17.2	108	2.6	Pepper, onion, lemon/lime, chilis
Greece	16.7	118	4.4	Pepper, onion, garlic, lemon/lime
Iran	16.7	85	5.0	Onion, pepper, lemon/lime, turmeric
Portugal	15.0	84	4.5	Pepper, garlic, parsley, onion
Japan	14.3	103	2.1	Onion, lemon/lime, ginger, chilis
Italy	14.0	86	3.4	Pepper, garlic, parsley, lemon/lime
Korea	12.1	81	3.5	Garlic, onion, pepper, sesame
France	12.1	216	3.8	Pepper, onion, garlic, parsley
Hungary	10.3	80	3.0	Onion, pepper, paprika, parsley
Ireland	9.6	90	3.2	Pepper, onion, garlic, parsley
England	8.8	223	2.1	Pepper, onion, lemon/lime, parsley
Germany	8.8	169	3.2	Onion, pepper, lemon/lime, parsley
Austria	8.8	188	2.7	Onion, pepper, parsley, lemon/lime
Denmark	8.3	87	1.9	Pepper, onion, bay leaf, parsley
Poland	7.8	141	0.3	Onion, pepper, bay leaf, parsley
Sweden	5.4	134	2.5	Pepper, onion, allspice, parsley
Finland	3.0	62	2.1	Pepper, onion, mustard, lemon/lime

Figure 6. Garlic (Liliaceae: *Allium sativum*; top), onion (*Allium cepa*; top), and chilis (Solanaceae: *Capsicum frutescens*; bottom) grow in all countries we sampled and have powerful antimicrobial effects. Photos: Thomas Neuhaus, Neuhaus Features.

ers (e.g., parsley and cilantro [i.e., coriander leaf]) are added near the end (Figure 10). According to cookbook authors, the "delicate" flavors of the latter would be destroyed by heat. If, as seems likely, thermostable spices are the ones added early and thermolabile spices are added later (or are used primarily as condiments), differences in timing of use may function to maintain beneficial antimicrobial properties (and corresponding flavors) until food is served.

Spice synergism

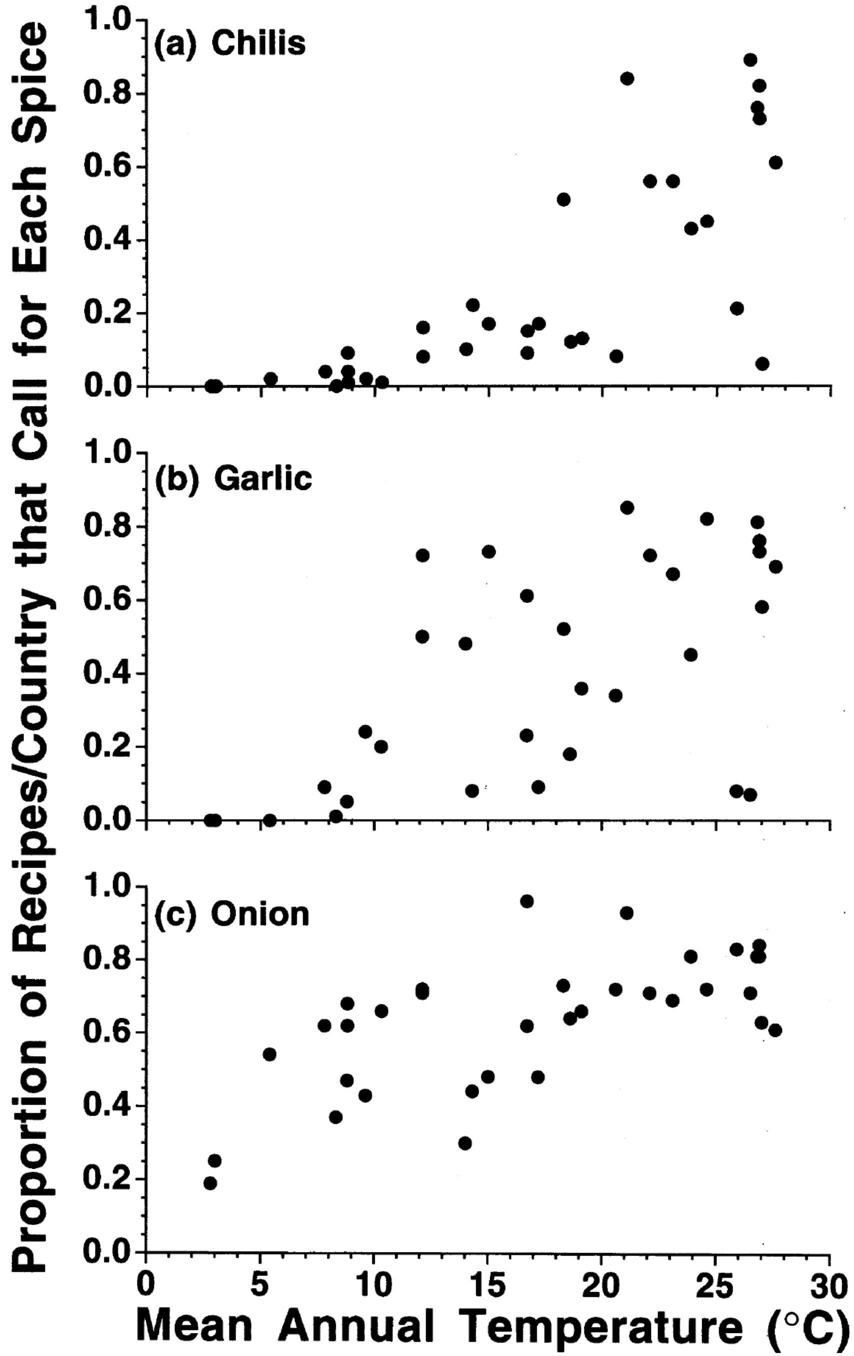
Pepper and lemon (and lime) juice are among the most frequently used spices (Figure 3).

spices), pickling spice (15 spices), and chili powder (10 spices), are broad-spectrum antimicrobial melanges.

Other uses of spices

In addition to their uses in cooking, individual spices and blends are employed as coloring agents, antivirals (including suppressing HIV), brain stimulants, and aphrodisiacs (Hirasa and Takemasa 1998). Among traditional societies, many spice plants also have ethnopharmacological uses, often as topical or ingested antibacterials and vermicides (Chevallier 1996, Cichewicz and Thorpe 1996). A few spices, particularly garlic, ginger, cinnamon, and chilis, have for centuries been used to counteract a broad spectrum of ailments, including dysentery, kidney stones, arthritis, and high blood pressure (Johns 1990, Duke 1994).

However, the use of


(a) Chilis
(b) Garlic
(c) Onion
Proportion of Recipes/Country that Call for Each Spice
Mean Annual Temperature (°C)
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15
20
25
30

SpiceRx

Home Search How To Use FAQs Contact Us CoSyLab

SpiceRx

A resource to explore health effects of culinary spices and herbs

Search Statistics How to Use FAQs Download Data

SpiceRx Summary

Spices and herbs are key dietary ingredients used in cuisines across the world. They have been reported to be of medicinal value for a wide variety of diseases through a large body of biomedical investigations. Bioactive phytochemicals in these plant products form the basis of their therapeutic potential as well as adverse effects.

SpiceRx is a systematic compilation of evidence-based knowledge pertaining to the health impacts of culinary spices and herbs. It provides a platform for exploring the health impact of culinary spices and herbs through a structured database of tripartite relationships, and facilitates disease-specific culinary recommendations as well as enquiry into molecular mechanisms underlying their health effects.

SpiceRx Search

Spice/Herb Disease Phytochemical

Common Name:

e.g. turmeric

RESEARCH ARTICLE

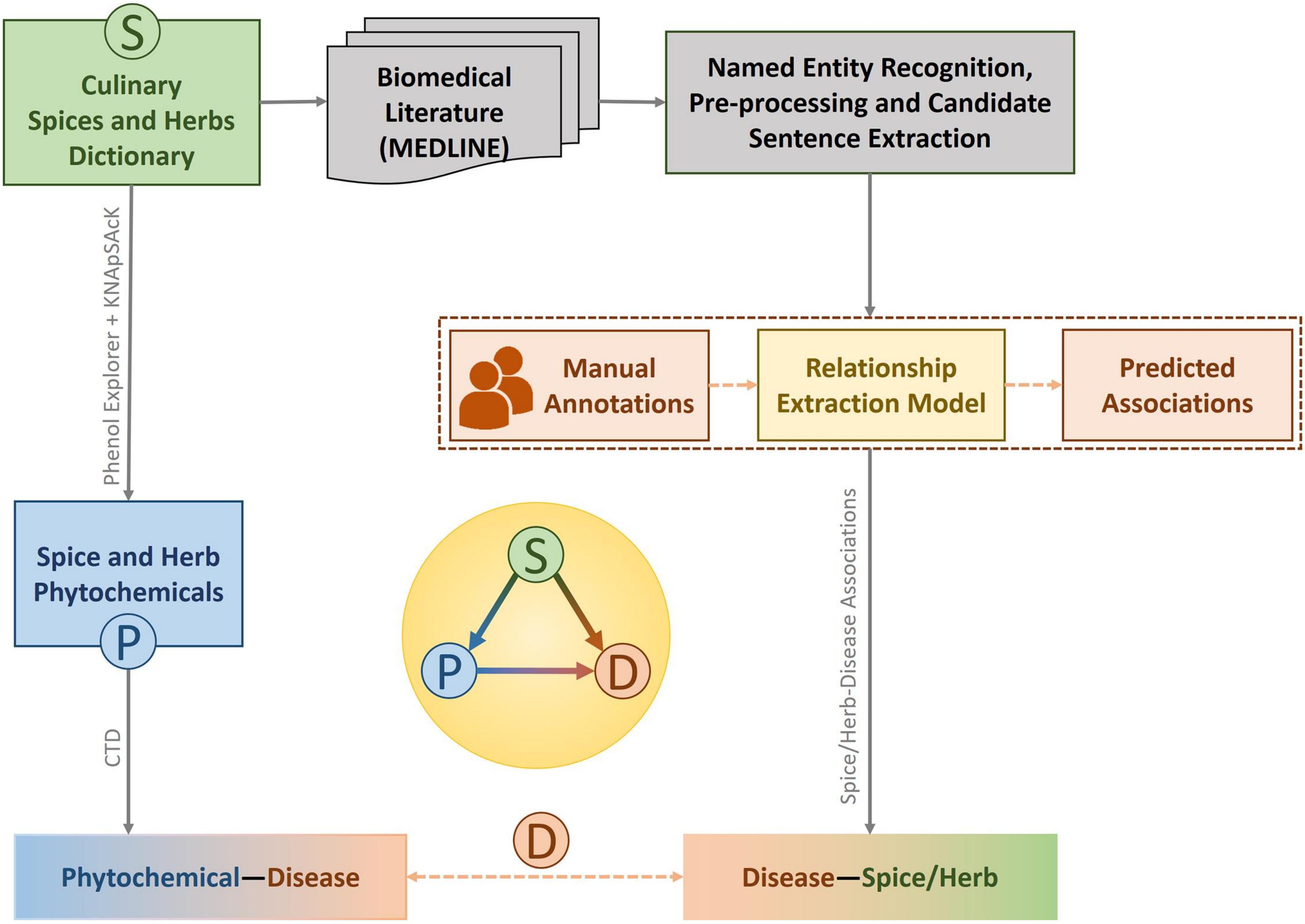
Data-driven analysis of biomedical literature suggests broad-spectrum benefits of culinary herbs and spices

N. K. Rakhi, Rudraksh Tuwani, Jagriti Mukherjee, Ganesh Bagler

Published: May 29, 2018 • https://doi.org/10.1371/journal.pone.0198030

Abstract

Spices and herbs are key dietary ingredients used across cultures worldwide. Beyond their use as flavoring and coloring agents, the popularity of these aromatic plant products in culinary preparations has been attributed to their antimicrobial properties. Last few decades have witnessed an exponential growth of biomedical literature investigating the impact of spices and herbs on health, presenting an opportunity to mine for patterns from empirical evidence. Systematic investigation of empirical evidence to enumerate the health consequences of culinary herbs and spices can provide valuable insights into their therapeutic utility. We implemented a text mining protocol to assess the health impact of spices by assimilating, both, their positive and negative effects. We conclude that spices show broad-spectrum benevolence across a range of disease categories in contrast to negative effects that are comparatively narrow-spectrum. We also implement a strategy for disease-specific culinary recommendations of spices based on their therapeutic tradeoff against adverse effects. Further by integrating spice-phytochemical-disease associations, we identify bioactive spice phytochemicals potentially involved in their therapeutic effects. Our study provides a systems perspective on health effects of culinary spices and herbs with applications for dietary recommendations as well as identification of phytochemicals potentially involved in underlying molecular mechanisms.


S
Culinary Spices and Herbs Dictionary
Biomedical Literature (MEDLINE)
Named Entity Recognition, Pre-processing and Candidate Sentence Extraction
Phenol Explorer + KNApSAcK
Manual Annotations
Relationship Extraction Model
Predicted Associations
Spice and Herb Phytochemicals
P
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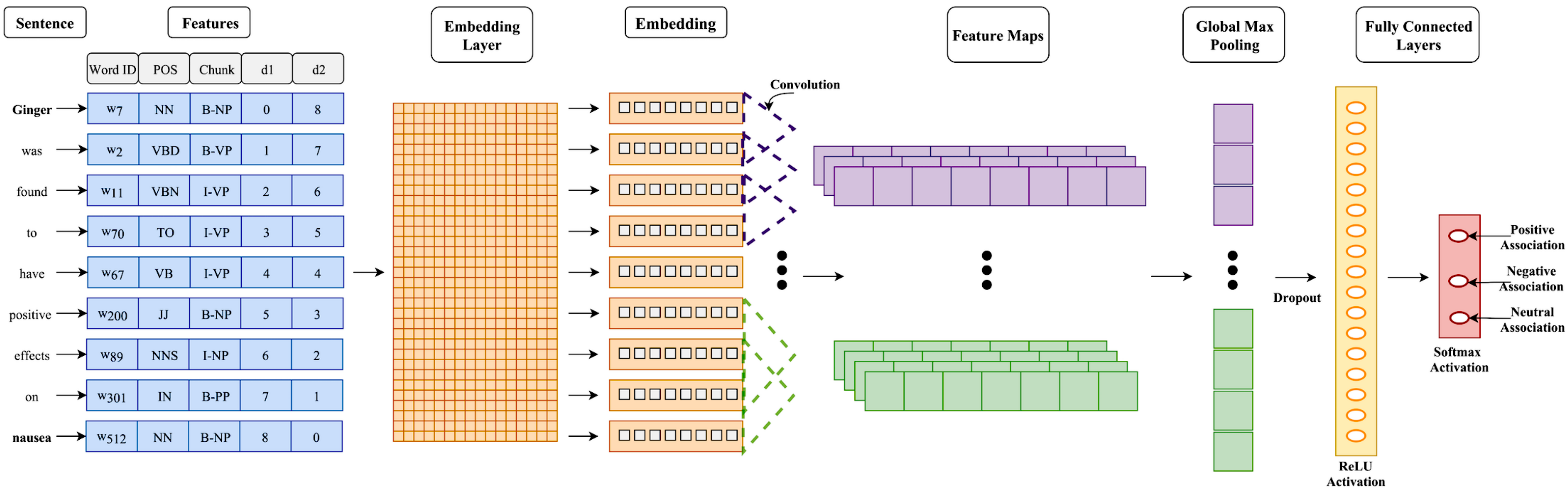
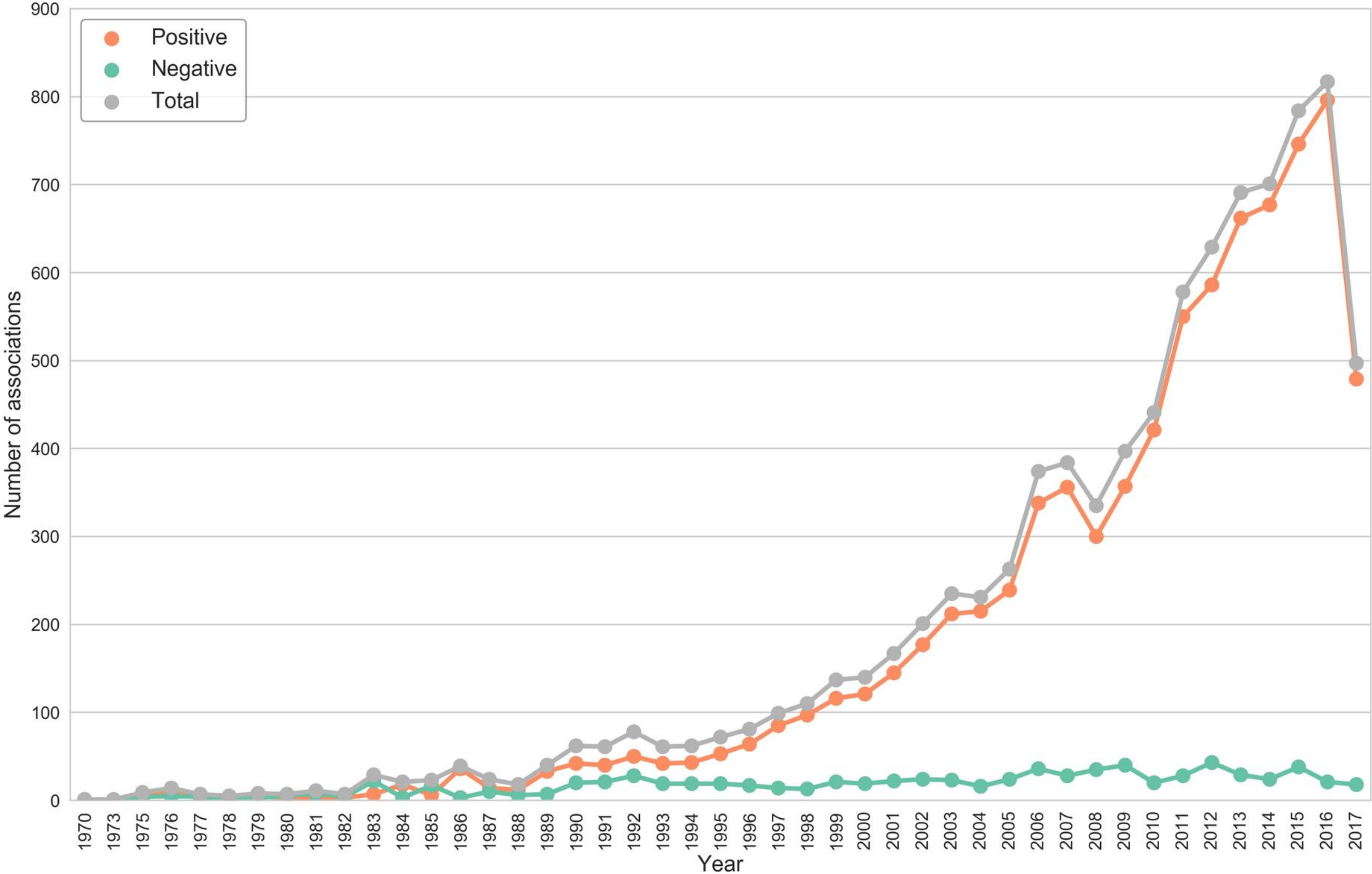
P
D
CTD
Spice/Herb-Disease Associations
D
Phytochemical—Disease
Disease—Spice/Herb


Sentence
Features
Embedding Layer
Embedding
Feature Maps
Global Max Pooling
Fully Connected Layers
Word ID
POS
Chunk
d1
d2
Ginger
was
found
to
have
positive
effects
on
nausea
w7 NN B-NP 0 8
w2 VBD B-VP 1 7
w11 VBN I-VP 2 6
w70 TO I-VP 3 5
w67 VB I-VP 4 4
w200 JJ B-NP 5 3
w89 NNS I-NP 6 2
w301 IN B-PP 7 1
w512 NN B-NP 8 0
Convolution
Dropout
ReLU Activation
Softmax Activation
Positive Association
Negative Association
Neutral Association



Positive
Negative
Total
Number of associations
Year
0
100
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300
400
500
600
700
800
900
1970
1973
1975
1976
1977
1978
1979
1980
1981
1982
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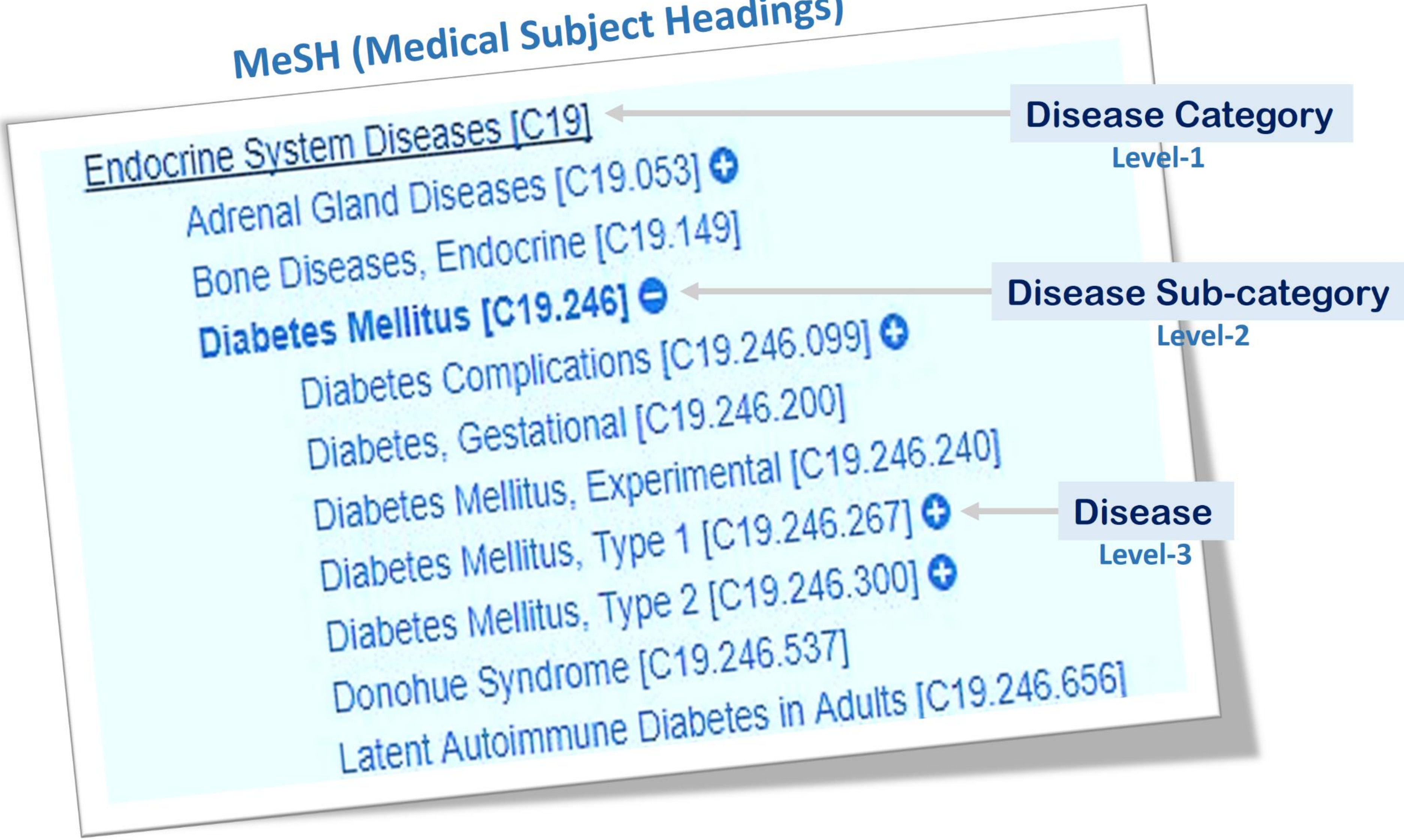
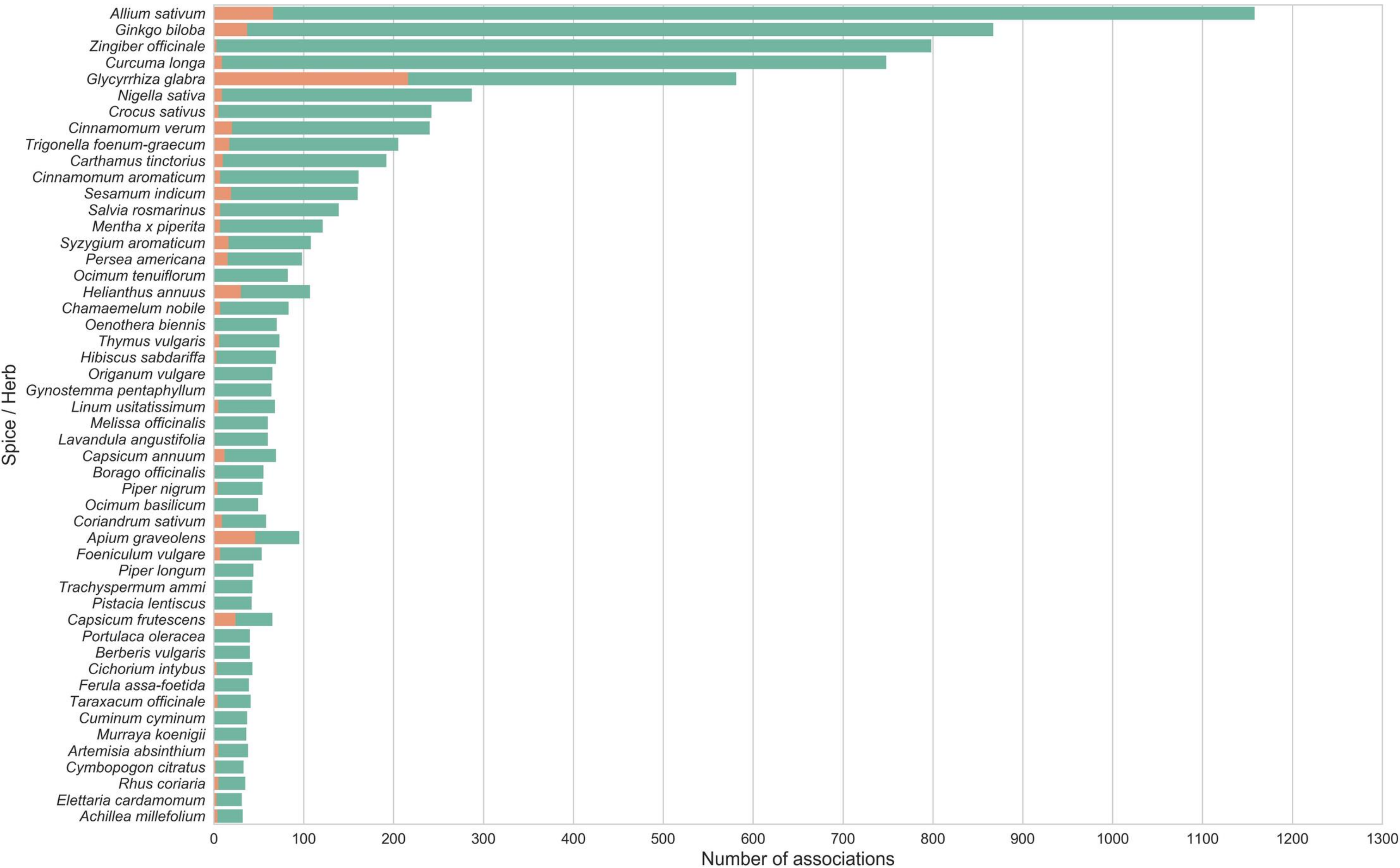
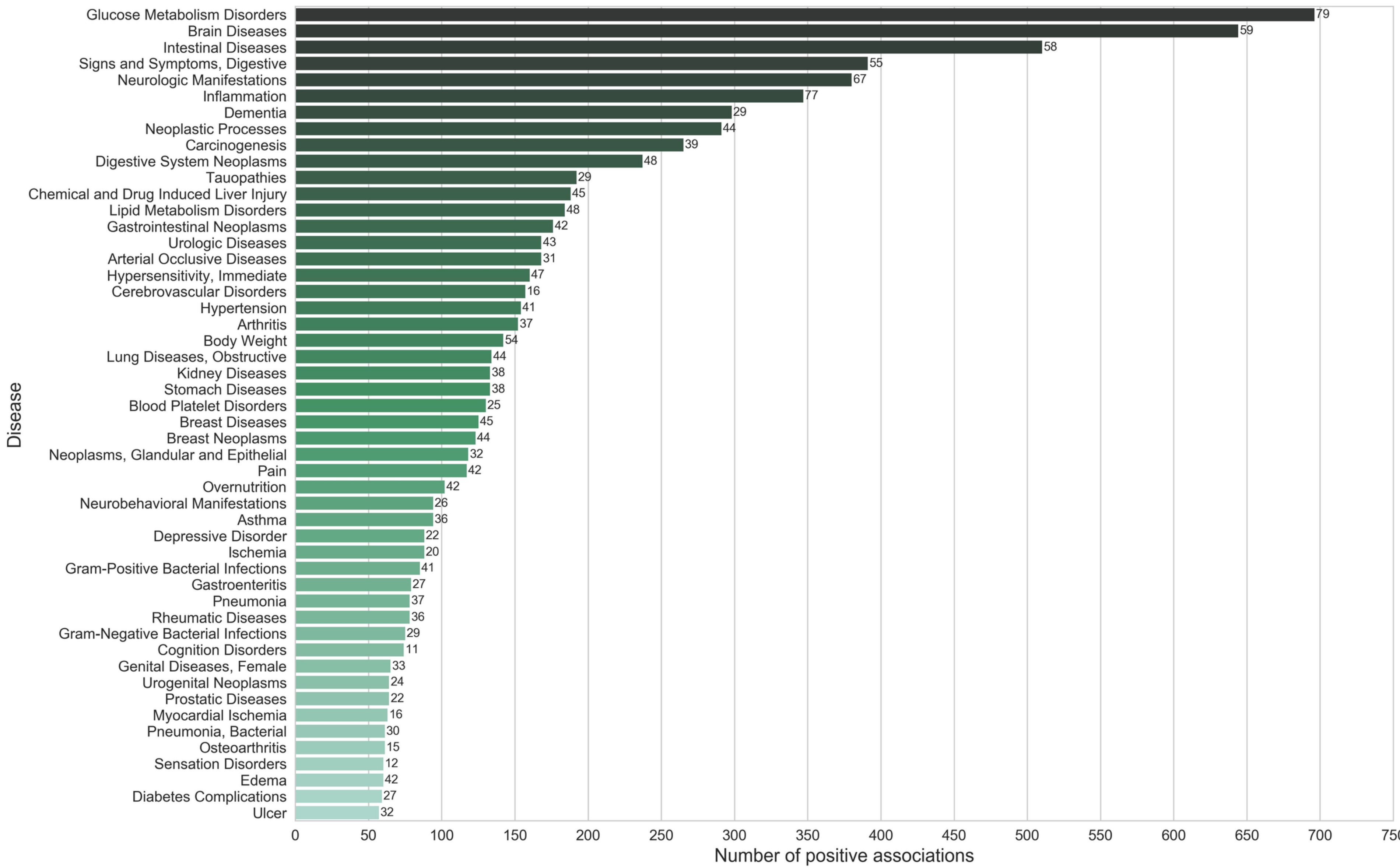
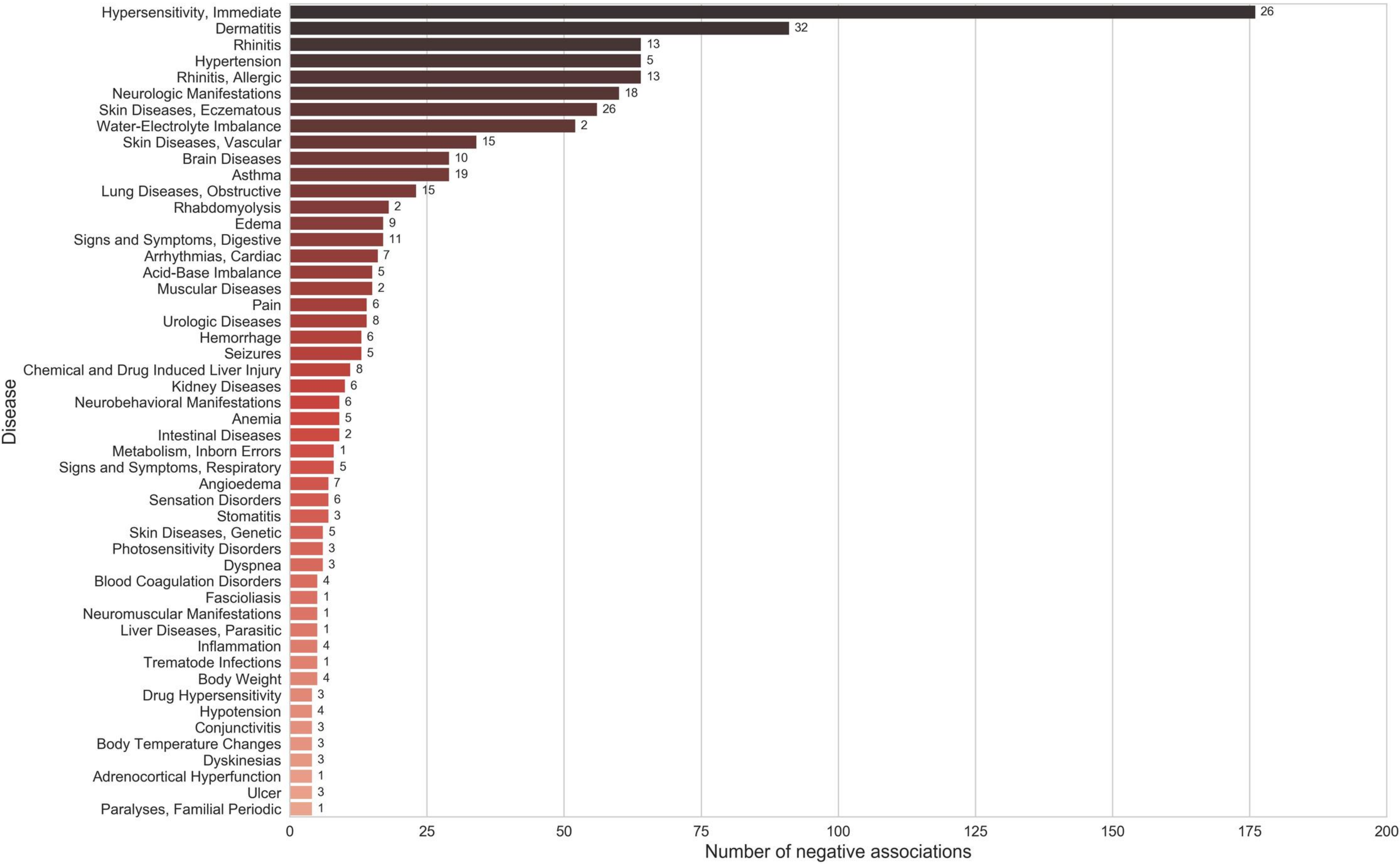
2015
2016
2017

MeSH (Medical Subject Headings)




Allium sativum
Ginkgo biloba
Zingiber officinale
Curcuma longa
Glycyrrhiza glabra
Nigella sativa
Crocus sativus
Cinnamomum verum
Trigonella foenum-graecum
Carthamus tinctorius
Cinnamomum aromaticum
Sesamum indicum
Salvia rosmarinus
Mentha x piperita
Syzygium aromaticum
Persea americana
Ocimum tenuiflorum
Helianthus annuus
Chamaemelum nobile
Oenothera biennis
Thymus vulgaris
Hibiscus sabdariffa
Origanum vulgare
Gynostemma pentaphyllum
Linum usitatissimum
Melissa officinalis
Lavandula angustifolia
Capsicum annuum
Borago officinalis
Piper nigrum
Ocimum basilicum
Coriandrum sativum
Apium graveolens
Foeniculum vulgare
Piper longum
Trachyspermum ammi
Pistacia lentiscus
Capsicum frutescens
Portulaca oleracea
Berberis vulgaris
Cichorium intybus
Ferula assa-foetida
Taraxacum officinale
Cuminum cyminum
Murraya koenigii
Artemisia absinthium
Cymbopogon citratus
Rhus coriaria
Elettaria cardamomum
Achillea millefolium
Spice / Herb
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
Number of associations


Glucose Metabolism Disorders 79
Brain Diseases 59
Intestinal Diseases 58
Signs and Symptoms, Digestive 55
Neurologic Manifestations 67
Inflammation 77
Dementia 29
Neoplastic Processes 44
Carcinogenesis 39
Digestive System Neoplasms 48
Tauopathies 29
Chemical and Drug Induced Liver Injury 45
Lipid Metabolism Disorders 48
Gastrointestinal Neoplasms 42
Urologic Diseases 43
Arterial Occlusive Diseases 31
Hypersensitivity, Immediate 47
Cerebrovascular Disorders 16
Hypertension 41
Arthritis 37
Body Weight 54
Lung Diseases, Obstructive 44
Kidney Diseases 38
Stomach Diseases 38
Blood Platelet Disorders 25
Breast Diseases 45
Breast Neoplasms 44
Neoplasms, Glandular and Epithelial 32
Pain 42
Overnutrition 42
Neurobehavioral Manifestations 26
Asthma 36
Depressive Disorder 22
Ischemia 20
Gram-Positive Bacterial Infections 41
Gastroenteritis 27
Pneumonia 37
Rheumatic Diseases 36
Gram-Negative Bacterial Infections 29
Cognition Disorders 11
Genital Diseases, Female 33
Urogenital Neoplasms 24
Prostatic Diseases 22
Myocardial Ischemia 16
Pneumonia, Bacterial 30
Osteoarthritis 15
Sensation Disorders 12
Edema 42
Diabetes Complications 27
Ulcer 32
Disease
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750
Number of positive associations



Hypersensitivity, Immediate
Dermatitis
Rhinitis
Hypertension
Rhinitis, Allergic
Neurologic Manifestations
Skin Diseases, Eczematous
Water-Electrolyte Imbalance
Skin Diseases, Vascular
Brain Diseases
Asthma
Lung Diseases, Obstructive
Rhabdomyolysis
Edema
Signs and Symptoms, Digestive
Arrhythmias, Cardiac
Acid-Base Imbalance
Muscular Diseases
Pain
Urologic Diseases
Hemorrhage
Seizures
Chemical and Drug Induced Liver Injury
Kidney Diseases
Neurobehavioral Manifestations
Anemia
Intestinal Diseases
Metabolism, Inborn Errors
Signs and Symptoms, Respiratory
Angioedema
Sensation Disorders
Stomatitis
Skin Diseases, Genetic
Photosensitivity Disorders
Dyspnea
Blood Coagulation Disorders
Fascioliasis
Neuromuscular Manifestations
Liver Diseases, Parasitic
Inflammation
Trematode Infections
Body Weight
Drug Hypersensitivity
Hypotension
Conjunctivitis
Body Temperature Changes
Dyskinesias
Adrenocortical Hyperfunction
Ulcer
Paralyses, Familial Periodic
26
32
13
5
13
18
26
2
15
10
19
15
2
9
11
7
5
2
6
8
6
5
8
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2
1
5
7
6
3
5
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3
4
1
1
1
4
1
4
3
4
3
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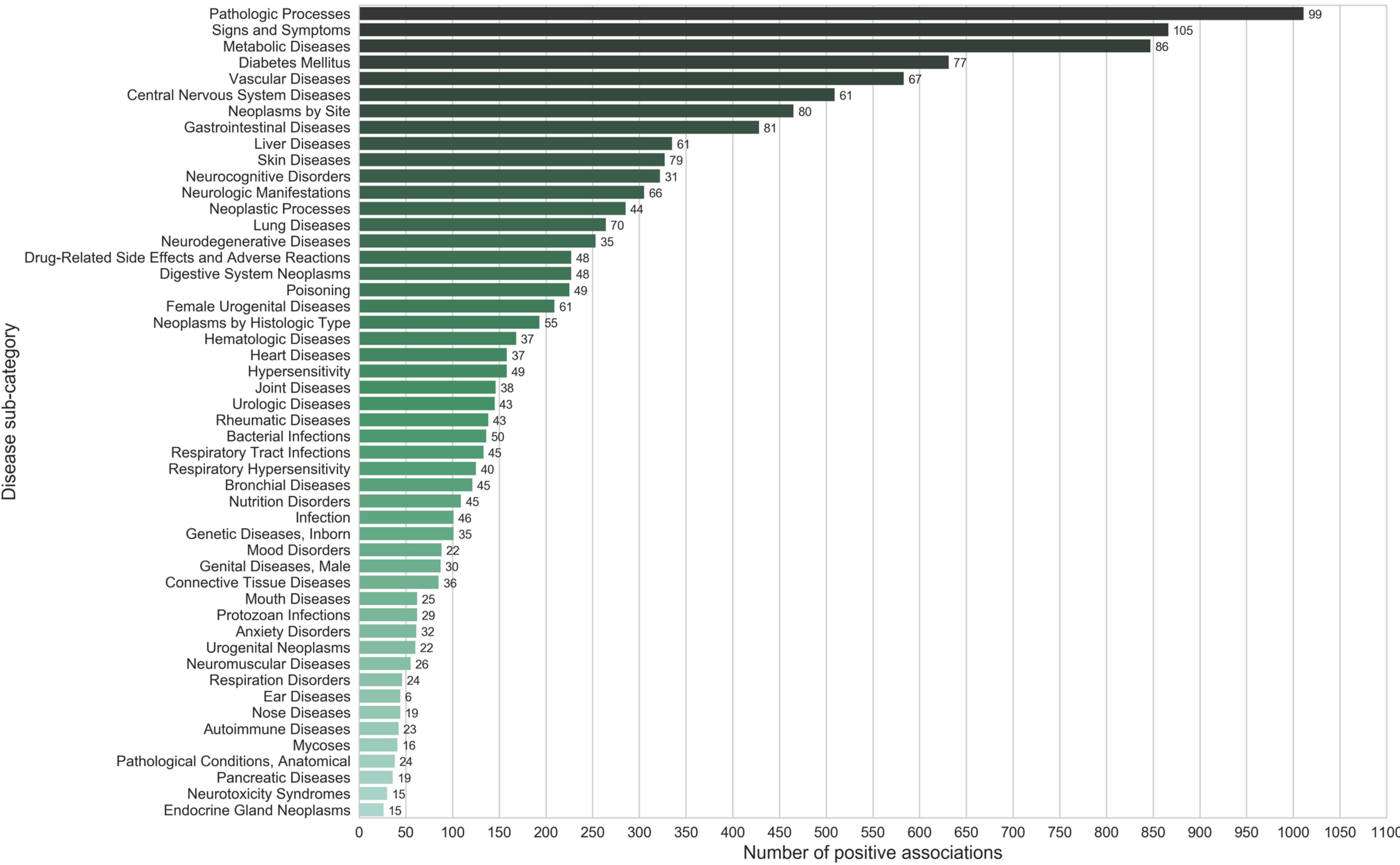
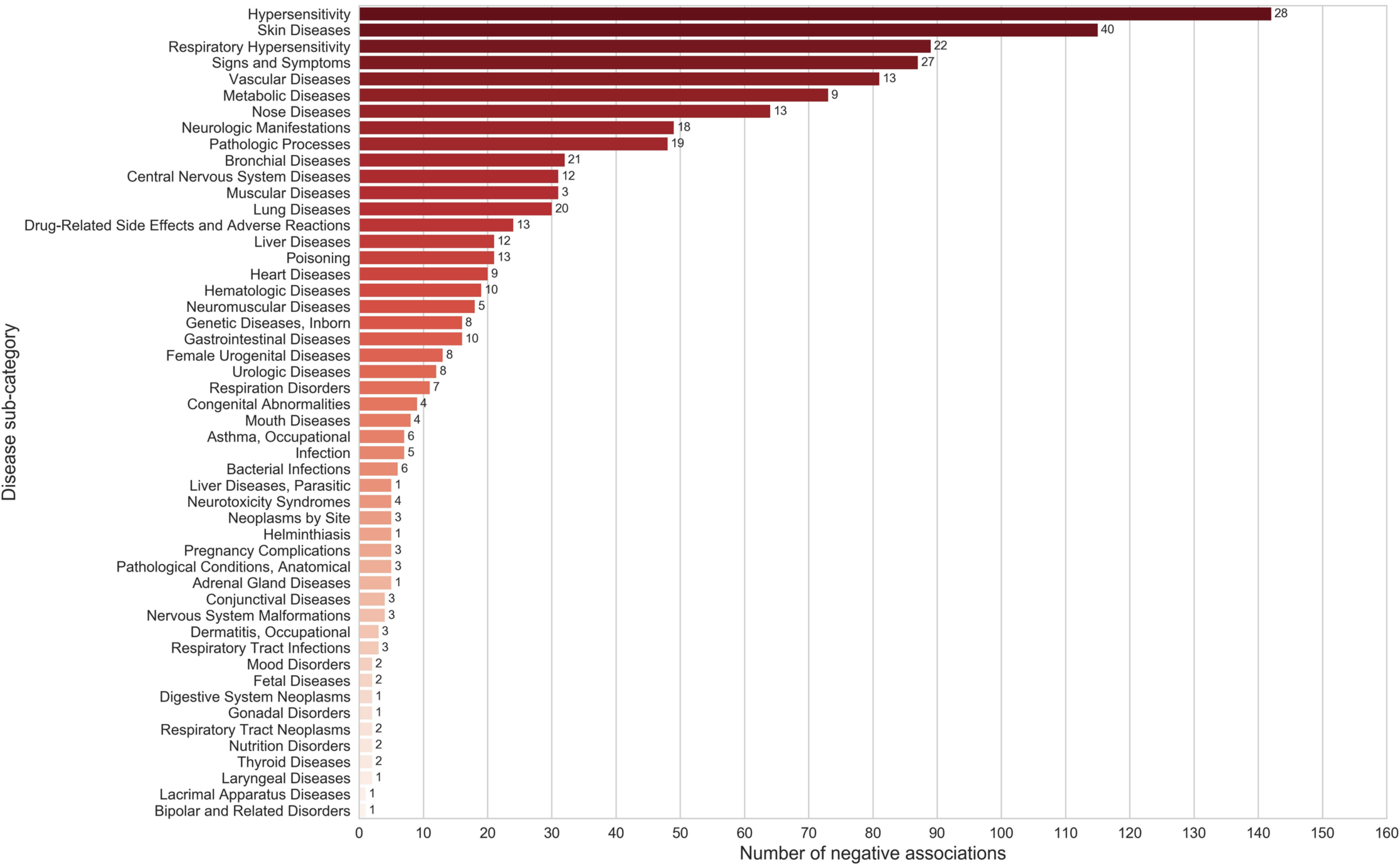
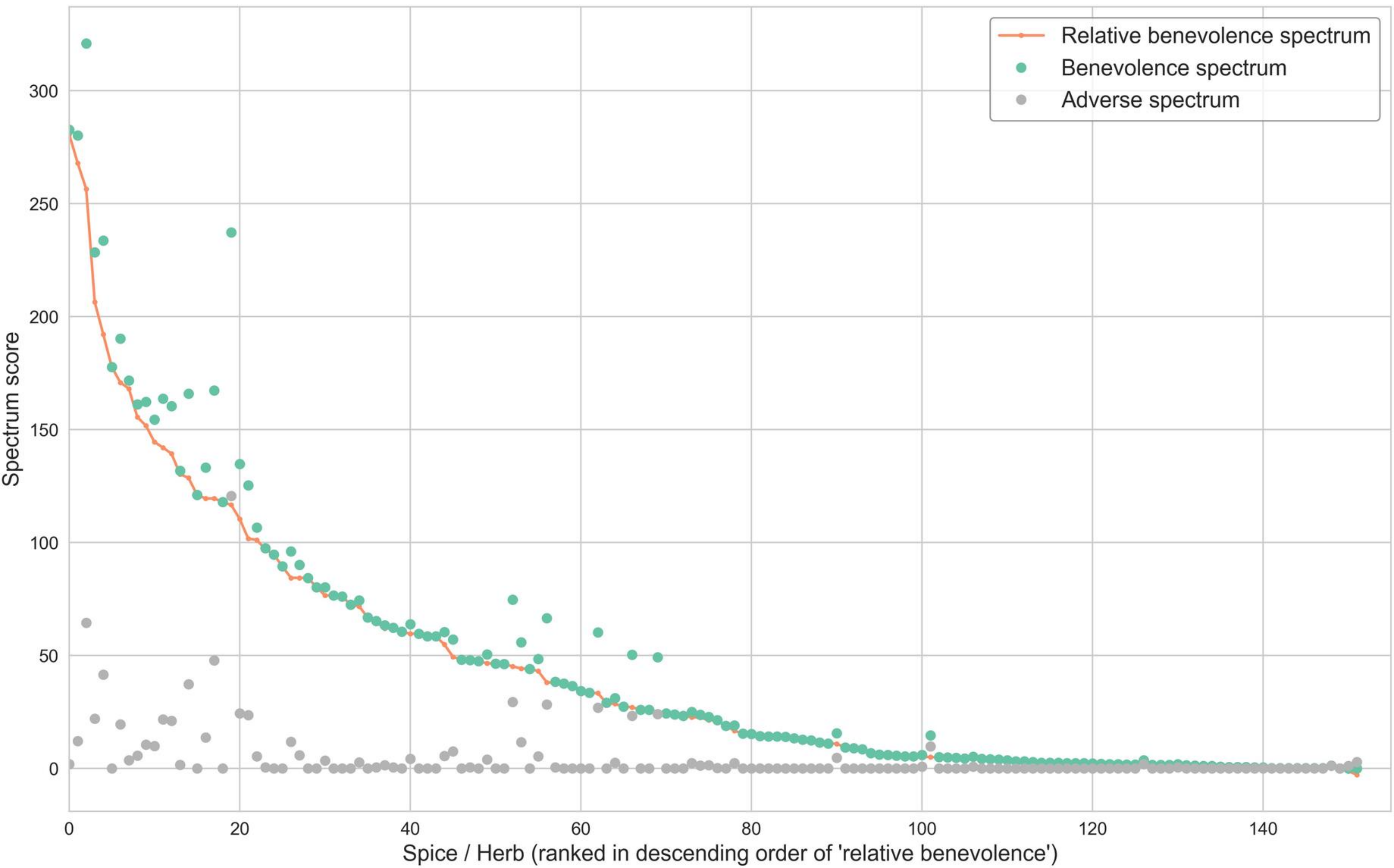
3
1
3
1
Disease
0
25
50
75
100
125
150
175
200
Number of negative associations


Disease sub-category
Number of positive associations
Pathologic Processes 99
Signs and Symptoms 105
Metabolic Diseases 86
Diabetes Mellitus 77
Vascular Diseases 67
Central Nervous System Diseases 61
Neoplasms by Site 80
Gastrointestinal Diseases 81
Liver Diseases 61
Skin Diseases 79
Neurocognitive Disorders 31
Neurologic Manifestations 66
Neoplastic Processes 44
Lung Diseases 70
Neurodegenerative Diseases 35
Drug-Related Side Effects and Adverse Reactions 48
Digestive System Neoplasms 48
Poisoning 49
Female Urogenital Diseases 61
Neoplasms by Histologic Type 55
Hematologic Diseases 37
Heart Diseases 37
Hypersensitivity 49
Joint Diseases 38
Urologic Diseases 43
Rheumatic Diseases 43
Bacterial Infections 50
Respiratory Tract Infections 45
Respiratory Hypersensitivity 40
Bronchial Diseases 45
Nutrition Disorders 45
Infection 46
Genetic Diseases, Inborn 35
Mood Disorders 22
Genital Diseases, Male 30
Connective Tissue Diseases 36
Mouth Diseases 25
Protozoan Infections 29
Anxiety Disorders 32
Urogenital Neoplasms 22
Neuromuscular Diseases 26
Respiration Disorders 24
Ear Diseases 6
Nose Diseases 19
Autoimmune Diseases 23
Mycoses 16
Pathological Conditions, Anatomical 24
Pancreatic Diseases 19
Neurotoxicity Syndromes 15
Endocrine Gland Neoplasms 15
0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000 1050 1100


Disease sub-category
Hypersensitivity 28
Skin Diseases 40
Respiratory Hypersensitivity 22
Signs and Symptoms 27
Vascular Diseases 13
Metabolic Diseases 9
Nose Diseases 13
Neurologic Manifestations 18
Pathologic Processes 19
Bronchial Diseases 21
Central Nervous System Diseases 12
Muscular Diseases 3
Lung Diseases 20
Drug-Related Side Effects and Adverse Reactions 13
Liver Diseases 12
Poisoning 13
Heart Diseases 9
Hematologic Diseases 10
Neuromuscular Diseases 5
Genetic Diseases, Inborn 8
Gastrointestinal Diseases 10
Female Urogenital Diseases 8
Urologic Diseases 8
Respiration Disorders 7
Congenital Abnormalities 4
Mouth Diseases 4
Asthma, Occupational 6
Infection 5
Bacterial Infections 6
Liver Diseases, Parasitic 1
Neurotoxicity Syndromes 4
Neoplasms by Site 3
Helminthiasis 1
Pregnancy Complications 3
Pathological Conditions, Anatomical 3
Adrenal Gland Diseases 1
Conjunctival Diseases 3
Nervous System Malformations 3
Dermatitis, Occupational 3
Respiratory Tract Infections 3
Mood Disorders 2
Fetal Diseases 2
Digestive System Neoplasms 1
Gonadal Disorders 1
Respiratory Tract Neoplasms 2
Nutrition Disorders 2
Thyroid Diseases 2
Laryngeal Diseases 1
Lacrimal Apparatus Diseases 1
Bipolar and Related Disorders 1
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
Number of negative associations


Relative benevolence spectrum
Benevolence spectrum
Adverse spectrum
Spectrum score
300
250
200
150
100
50
0
0
20
40
60
80
100
120
140
Spice / Herb (ranked in descending order of 'relative benevolence')

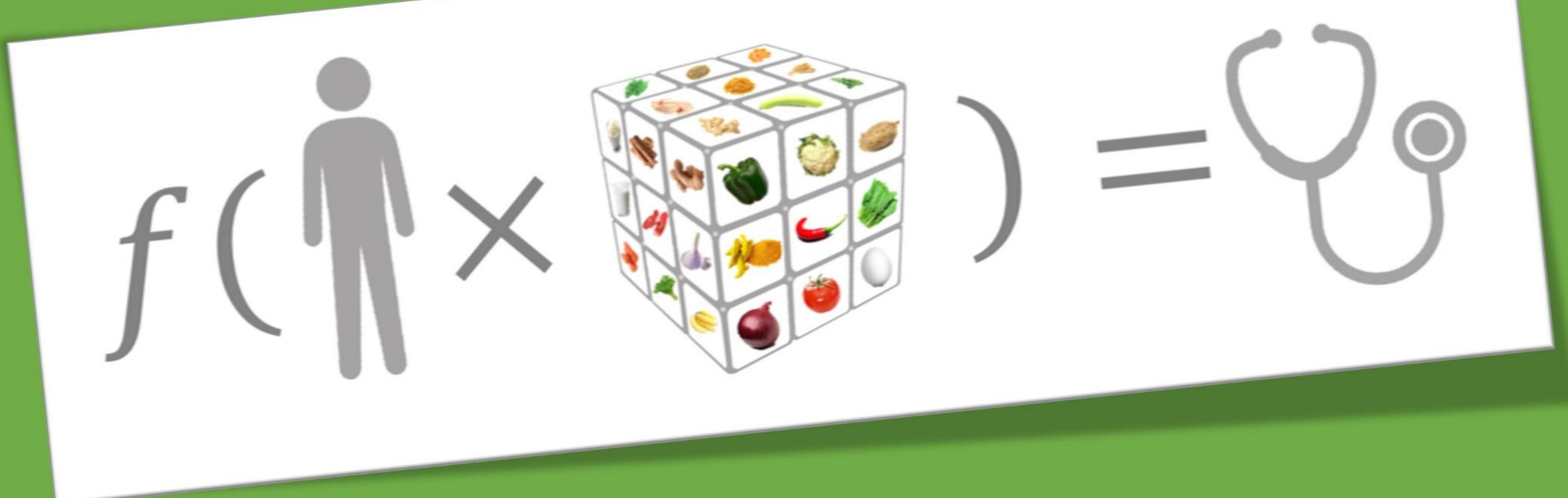
DietRx

An integrative resource to explore interrelationships among foods, diseases, genes and chemicals.

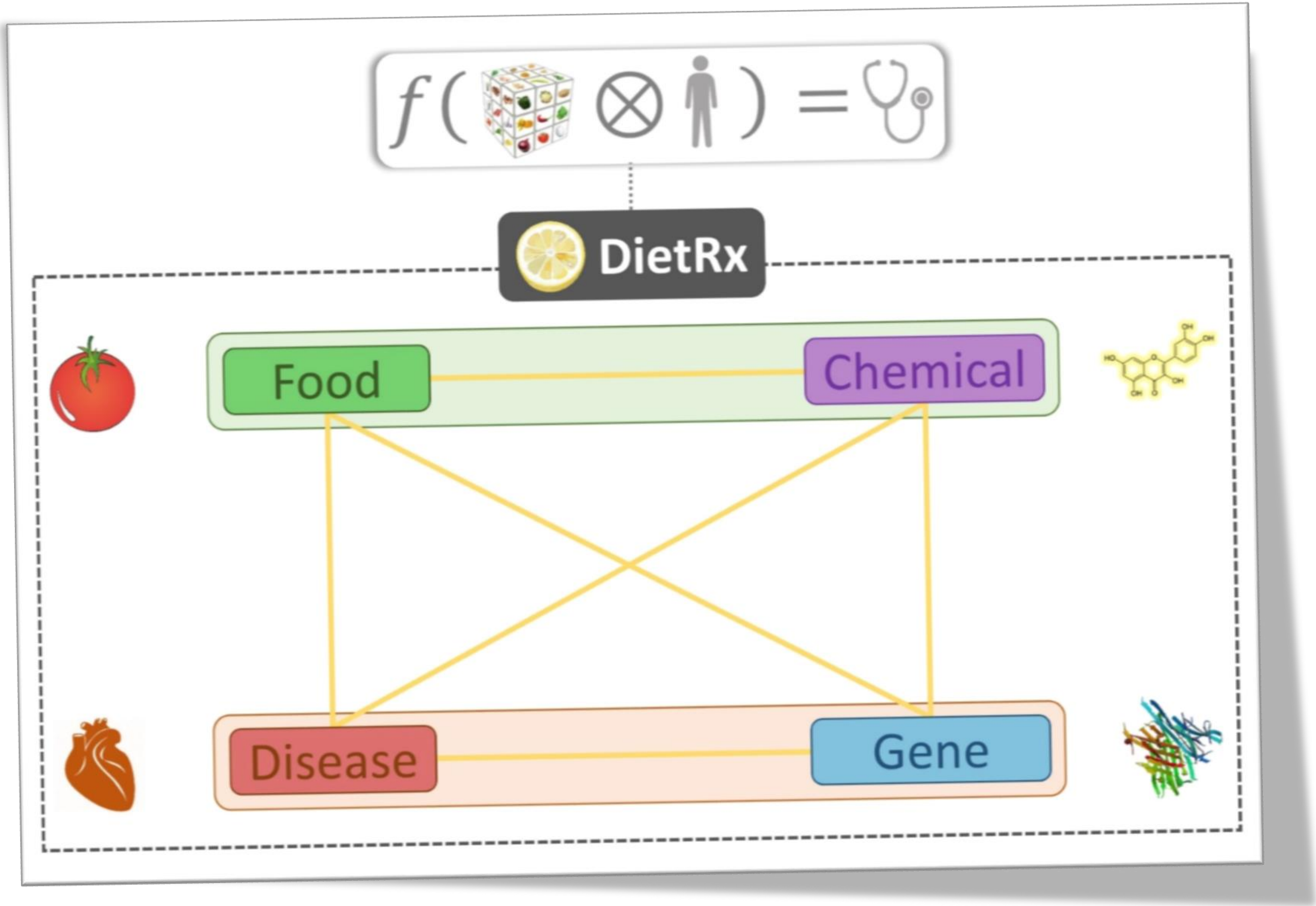
DietRx Summary

DietRx provides a platform for exploring health impacts of dietary ingredients by integrating interrelationships among food and key molecular agents. The resource assimilates dietary factors (food and chemicals), their health consequences (diseases) and genetic mechanisms to facilitate queries for investigating associations among these entities. At the core of the DietRx is the data of 21207 positive/negative food-disease associations for 1781 food entities belonging to 24 categories (vegetable, plant, fruit, meat & egg, herbs & spices etc.) text-mined from biomedical literature (27 million MEDLINE abstracts) using state-of-the-art named entity recognition tools, and a deep learning based relation classification model (Precision=0.87, Recall=0.8, and F1 Score = 0.84) which was trained with significant amount of manually curated data. These data are further interlinked with those involving 6992 food chemicals and 20550 genes, compiled from curated data sources, thereby creating a seamless platform for probing elements central to diet and their health consequences. DietRx facilitates the study of associations among food, disease, chemicals, and genes to enable data-driven inferences to be used for culinary interventions, nutrigenomics insights as well as for drug discovery endeavors.

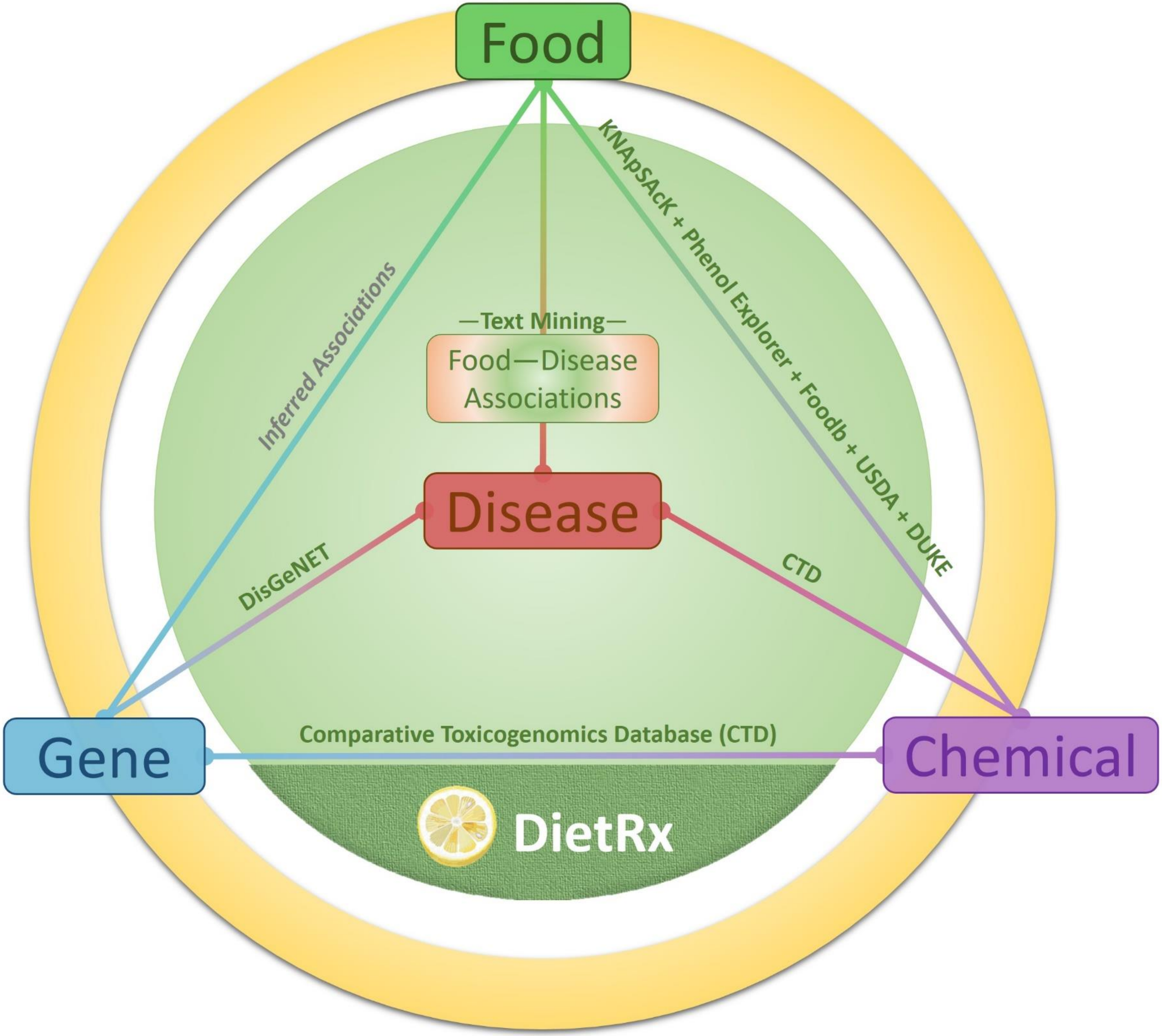
Dietary Interventions Strategies



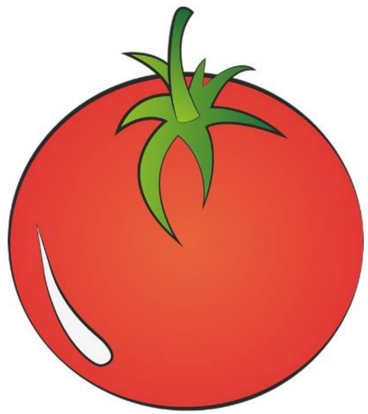
DietRx: An integrated resource for health impact of food



R Tuwani, Rakhi NK, N Garg and G Bagler*, Analytics-**Under Review** (2018); R Tuwani, Rakhi NK, and G Bagler*, Database-**Under Review** (2018).


Food
KNApSAcK + Phenol Explorer + Foodb + USDA + DUKE
Inferred Associations
—Text Mining—
Food—Disease Associations
Disease
DisGeNET
CTD
Comparative Toxicogenomics Database (CTD)
Gene
Chemical
DietRx

Food

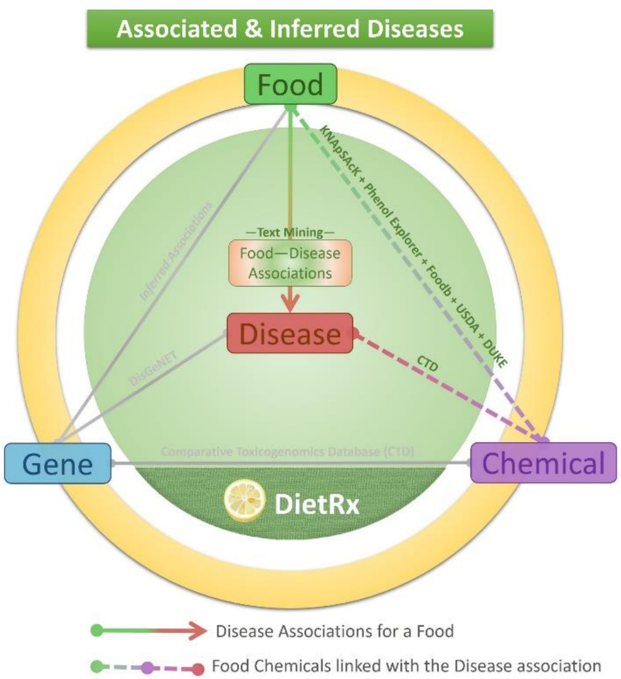


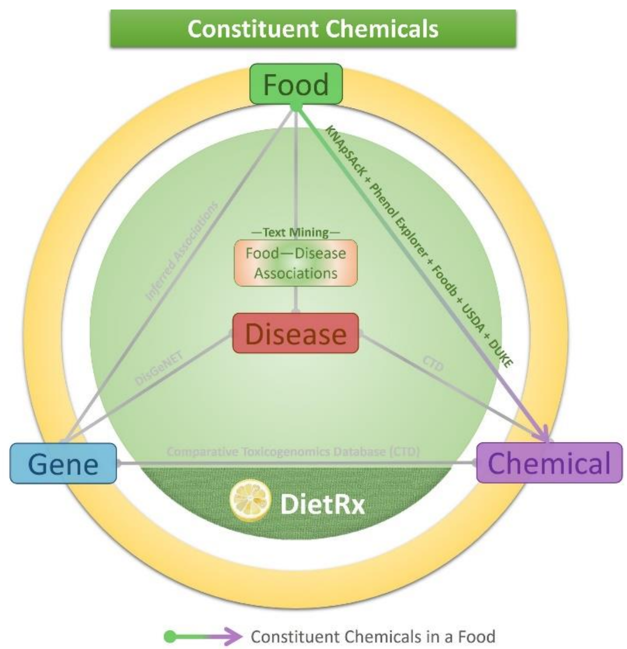
Common Names: Tomato, Cherry Tomato

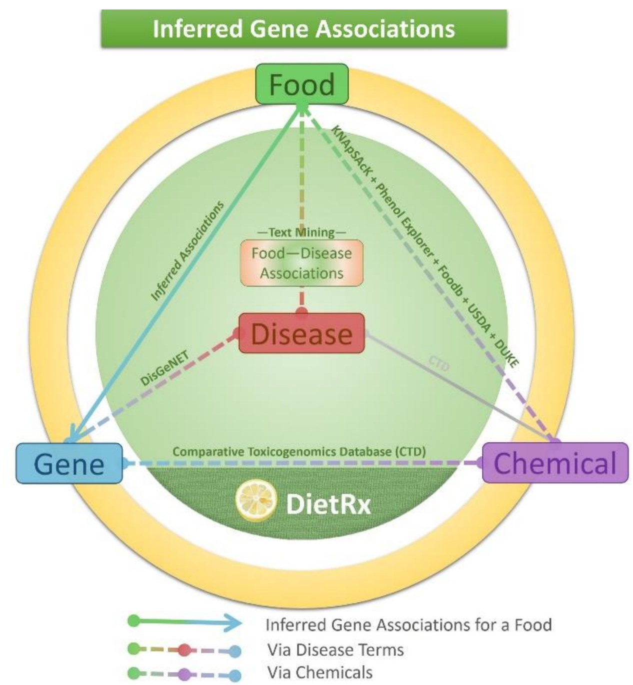
NCBI Taxonomy ID: 4081

Scientific Name: *Solanum lycopersicum*

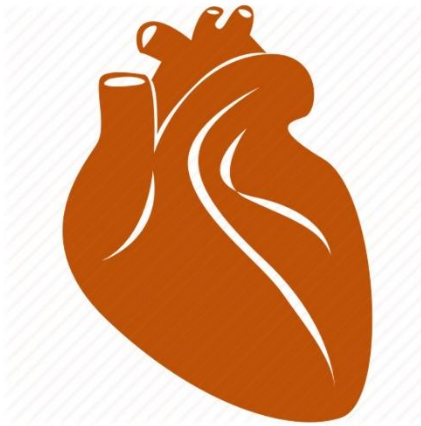
Category: Vegetable-Fruit







Disease



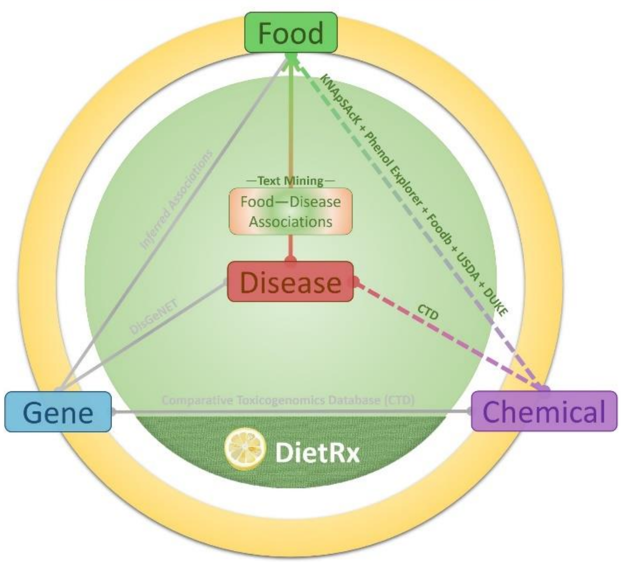
MeSH Disease ID: D002318

Disease Name: Cardiovascular Diseases

Synonyms: Cardiovascular Disease | Disease, Cardiovascular | Diseases, Cardiovascular

Category: Cardiovascular disease

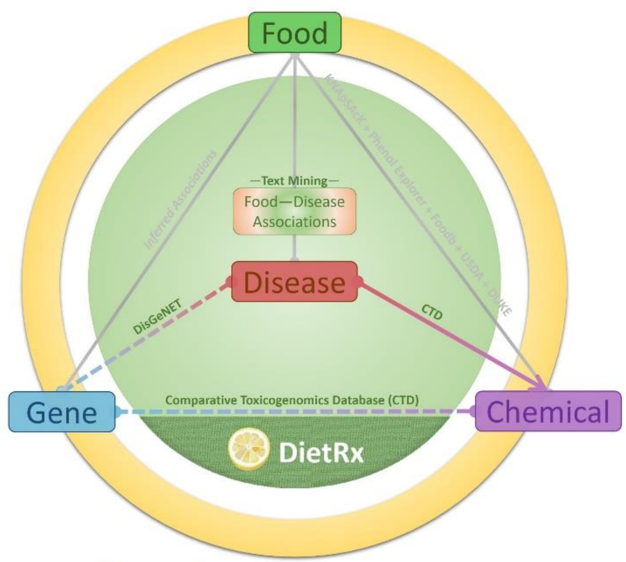
Associated & Inferred Foods



Food Associations for a Disease Term

Food Chemicals linked with the Disease association

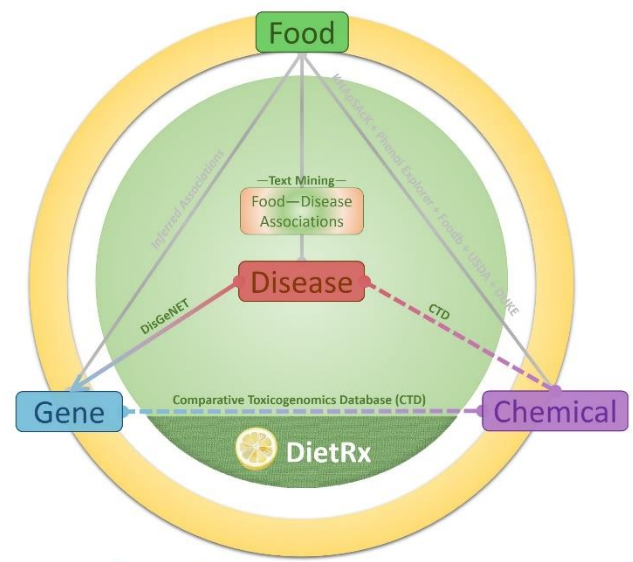
Associated and Inferred Chemicals



Chemicals Associated with a Disease Term

Via Genes

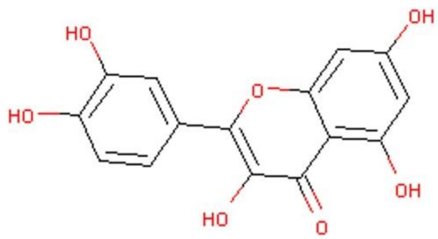
Associated and Inferred Genes



Genes Associated with a Disease Term

Via Chemicals

Chemical



PubChem CID: 5280343

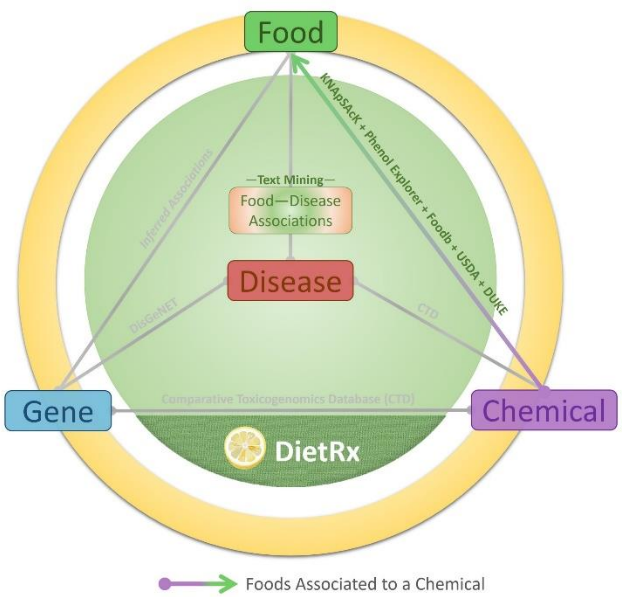
SMILES:
C1=CC(=C(C=C1C2=C(C(=O)C3=C(C=C(C=C3O2)O)O)O)O)O

Common Name: Quercetin

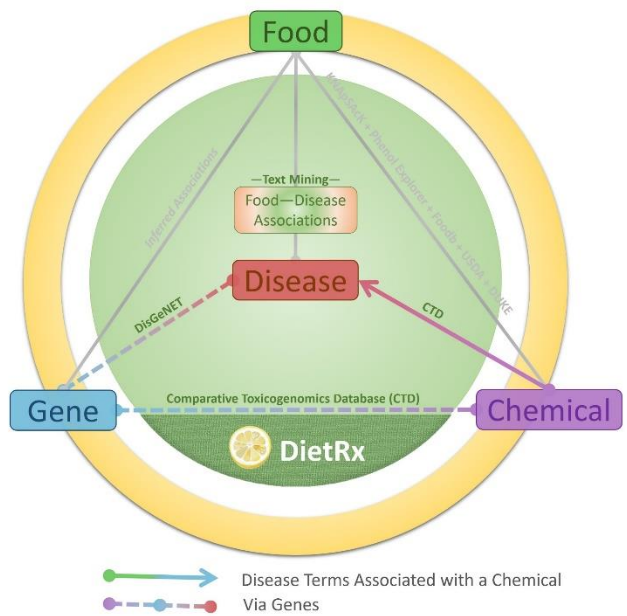
IUPAC Name: 2-(3,4-dihydroxyphenyl)-3,5,7-trihydroxychromen-4-one

Functional Group(s): Carbonyl compound, Hydroxy compound, Phenol, 1,2-diphenol, Oxohetarene, Aromatic compound, Heterocyclic compound

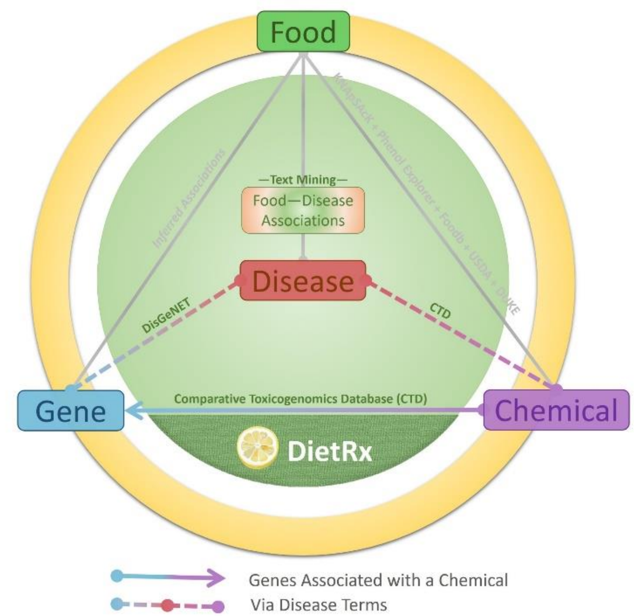
Associated Foods



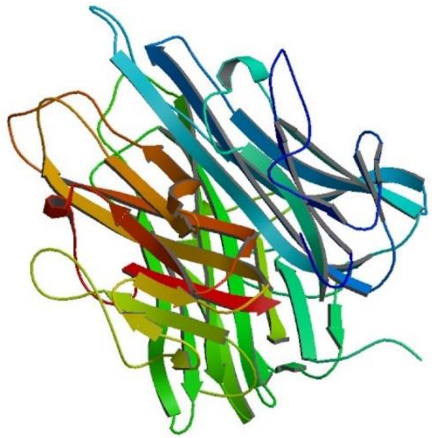
Associated and Inferred Diseases



Associated and Inferred Genes



Gene



Entrez Gene ID: 7132

Official Gene Symbol: TNFRSF1A

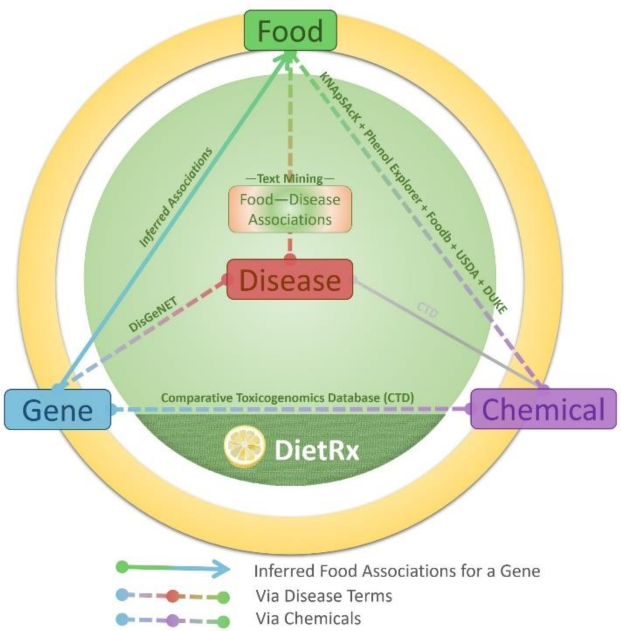
Official Gene Name: TNF receptor superfamily member 1A

Organism: Homo sapiens

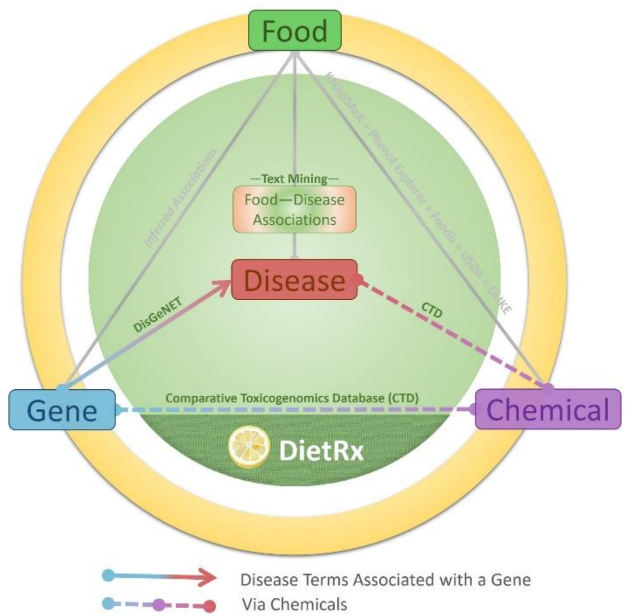
Other Symbols: CD120a, FPF, TBP1, TNF-R, TNF-R-I, TNF-R55, TNFAR, TNFR1, TNFR55, TNFR60, p55, p55-R, p60

Other Names: tumor necrosis factor receptor superfamily member 1A|TNF-R1|TNF-RI|TNFR-I|tumor necrosis factor…

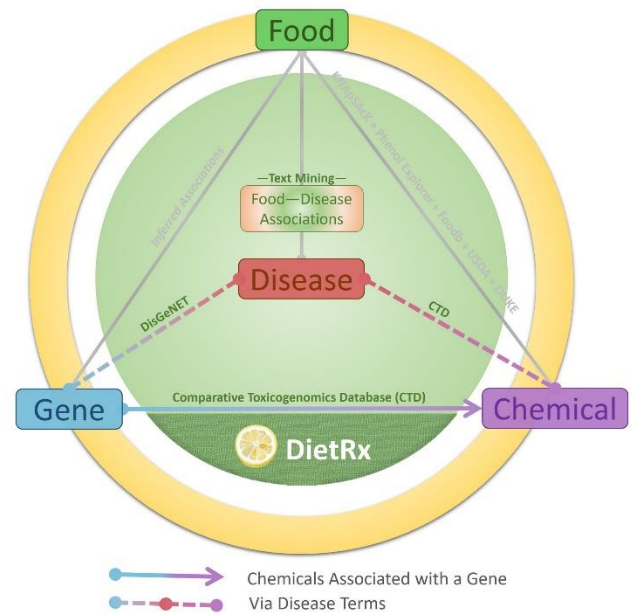
Inferred Food Associations

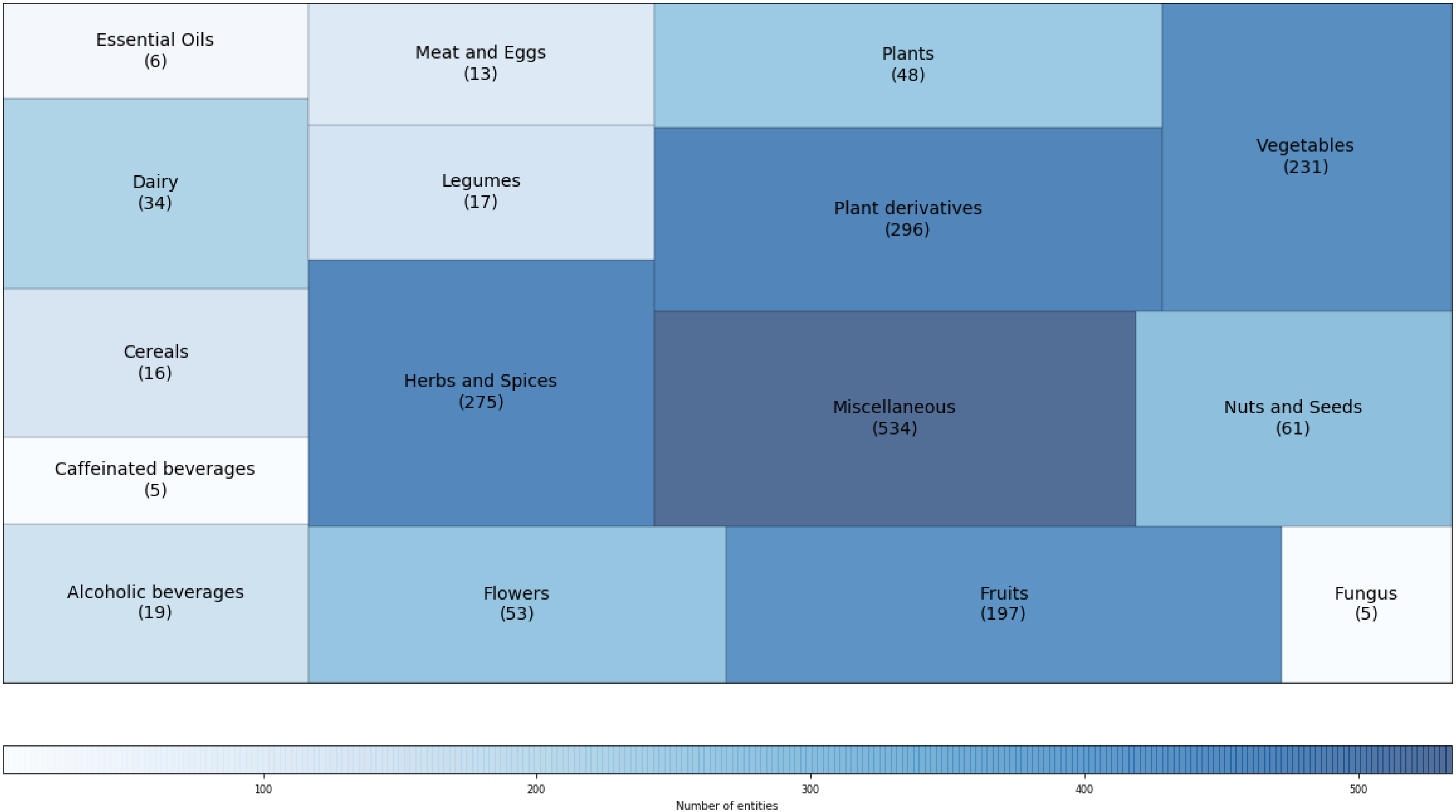


Associated & Inferred Diseases



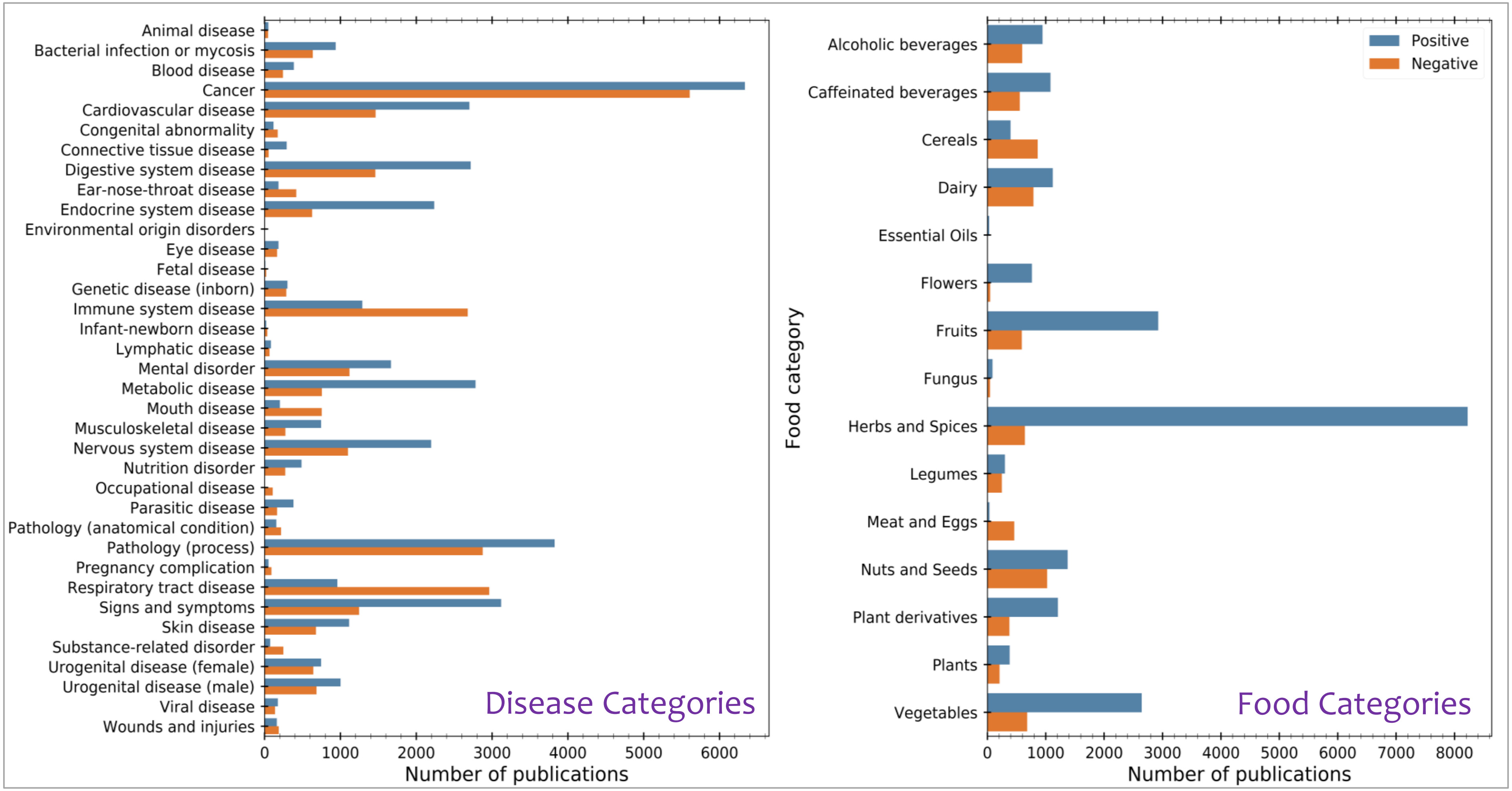
Associated & Inferred Chemicals



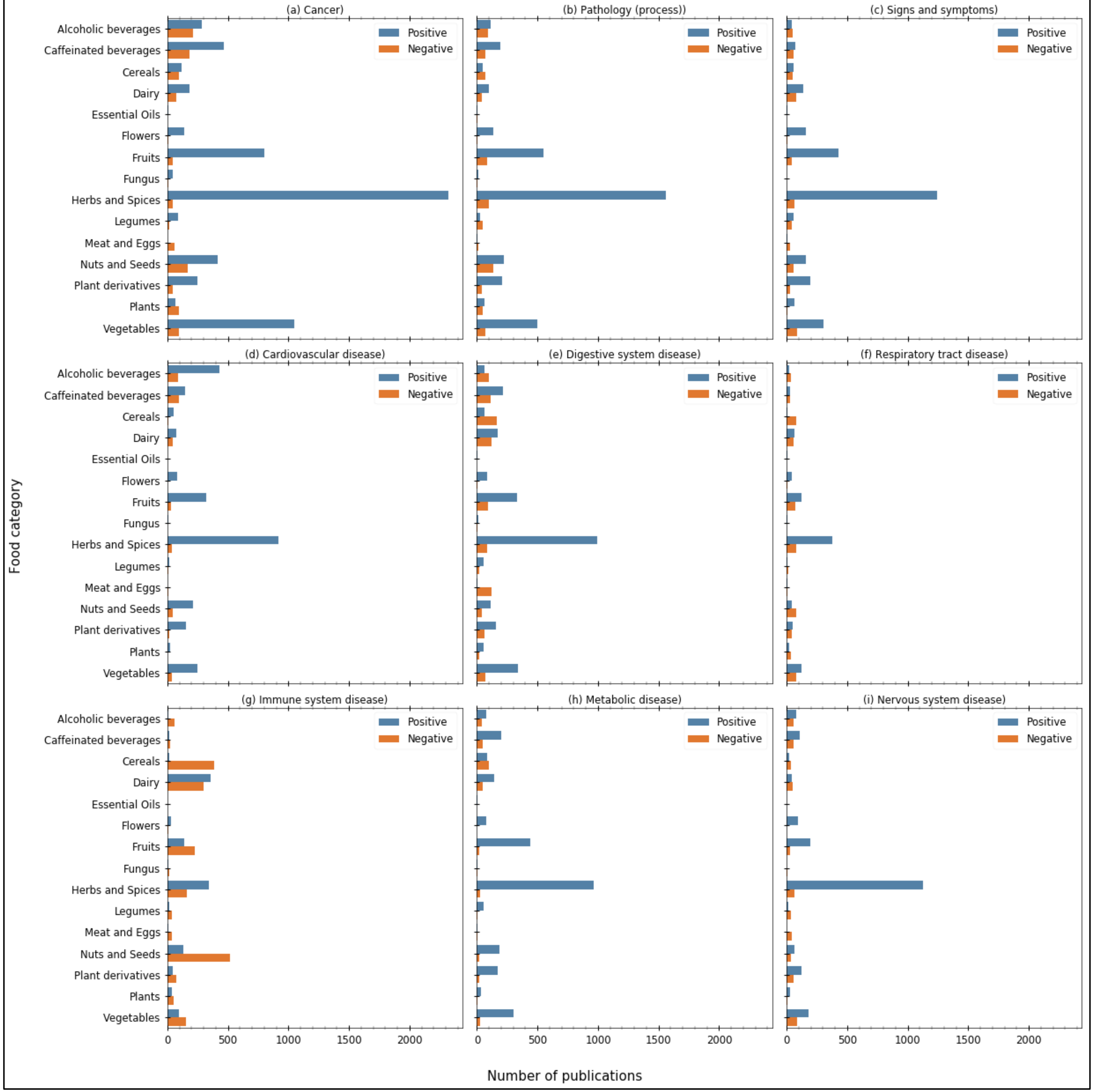


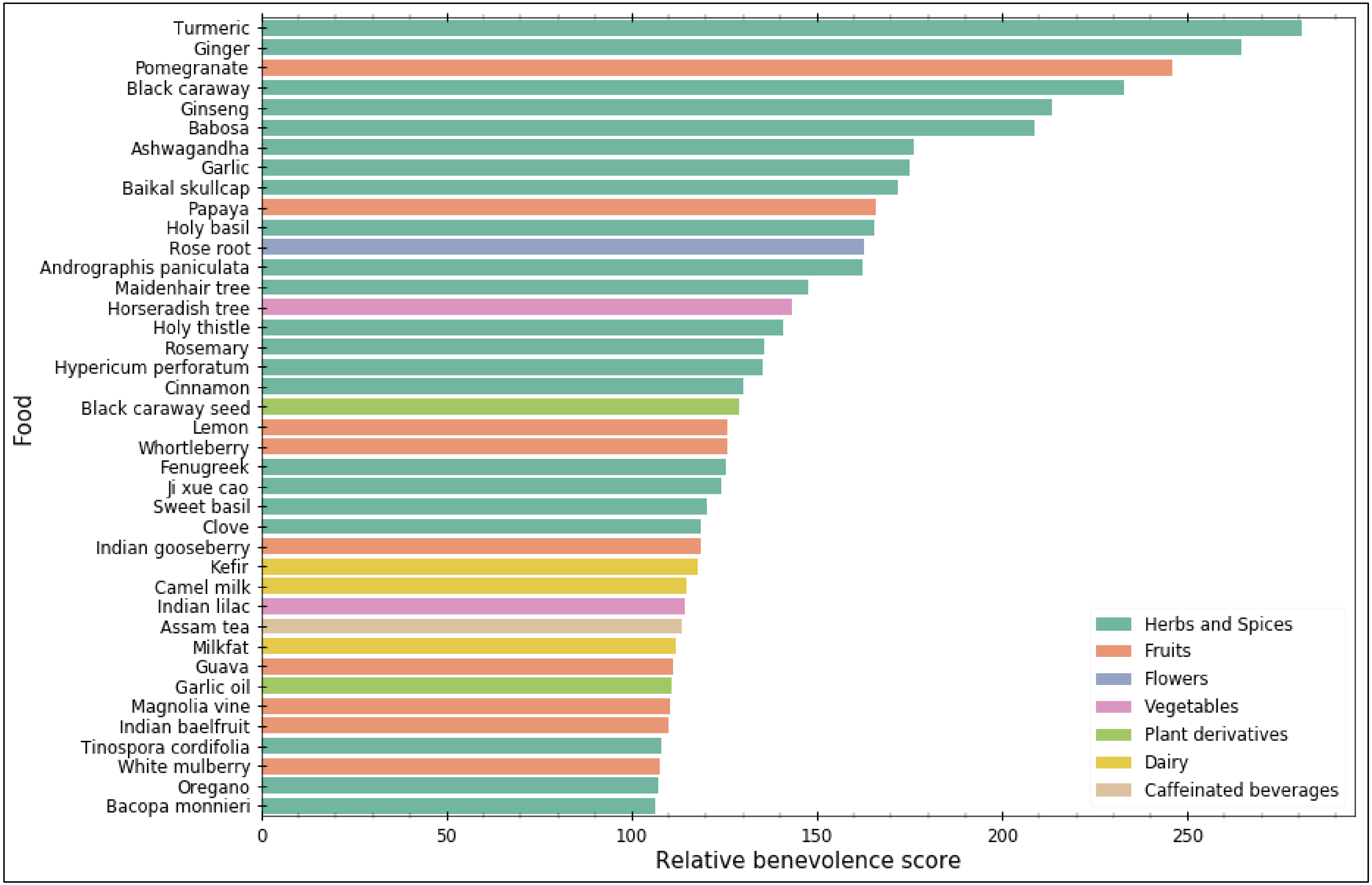
Coarse-grained categories of foods along with the number of foods in each.

Statistics of Positive and Negative Associations



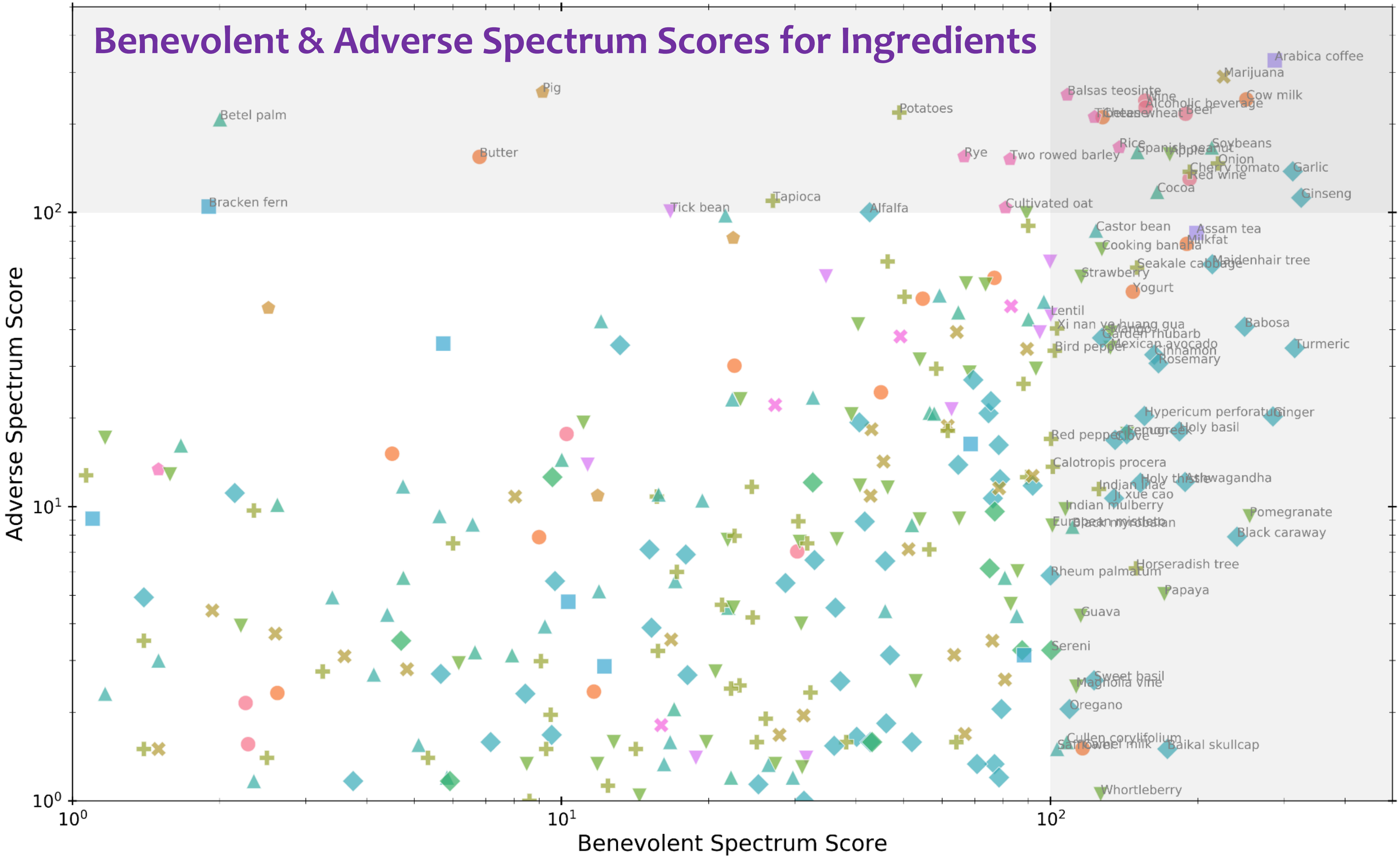
Number of publications reporting positive/negative associations for: (a) Disease categories (with foods); (b) Food categories (with diseases). The 'Miscellaneous' food category consisting of heterogeneous ingredients is excluded from display in (b).


(a) Cancer
(b) Pathology (process))
(c) Signs and symptoms)
(d) Cardiovascular disease)
(e) Digestive system disease)
(f) Respiratory tract disease)
(g) Immune system disease)
(h) Metabolic disease)
(i) Nervous system disease)
Positive
Negative
Alcoholic beverages
Caffeinated beverages
Cereals
Dairy
Essential Oils
Flowers
Fruits
Fungus
Herbs and Spices
Legumes
Meat and Eggs
Nuts and Seeds
Plant derivatives
Plants
Vegetables
Food category
0
500
1000
1500
2000
Number of publications



Foods with the highest relative benevolence scores.

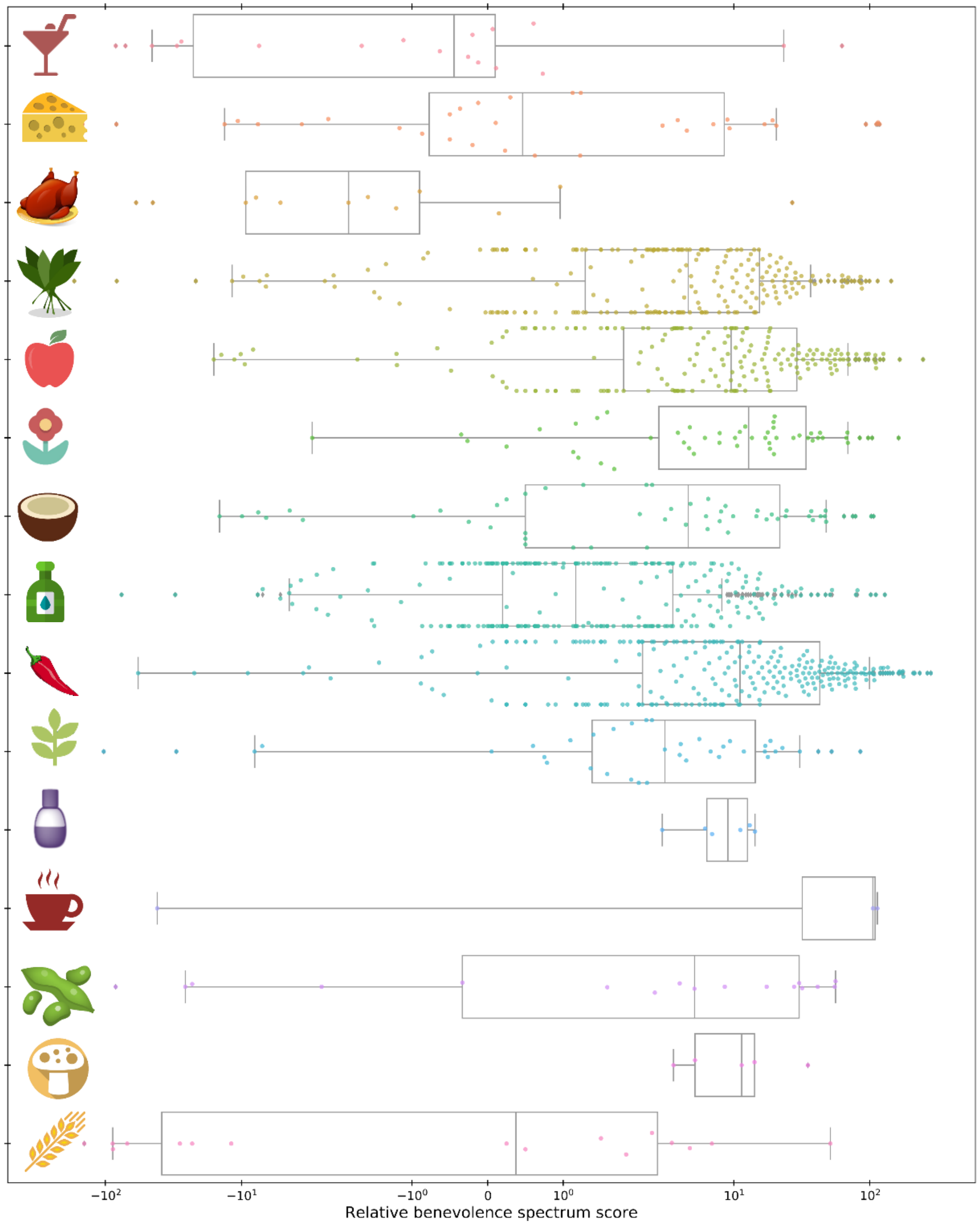
Benevolent & Adverse Spectrum Scores of Food



Scatterplot representing benevolence and adverse spectrum scores of different foods.

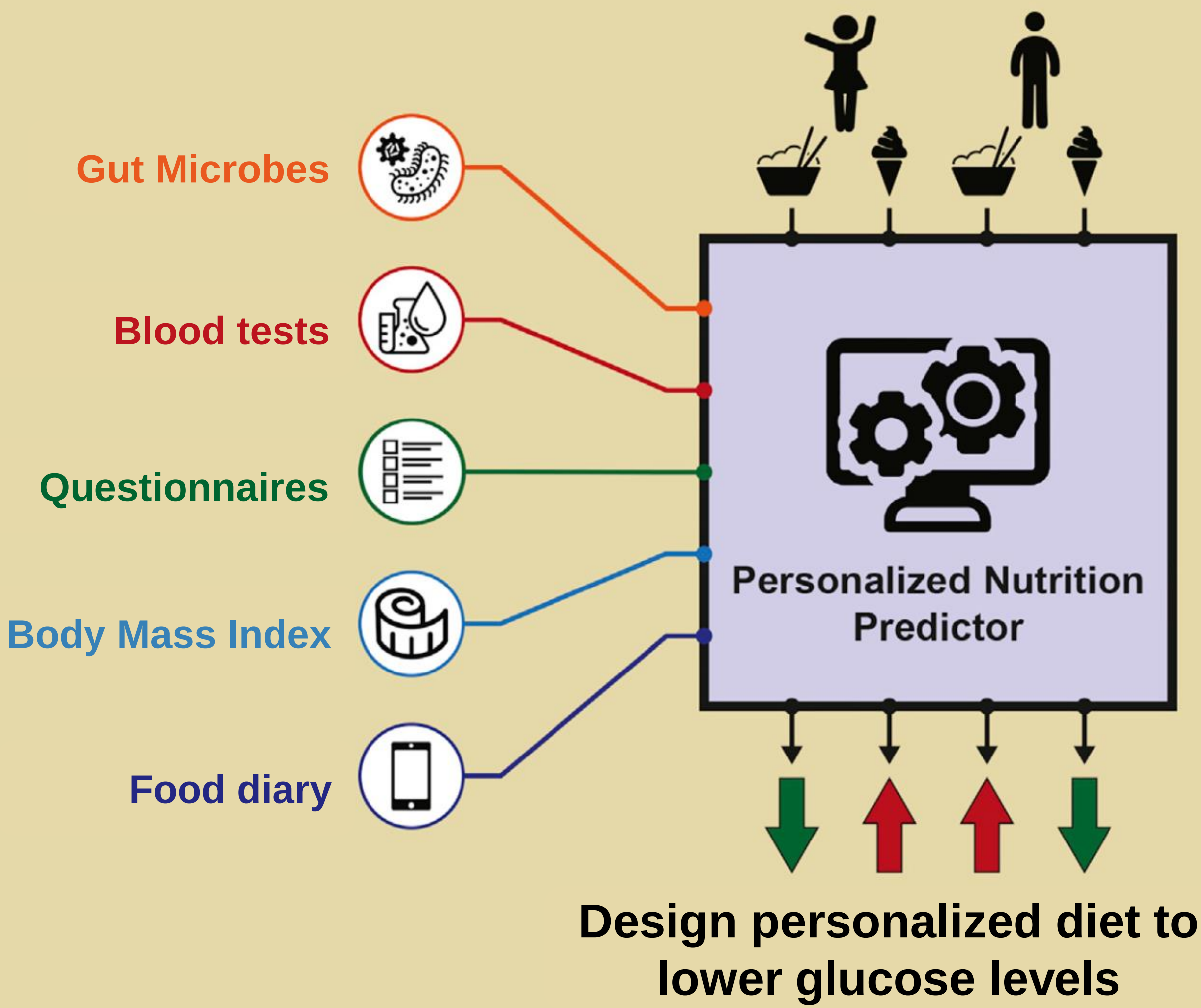
R Tuwani, Rakhi NK, N Garg and G Bagler*, Analytics-**Under Review** (2018); R Tuwani, Rakhi NK, and G Bagler*, Database-**Under Review** (2018).

Relative Benevolence of Food



R Tuwani, Rakhi NK, N Garg and G Bagler*, Analytics-**Under Review** (2018); R Tuwani, Rakhi NK, and G Bagler*, Database-**Under Review** (2018).

Personalized Nutrition



ED Sonnenburg and JL Sonnenburg, Nature, 528, 484 (2015).
Zeevi et al., “Personalized nutrition by prediction of glycemic response”, Cell, 163, 1079 (2015).