

Supplementary materials

PRWHMDA: Human Microbe-Disease Association Prediction by Random Walk on the Heterogeneous Network with PSO

Chuanyan Wu¹, Rui Gao^{1*}, Daoliang Zhang¹, Shiyun Han², Yusen Zhang³

¹ School of Control Science and Engineering, Shandong University, Jinan, 250061, China.

² General Clinic, The No. 2 People's Hospital of Tianqiao, Jinan, 250032, China.

³ School of Mathematics and Statistics, Shandong University, Weihai, 264209, China.

* Corresponding author: **Rui Gao**, School of Control Science and Engineering, Shandong University, No.17923 of Jingshi Road, Jinan 250061, China. E-mail: gaorui@sdu.edu.cn.

Table s1

The top-10 potential associated microbes for all the 39 diseases.

Disease	Microbe	Rank
Allergic asthma	Comamonadaceae	1
Allergic asthma	Oxalobacteraceae	2
Allergic asthma	Sphingomonadaceae	3
Allergic asthma	Staphylococcus	4
Allergic asthma	Haemophilus	5
Allergic asthma	Prevotella	6
Allergic asthma	Bacteroidetes	7
Allergic asthma	Proteobacteria	8
Allergic asthma	Actinobacteria	9
Allergic asthma	Firmicutes	10
Allergic sensitization	Dietzia maris	1
Allergic sensitization	Staphylococcus epidermidis	2
Allergic sensitization	Escherichia coli	3
Allergic sensitization	Stenotrophomonas maltophilia	4
Allergic sensitization	Staphylococcus aureus	5
Allergic sensitization	Lysobacter	6
Allergic sensitization	Rickettsiales	7
Allergic sensitization	Streptococcus mitis	8
Allergic sensitization	Xanthomonas	9
Allergic sensitization	Burkholderia	10
Allergy	Comamonadaceae	1
Allergy	Oxalobacteraceae	2
Allergy	Sphingomonadaceae	3
Allergy	Staphylococcus	4
Allergy	Haemophilus	5
Allergy	Prevotella	6
Allergy	Bacteroidetes	7
Allergy	Proteobacteria	8
Allergy	Actinobacteria	9

Allergy	Firmicutes	10
Asthma	Actinobacteria	1
Asthma	Firmicutes	2
Asthma	Clostridium coccoides	3
Asthma	Streptococcus	4
Asthma	Lactobacillus	5
Asthma	Lachnospiraceae	6
Asthma	Veillonella	7
Asthma	Propionibacterium	8
Asthma	Propionibacterium acnes	9
Asthma	Fusobacterium	10
Atopic dermatitis	Escherichia coli	1
Atopic dermatitis	Lysobacter	2
Atopic dermatitis	Rickettsiales	3
Atopic dermatitis	Streptococcus mitis	4
Atopic dermatitis	Xanthomonas	5
Atopic dermatitis	Burkholderia	6
Atopic dermatitis	Coxiellaceae	7
Atopic dermatitis	Lactobacillus	8
Atopic dermatitis	Alcaligenaceae	9
Atopic dermatitis	Coriobacteriaceae	10
Atopic sensitisation	Dietzia maris	1
Atopic sensitisation	Staphylococcus epidermidis	2
Atopic sensitisation	Escherichia coli	3
Atopic sensitisation	Stenotrophomonas maltophilia	4
Atopic sensitisation	Staphylococcus aureus	5
Atopic sensitisation	Lysobacter	6
Atopic sensitisation	Rickettsiales	7
Atopic sensitisation	Streptococcus mitis	8
Atopic sensitisation	Xanthomonas	9
Atopic sensitisation	Burkholderia	10
Atopy	Bacteroidetes	1
Atopy	Firmicutes	2
Atopy	Bacteroides	3
Atopy	Prevotella	4
Atopy	Fusobacterium	5
Atopy	Fusobacterium nucleatum	6
Atopy	Proteobacteria	7
Atopy	Lactobacillus	8
Atopy	Clostridium coccoides	9
Atopy	Bacilli	10

Bacterial Vaginosis	Proteobacteria	1
Bacterial Vaginosis	Bacteroidetes	2
Bacterial Vaginosis	Clostridium coccoides	3
Bacterial Vaginosis	Clostridia	4
Bacterial Vaginosis	Faecalibacterium prausnitzii	5
Bacterial Vaginosis	Lachnospiraceae	6
Bacterial Vaginosis	Haemophilus	7
Bacterial Vaginosis	Bacilli	8
Bacterial Vaginosis	Streptococcus	9
Bacterial Vaginosis	Fusobacterium	10
Clostridium difficile infection CDI	Actinobacteria	1
Clostridium difficile infection CDI	Prevotella	2
Clostridium difficile infection CDI	Haemophilus	3
Clostridium difficile infection CDI	Clostridium coccoides	4
Clostridium difficile infection CDI	Lactobacillus	5
Clostridium difficile infection CDI	Bacteroides	6
Clostridium difficile infection CDI	Veillonella	7
Clostridium difficile infection CDI	Clostridia	8
Clostridium difficile infection CDI	Streptococcus	9
Clostridium difficile infection CDI	Fusobacterium	10
Colon cancer	Acidobacteriaceae	1
Colon cancer	Aeromonadaceae	2
Colon cancer	Alteromonadaceae	3
Colon cancer	Anaerovorax	4
Colon cancer	Bacillaceae	5
Colon cancer	Bifidobacterium catenulatum	6
Colon cancer	Cellulomonadaceae	7
Colon cancer	Clostridiaceae	8
Colon cancer	Clostridium cocleatum	9
Colon cancer	Desulfobacteraceae	10
Colorectal carcinoma	Proteobacteria	1
Colorectal carcinoma	Haemophilus	2
Colorectal carcinoma	Lactobacillus	3
Colorectal carcinoma	Clostridium coccoides	4
Colorectal carcinoma	Streptococcus	5
Colorectal carcinoma	Lachnospiraceae	6
Colorectal carcinoma	Actinobacteria	7
Colorectal carcinoma	Clostridium	8
Colorectal carcinoma	Faecalibacterium prausnitzii	9
Colorectal carcinoma	Bifidobacterium	10
Constipation Irritable bowel syndrome IBS	Proteobacteria	1

Constipation Irritable bowel syndrome IBS	Bacteroidetes	2
Constipation Irritable bowel syndrome IBS	Enterobacteriaceae	3
Constipation Irritable bowel syndrome IBS	Gammaproteobacteria	4
Constipation Irritable bowel syndrome IBS	Actinobacteria	5
Constipation Irritable bowel syndrome IBS	Klebsiella	6
Constipation Irritable bowel syndrome IBS	Firmicutes	7
Constipation Irritable bowel syndrome IBS	Citrobacter	8
Constipation Irritable bowel syndrome IBS	Bacteroides	9
Constipation Irritable bowel syndrome IBS	Lachnospiraceae	10
COPD	Firmicutes	1
COPD	Clostridium coccoides	2
COPD	Actinobacteria	3
COPD	Lysobacter	4
COPD	Rickettsiales	5
COPD	Streptococcus mitis	6
COPD	Xanthomonas	7
COPD	Staphylococcus aureus	8
COPD	Coxiellaceae	9
COPD	Stenotrophomonas maltophilia	10
CrohnS disease CD	Clostridium difficile	1
CrohnS disease CD	Prevotella	2
CrohnS disease CD	Lachnospiraceae	3
CrohnS disease CD	Clostridium coccoides	4
CrohnS disease CD	Bacteroidetes	5
CrohnS disease CD	Proteobacteria	6
CrohnS disease CD	Bacteroides fragilis	7
CrohnS disease CD	Lactobacillus	8
CrohnS disease CD	Clostridium	9
CrohnS disease CD	Klebsiella	10
Cystic fibrosis	Dietzia maris	1
Cystic fibrosis	Staphylococcus epidermidis	2
Cystic fibrosis	Clostridium difficile	3
Cystic fibrosis	Bacteroidetes	4
Cystic fibrosis	Proteobacteria	5
Cystic fibrosis	Pseudomonas	6
Cystic fibrosis	Haemophilus	7
Cystic fibrosis	Prevotella	8
Cystic fibrosis	Prevotellaceae	9
Cystic fibrosis	Alcaligenaceae	10
Diarrhea Irritable bowel syndrome IBS	Prevotella	1
Diarrhea Irritable bowel syndrome IBS	Clostridium coccoides	2

Diarrhea Irritable bowel syndrome IBS	Proteobacteria	3
Diarrhea Irritable bowel syndrome IBS	Bacteroidetes	4
Diarrhea Irritable bowel syndrome IBS	Actinobacteria	5
Diarrhea Irritable bowel syndrome IBS	Acetone	6
Diarrhea Irritable bowel syndrome IBS	Actinobacillus	7
Diarrhea Irritable bowel syndrome IBS	Aggregatibacter	8
Diarrhea Irritable bowel syndrome IBS	Akkermansia	9
Diarrhea Irritable bowel syndrome IBS	Anaerofilum	10
Eczema	Dietzia maris	1
Eczema	Staphylococcus epidermidis	2
Eczema	Stenotrophomonas maltophilia	3
Eczema	Staphylococcus aureus	4
Eczema	Bacteroidales	5
Eczema	Enterococcus faecium	6
Eczema	Erysipelotrichales	7
Eczema	Clostridium leptum	8
Eczema	Fusobacteriaceae	9
Eczema	Veillonellaceae	10
Gastric and duodenal ulcer	Comamonadaceae	1
Gastric and duodenal ulcer	Oxalobacteraceae	2
Gastric and duodenal ulcer	Sphingomonadaceae	3
Gastric and duodenal ulcer	Staphylococcus	4
Gastric and duodenal ulcer	Haemophilus	5
Gastric and duodenal ulcer	Prevotella	6
Gastric and duodenal ulcer	Bacteroidetes	7
Gastric and duodenal ulcer	Proteobacteria	8
Gastric and duodenal ulcer	Actinobacteria	9
Gastric and duodenal ulcer	Firmicutes	10
Gastro-oesophageal reflux	Comamonadaceae	1
Gastro-oesophageal reflux	Oxalobacteraceae	2
Gastro-oesophageal reflux	Sphingomonadaceae	3
Gastro-oesophageal reflux	Staphylococcus	4
Gastro-oesophageal reflux	Haemophilus	5
Gastro-oesophageal reflux	Prevotella	6
Gastro-oesophageal reflux	Bacteroidetes	7
Gastro-oesophageal reflux	Proteobacteria	8
Gastro-oesophageal reflux	Actinobacteria	9
Gastro-oesophageal reflux	Firmicutes	10
Guttate psoriasis	Stenotrophomonas maltophilia	1
Guttate psoriasis	Dietzia maris	2
Guttate psoriasis	Staphylococcus epidermidis	3

Guttate psoriasis	Clostridium difficile	4
Guttate psoriasis	Lysobacter	5
Guttate psoriasis	Rickettsiales	6
Guttate psoriasis	Streptococcus mitis	7
Guttate psoriasis	Xanthomonas	8
Guttate psoriasis	Alcaligenaceae	9
Guttate psoriasis	Coriobacteriaceae	10
Ileal CrohnS disease CD	Proteobacteria	1
Ileal CrohnS disease CD	Firmicutes	2
Ileal CrohnS disease CD	Actinobacteria	3
Ileal CrohnS disease CD	Bacteroidetes	4
Ileal CrohnS disease CD	Bifidobacterium	5
Ileal CrohnS disease CD	Faecalibacterium prausnitzii	6
Ileal CrohnS disease CD	Enterobacteriaceae	7
Ileal CrohnS disease CD	Bacteroidales	8
Ileal CrohnS disease CD	Enterococcus faecium	9
Ileal CrohnS disease CD	Erysipelotrichales	10
Infectious colitis	Bacteroidetes	1
Infectious colitis	Prevotella	2
Infectious colitis	Fusobacterium	3
Infectious colitis	Clostridia	4
Infectious colitis	Firmicutes	5
Infectious colitis	Fusobacterium nucleatum	6
Infectious colitis	Proteobacteria	7
Infectious colitis	Veillonella	8
Infectious colitis	Lachnospiraceae	9
Infectious colitis	Eubacterium	10
Inflammatory bowel disease IBD	Clostridium coccoides	1
Inflammatory bowel disease IBD	Firmicutes	2
Inflammatory bowel disease IBD	Bacteroidetes	3
Inflammatory bowel disease IBD	Prevotella	4
Inflammatory bowel disease IBD	Staphylococcus	5
Inflammatory bowel disease IBD	Streptococcus	6
Inflammatory bowel disease IBD	Haemophilus	7
Inflammatory bowel disease IBD	Lactobacillus	8
Inflammatory bowel disease IBD	Veillonella	9
Inflammatory bowel disease IBD	Bacteroidaceae	10
Irritable bowel syndrome IBS	Prevotella	1
Irritable bowel syndrome IBS	Actinobacteria	2
Irritable bowel syndrome IBS	Firmicutes	3
Irritable bowel syndrome IBS	Lactobacillus	4

Irritable bowel syndrome IBS	Bacteroides uniformis	5
Irritable bowel syndrome IBS	Alistipes	6
Irritable bowel syndrome IBS	Parabacteroides	7
Irritable bowel syndrome IBS	Klebsiella	8
Irritable bowel syndrome IBS	Fusobacterium	9
Irritable bowel syndrome IBS	Faecalibacterium prausnitzii	10
Kidney stones	Acetonema	1
Kidney stones	Acidobacteriaceae	2
Kidney stones	Acinetobacter	3
Kidney stones	Actinobacillus	4
Kidney stones	Actinobacteria	5
Kidney stones	Actinomyces	6
Kidney stones	Aerococcus	7
Kidney stones	Aeromonadaceae	8
Kidney stones	Aggregatibacter	9
Kidney stones	Akkermansia	10
Liver cirrhosis	Firmicutes	1
Liver cirrhosis	Clostridium coccoides	2
Liver cirrhosis	Actinobacteria	3
Liver cirrhosis	Bacteroides vulgatus	4
Liver cirrhosis	Clostridia	5
Liver cirrhosis	Porphyromonadaceae	6
Liver cirrhosis	Bacteroides ovatus	7
Liver cirrhosis	Klebsiella	8
Liver cirrhosis	Staphylococcus	9
Liver cirrhosis	Eubacteriaceae	10
Necrotizing Enterocolitis	Lachnospiraceae	1
Necrotizing Enterocolitis	Prevotella	2
Necrotizing Enterocolitis	Clostridium coccoides	3
Necrotizing Enterocolitis	Haemophilus	4
Necrotizing Enterocolitis	Streptococcus	5
Necrotizing Enterocolitis	Propionibacterium	6
Necrotizing Enterocolitis	Propionibacterium acnes	7
Necrotizing Enterocolitis	Bacteroides	8
Necrotizing Enterocolitis	Lactobacillus	9
Necrotizing Enterocolitis	Bacteroidaceae	10
New-onset untreated rheumatoid arthritis	Acetonema	1
New-onset untreated rheumatoid arthritis	Acidobacteriaceae	2
New-onset untreated rheumatoid arthritis	Acinetobacter	3
New-onset untreated rheumatoid arthritis	Actinobacillus	4
New-onset untreated rheumatoid arthritis	Actinobacteria	5

New-onset untreated rheumatoid arthritis	Actinomyces	6
New-onset untreated rheumatoid arthritis	Aerococcus	7
New-onset untreated rheumatoid arthritis	Aeromonadaceae	8
New-onset untreated rheumatoid arthritis	Aggregatibacter	9
New-onset untreated rheumatoid arthritis	Akkermansia	10
Obesity	Stenotrophomonas maltophilia	1
Obesity	Proteobacteria	2
Obesity	Lactobacillus	3
Obesity	Dietzia maris	4
Obesity	Staphylococcus epidermidis	5
Obesity	Clostridium difficile	6
Obesity	Coxiellaceae	7
Obesity	Prevotella	8
Obesity	Burkholderia	9
Obesity	Lysobacter	10
Periodontal	Bacteroidetes	1
Periodontal	Proteobacteria	2
Periodontal	Firmicutes	3
Periodontal	Bacteroides	4
Periodontal	Clostridium coccoides	5
Periodontal	Lactobacillus	6
Periodontal	Bifidobacterium	7
Periodontal	Clostridia	8
Periodontal	Lachnospiraceae	9
Periodontal	Staphylococcus	10
Psoriasis	Bacteroidetes	1
Psoriasis	Prevotella	2
Psoriasis	Lachnospiraceae	3
Psoriasis	Clostridium coccoides	4
Psoriasis	Haemophilus	5
Psoriasis	Veillonella	6
Psoriasis	Enterobacteriaceae	7
Psoriasis	Citrobacter	8
Psoriasis	Enterobacter aerogenes	9
Psoriasis	Enterobacter hormaechei	10
Recurrent wheeze	Dietzia maris	1
Recurrent wheeze	Staphylococcus epidermidis	2
Recurrent wheeze	Escherichia coli	3
Recurrent wheeze	Stenotrophomonas maltophilia	4
Recurrent wheeze	Staphylococcus aureus	5
Recurrent wheeze	Lysobacter	6

Recurrent wheeze	Rickettsiales	7
Recurrent wheeze	Streptococcus mitis	8
Recurrent wheeze	Xanthomonas	9
Recurrent wheeze	Burkholderia	10
Rheumatoid arthritis	Desulfovibrio	1
Rheumatoid arthritis	Proteobacteria	2
Rheumatoid arthritis	Bacteroidetes	3
Rheumatoid arthritis	Actinobacteria	4
Rheumatoid arthritis	Lachnospiraceae	5
Rheumatoid arthritis	Haemophilus	6
Rheumatoid arthritis	Bacteroides vulgatus	7
Rheumatoid arthritis	Firmicutes	8
Rheumatoid arthritis	Lactobacillus	9
Rheumatoid arthritis	Bacteroides uniformis	10
Skin and mucosal infections	Acetone	1
Skin and mucosal infections	Acidobacteriaceae	2
Skin and mucosal infections	Acinetobacter	3
Skin and mucosal infections	Actinobacillus	4
Skin and mucosal infections	Actinobacteria	5
Skin and mucosal infections	Actinomyces	6
Skin and mucosal infections	Aerococcus	7
Skin and mucosal infections	Aeromonadaceae	8
Skin and mucosal infections	Aggregatibacter	9
Skin and mucosal infections	Akkermansia	10
Systemic inflammatory response syndrome	Enterobacter aerogenes	1
Systemic inflammatory response syndrome	Enterobacter hormaechei	2
Systemic inflammatory response syndrome	Klebsiella pneumoniae	3
Systemic inflammatory response syndrome	Shigella dysenteriae	4
Systemic inflammatory response syndrome	Gamma-proteobacteria	5
Systemic inflammatory response syndrome	Veillonella	6
Systemic inflammatory response syndrome	Citrobacter	7
Systemic inflammatory response syndrome	Proteobacteria	8
Systemic inflammatory response syndrome	Firmicutes	9
Systemic inflammatory response syndrome	Staphylococcus	10
Type 1 diabetes	Clostridium coccoides	1
Type 1 diabetes	Enterobacteriaceae	2
Type 1 diabetes	Staphylococcus	3
Type 1 diabetes	Faecalibacterium prausnitzii	4
Type 1 diabetes	Clostridium	5
Type 1 diabetes	Clostridium leptum	6
Type 1 diabetes	Enterococcus	7

Type 1 diabetes	Desulfovibrio	8
Type 1 diabetes	Tannerella	9
Type 1 diabetes	Bacilli	10
Type 2 diabetes	Prevotella	1
Type 2 diabetes	Actinobacteria	2
Type 2 diabetes	Lachnospiraceae	3
Type 2 diabetes	Haemophilus	4
Type 2 diabetes	Bacteroides	5
Type 2 diabetes	Fusobacterium	6
Type 2 diabetes	Fusobacteria	7
Type 2 diabetes	Enterobacteriaceae	8
Type 2 diabetes	Bacteroides uniformis	9
Type 2 diabetes	Megasphaera	10
Ulcerative colitis	Lachnospiraceae	1
Ulcerative colitis	Prevotella	2
Ulcerative colitis	Bacteroidetes	3
Ulcerative colitis	Firmicutes	4
Ulcerative colitis	Bifidobacterium	5
Ulcerative colitis	Staphylococcus	6
Ulcerative colitis	Lactobacillus	7
Ulcerative colitis	Haemophilus	8
Ulcerative colitis	Bacteroides vulgatus	9
Ulcerative colitis	Veillonella	10
WhippleS disease	Acetonema	1
WhippleS disease	Acidobacteriaceae	2
WhippleS disease	Acinetobacter	3
WhippleS disease	Actinobacillus	4
WhippleS disease	Actinobacteria	5
WhippleS disease	Actinomyces	6
WhippleS disease	Aerococcus	7
WhippleS disease	Aeromonadaceae	8
WhippleS disease	Aggregatibacter	9
WhippleS disease	Akkermansia	10