An Automation Framework for Clinical Codelist Development and Comprehensive Codelists in UK validated within NIHR-DynAIRx

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Outline

I. Introduction to DynAIRx and Motivation

II. Approach: Generalised Codelist Automation Framework (GCAF)

III. Results using GCAF on DynAIRx Case-Study with Clinical Intervention

IV. Conclusion and Future Work

Section I/IV

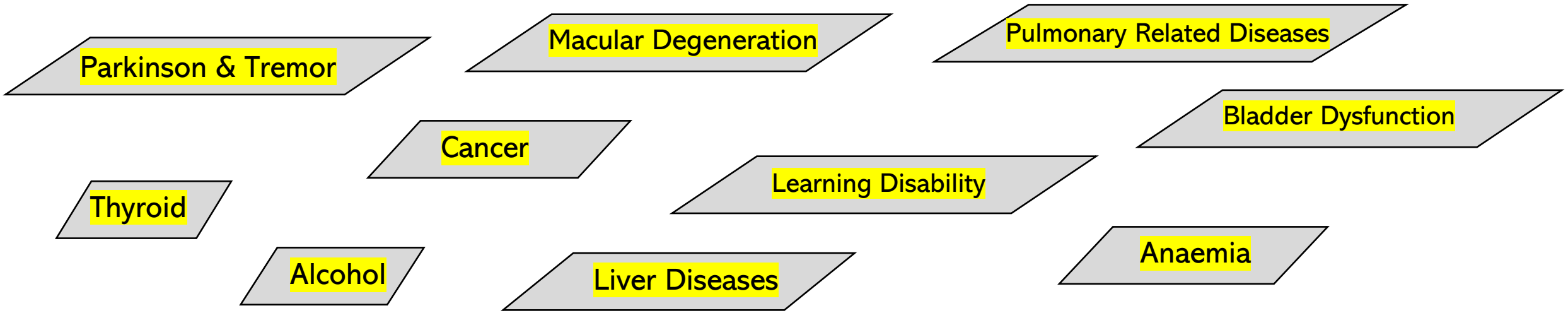
- Introduction to DynAIRx & Motivation

Introduction & Motivation

- **DynAIRx**: DynAIRx (Artificial Intelligence for dynamic prescribing optimisation and care integration in multimorbidity) NIHR funded project aims to develop new, easy to use, artificial intelligence (AI) tools that support General Practitioners (GPs) and pharmacists to find patients living with multimorbidity who might be offered a better combination of medicines.

- To train robust AI models and data preprocessing, my work package needs comprehensive codelists

- This work proposed a Codelist Generation Framework which derives a process for building codelists using automation where possible to reduce the amount clinical effort required whilst retaining high-quality. I used the ongoing DynAIRx project, as a case study to show the impact of the framework, and release the code required to implement our framework as open-source software.



Introduction & Motivation

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Section I/IV

- Codelists play a crucial role in ensuring accurate and standardized communication within healthcare.
- Preparation of high-quality codelists is rigorous involves a range clinical, technical, and informatics expertise, meaning it can become a time-consuming process.
- Literature
  - encouraged transparency of clinical codelists and overlooks the utility of automation.
  - recognized the importance of constructing reliable and reusable codelists.
  - concluded that although codelists are reusable but require extensive involvement of clinical expertise during codelist modification for future projects.
  - involve projects that often need to create/modify these existing codelists leading to issues of transparency and reproducibility.
- Efforts to be transparent and share codelists are proposed, but there will always be a need to create new codelists.
- There is not clear framework and how to leverage automation to decrease the amount of manual effort required.
- In this work, I proposed a Generalised Codelist Automation Framework (GCAF) for the construction of codelists, complied codelists of ≈14000 codes with only 7-9 hours of clinician's required time (while existing methods takes months), and reduce the workload by >80% through automation. Release GitHub Codes and Codelists publicly.

Section II/IV

- Approach: Generalised Codelist Automation Framework (GCAF)

Proposed Generalised Codelist Automation Framework (GCAF)

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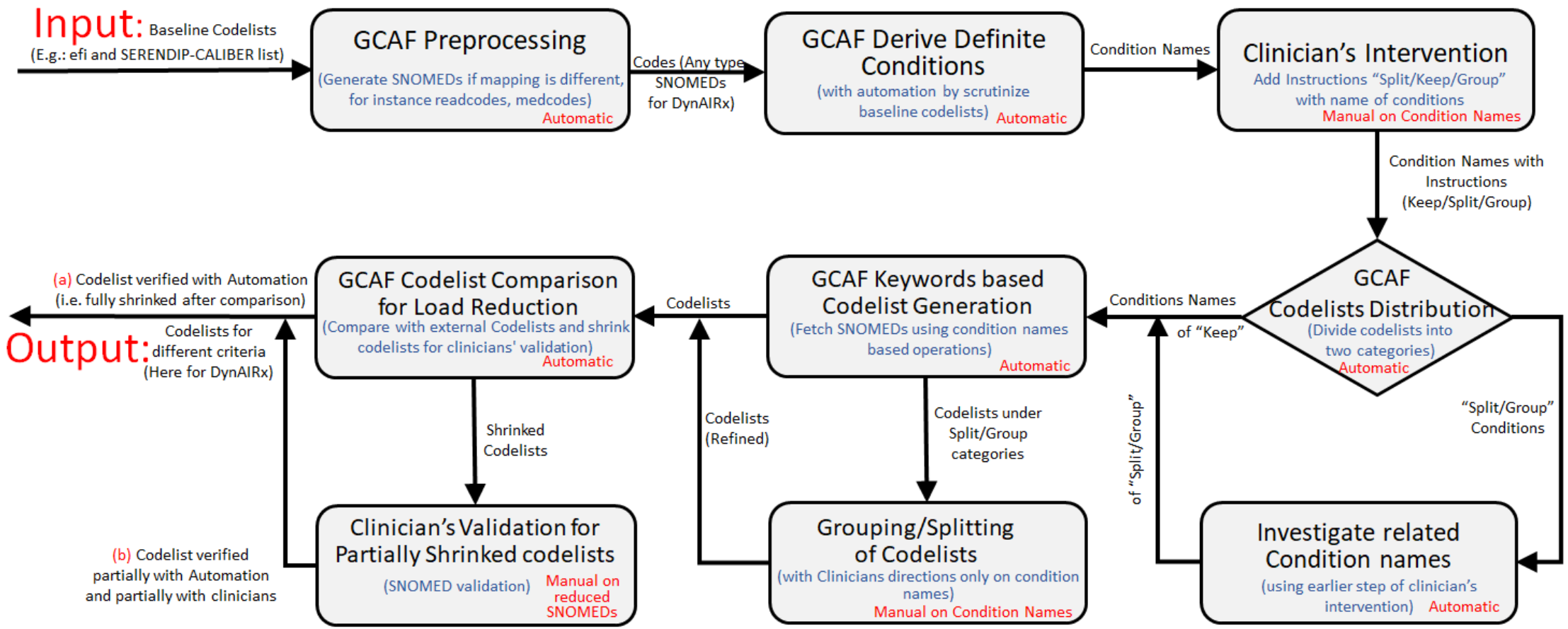
Section II/IV



Generalised Codelist Automation Framework (GCAF)

Proposed Generalised Codelist Automation Framework (GCAF)

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Section II/IV

1. GCAF Preprocessing

- Map files using NHS TRUD to convert initial lists containing Readcodes, Medcodes, SNOMEDs etc., into one common format (which is SNOMED for DynAIRx)
- For DynAIRx, SERENDIP codes needed converting from Read v3 to SNOMED. Once mapped into a uniform ontology, these codelists are transferred to the next module.

2. GCAF Derive Definite Conditions

- We found NO Consistency in names of conditions: same concepts are with different names across codelists, including use of spaces, under-scores, capital letters, joining two names, and plurals etc., though we need to have consistency in the names for automation.
- This module scan all input codelist, perform text operations on condition names, and generate a list of definitive conditions. For instance, name of conditions like Alcohol-related Brain Injury, Autoimmune liver Disease, Pulmonary hypertension, Chronic Obstructive Pulmonary Disease (COPD), Anaemia Folate Deficiency, Schizoaffective etc.

3. Clinical Intervention

- In this phase, clinician's add comments like "keep", "group", "split" or any other guidance comments for condition names.
- For instance, on "split" comment "Alcohol" is classified into "Alcohol related Brain Injury", "Alcoholic Liver Disease", "Alcohol Problems" and other problems. Or split mental health into subsets for depression, anxiety, learning disability etc.
- This manual step is only working with the names of conditions rather than individual SNOMED codes at this stage.

4. GCAF Codelists Distribution

- On the basis of the clinicians' comments, this module distribute conditions into two types "keep" and "Group/Split" type comments.
- It takes decision and direct to below two modules:
  - Keywords based Codelist Generation
  - Investigate related condition names
- An automated decision phase, which helps in deciding which list of conditions can be processed directly by GCAF and which need more attention.

5. Investigate related condition names

- In this module, we focus on condition names with grouped and/or split but can largely be done without clinical oversight at this stage.
- This modules takes care of finding similar texts using comments and generate list of related condition names.
- For example, our draft list of concepts for Macular Degeneration is "Macular Degeneration", "Cataract", "Visual Impairment and Blindness", and finally "Visual impairment" to catch non-specific terms.

Proposed Generalised Codelist Automation Framework (GCAF)

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Section II/IV

6. GCAF Keywords based Codelist Generation

- This phase performs a keyword search across the codelists
- Fetch the associated SNOMED codes, and generating draft codelists for condition names
- For simpler conditions this can often complete the majority of the codelists

7. Grouping/Splitting of Codelists

- This module we focus on those concepts that are difficult due to the need for splitting and grouping,
- This uses the draft list of concepts from Module-5
- In this module clinicians agree upon the final divisions or grouping of categories using condition names.
- For example: Macular Degeneration, intermediate categories were “Macular Degeneration”, “Visual impairment”, “Cataract”, and “Visual Impairment and Blindness”. After clinical feedback these conditions were split into Cataract, Macular Degeneration, Blindness, Visual Impairment and Blindness, Visual Impairment Diabetic, Visual Impairment Macular, Visual Impairment Diabetic and Macular, Visual Impairment Diabetic and Cataract, and Visual Impairment Other.

8. GCAF Codelist Comparison for Load Reduction

- This module shrunk codelist for clinician validation using trusted sources, in DynAIRx, we used the CALIBER codelist for matching of codes.
- This process automatically verified > 90% of the codes, leading to a huge reduction in the amount of time needed by our clinical team.
- Specifically, “shrinking” means automatically validating codes using a trusted source (CALIBER for DynAIRx), as such codelists have already been clinically validated.
- If the codelist gets “Fully Shrunk” i.e. 100% that means “all” codes were already present in the trusted sources and therefore No validation from clinicians needed.
- If it’s “Partially Shrunk” then some were validated via automation and a few codes need manual validation from clinicians.

9. Clinician’s Validation of Partially Shrunken codelists

- This phase is related to meetings with clinicians and validate partially shrunk codelists.
- This is the final verification of new SNOMEDs by clinicians which can be trusted in future projects.

Input/Output

- Input: Baseline Codelists (eFI and SERENDIP Codelists)
- Output: Verified Codelists (either fully or partially validated through automation, then with clinicians)

Publicly Available GitHub Repositories for any Future Project:

1. Codelist Generation Framework: https://github.com/DynAIRx/GCAF_DynAIRx
2. DynAIRx Codelists https://github.com/DynAIRx/Codelists_DynAIRx

Section III/IV

- Approach: Results using GCAF on DynAIRx Case-Study with Clinical Intervention

Results using GCAF on DynAIRx Case-Study

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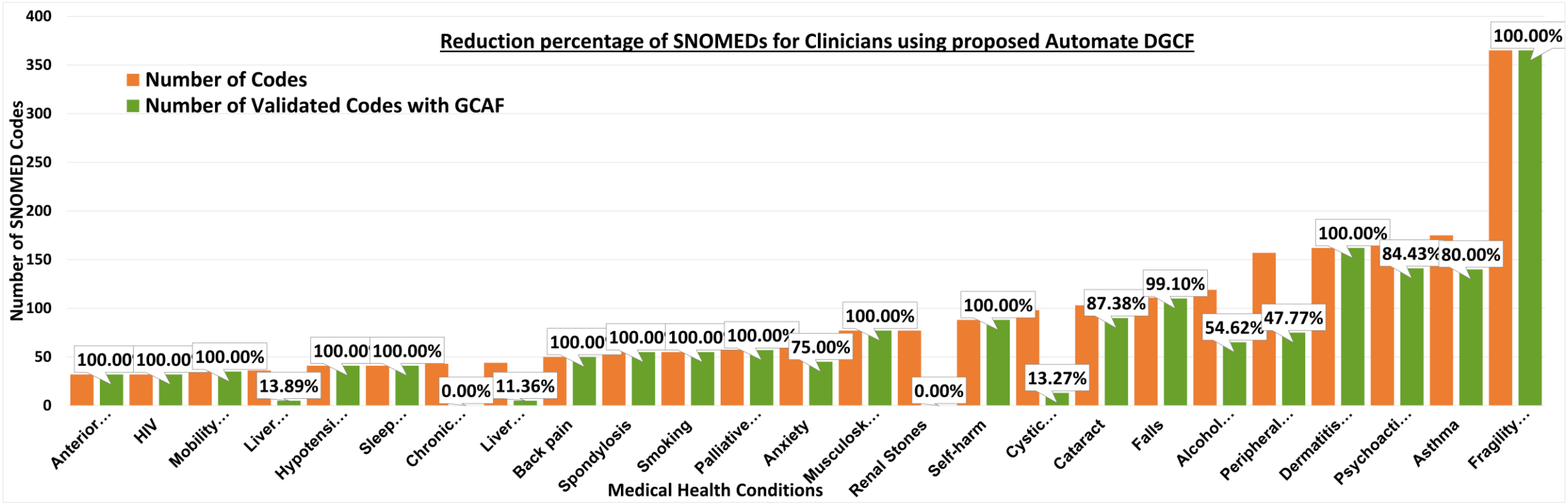
Section III/IV

- Generalised Codelist Automation Framework (GCAF)) shrinking (displayed on top of each) of codelists with having 30-370 codes.



Results using GCAF on DynAIRx Case-Study

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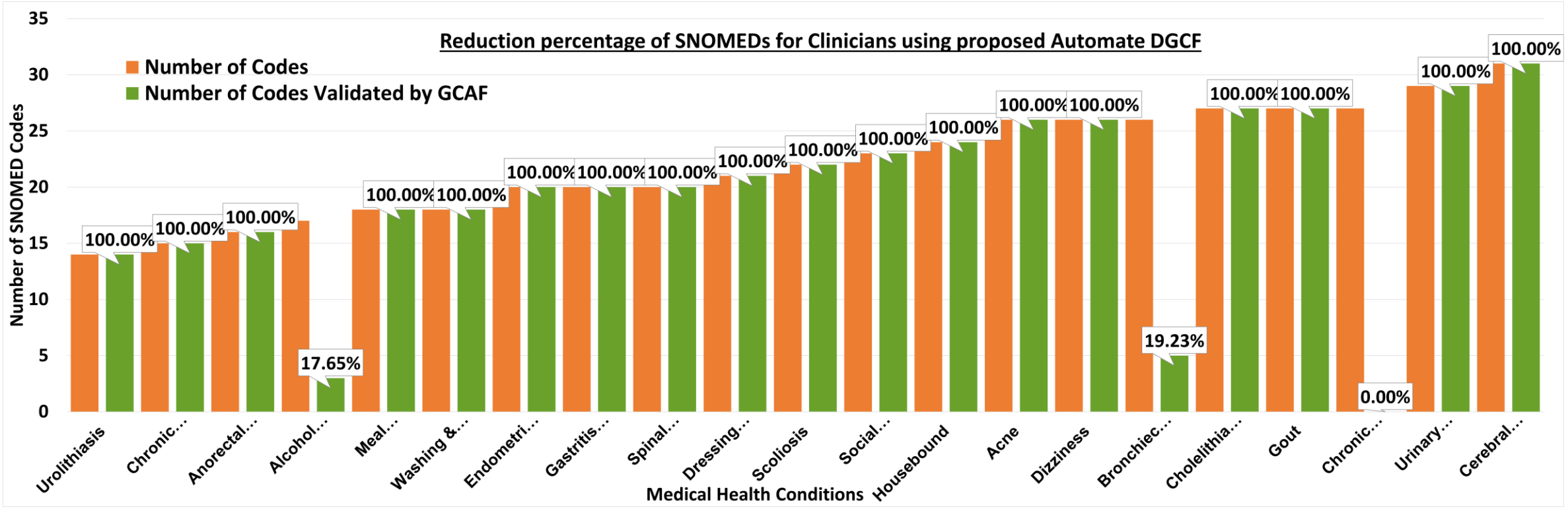
Section III/IV

- Generalised Codelist Automation Framework (GCAF) shrinking (displayed on top of each) of codelists with having 15-30 codes.



Results using GCAF on DynAIRx Case-Study

- Comparison of existing codelists used within MLTC research and codes (all based on SNOMED).

Codelists	OPTIMAL	CALIBER	eFI2	AI-MULTIPLY	DynAIRx
Number of Conditions	167	357	77	210	214
Number of Codes	30061	13105	7557	11764	14000
Number of Conditions related to MLTC	129	168	57	203	214
Number of Codes related to MLTC	27828	11738	6948	11287	14000

Results using GCAF on DynAIRx Case-Study

- Conditions with new SNOMED codes added in DynAIRx compared to CALIBER codelists.

Condition Name	Number of New Codes Added	Condition Name	Number of New Codes Added
Abdominal Aortic Aneurysm	8	End Stage Renal Disease	37
Alcohol Problems	55	Fatty Liver	2
Alcohol Problems Others	15	Falls	2
Alcoholic Liver Disease	2	Hypertension	56
Anaemia B12 Deficiency	13	Hypertrophic Cardiomyopathy	4
Anaemia Folate Deficiency	5	Hypotension/Syncope	23
Anaemia Haemolytic	13	Liver Disease - Other	40
Anaemia Iron Deficiency	8	Liver Disease - Unknown	2
Anaemia Other	25	Liver Disease - Viral	32
Anxiety	16	Migraine	7
Asthma	36	OCD	6
Back pain	78	Osteoporosis	39
Benign	33	Peptic ulcer Disease	34
Bronchiectasis	22	Peripheral Neuropathies	83
Cataract	14	Polycystic Ovarian Syndrome	2
Chronic Dermatitis Eczema	44	Polycythaemia vera	6
Chronic Tinnitus	10	Psychoactive Substance Misuse	27
Chronic Urticaria	28	Pulmonary Fibrosis	2
CKD	15	Renal Stones	78
Cystic fibrosis	86	Sick sinus Syndrome	3
Depression	62	Sickle cell anaemia	17
Dilated Cardiomyopathy	4	Thyroid Problem	79

Results using GCAF on DynAIRx Case-Study

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Section III/IV

- Table displays the type and time investment of clinicians for the development and validation of codelists generated in DynAIRx, using GCAF.

- In these clinical meetings we covered simple codelists codelists in Phase-1, then complicated ones Phase-2, Phase-3, and Phase-4.

No.	Feedback	Expertise	Number of Experts	Total Duration	GCAF Module
1	Add comments like keep, group, and split for condition names (no SNOMED codes)	Clinical Pharmacist	1	2-3 hours	Clinician's Intervention
2	Feedback on condition names splitting and grouping before generation of automated codelists (no SNOMED codes)	Clinical Pharmacist	1	1-2 hours	Clinician's Intervention
3	Reviewing codes for partially shrunk codelists	Experts from Mental Health,Primary Care, Pharmacy, and General Practitioner (Part-1)	4	1 hour	Clinician's Validation
4	Reviewing codes for partially shrunk codelists	Experts from Mental Health,Primary Care, Pharmacy, and General Practitioner (Part-2)	4	1 hour	Clinician's Validation
5	Reviewing codes for partially shrunk codelists	Experts from Mental Health,Primary Care, Pharmacy, and General Practitioner (Part-3)	4	1 hour	Clinician's Validation
6	Reviewing codes for partially shrunk codelists	Experts from Mental Health,Primary Care, Pharmacy, and General Practitioner (Part-4)	4	1 hour	Clinician's Validation
Total Time Required by Clinicians = after applying proposed GCAF Automation				**7-9 hours**	

Section IV/IV

- Conclusion and Future Work

Conclusion and Future Work

- Contributions Summary:
  - Design of a Codelist Generation Framework, applicable to any codelist generation task
  - Reduce clinical validation effort significantly.
  - Generation of large codelists for the DynAIRx case-study, for preprocessing different cohorts on CPRD.
  - Comprehensive evaluation on codelist generation a reduction in clinicians' workload in generating and validating codes.
  - Releasing codelists and making the Generalised Codelist Automation Framework "GCAF" (Python Repository) publicly available for codelist generation.

- In this work, a codelist (~210 conditions) with ≈ 14000 items was compiled using only 7–9 hours of clinicians' time by employing the proposed framework, and more than 80% of the codes were generated and validated using the framework before clinical validation.

- Publicly Available GitHub Repositories for any Future Project:
  - 1. Codelist Generation Framework: https://github.com/DynAIRx/GCAF_DynAIRx
  - 2. DynAIRx Codelists https://github.com/DynAIRx/Codelists_DynAIRx
  - 3. Paper: An Automation Framework for Clinical Codelist Development Validated with UK Data from Patients with Multiple Long-term Conditions | medRxiv

- This work will be utilised in preprocessing data, extract patient trajectories, and ultimately train AI models for NIHR DynAIRx Medication Optimisation

Conclusion and Future Work

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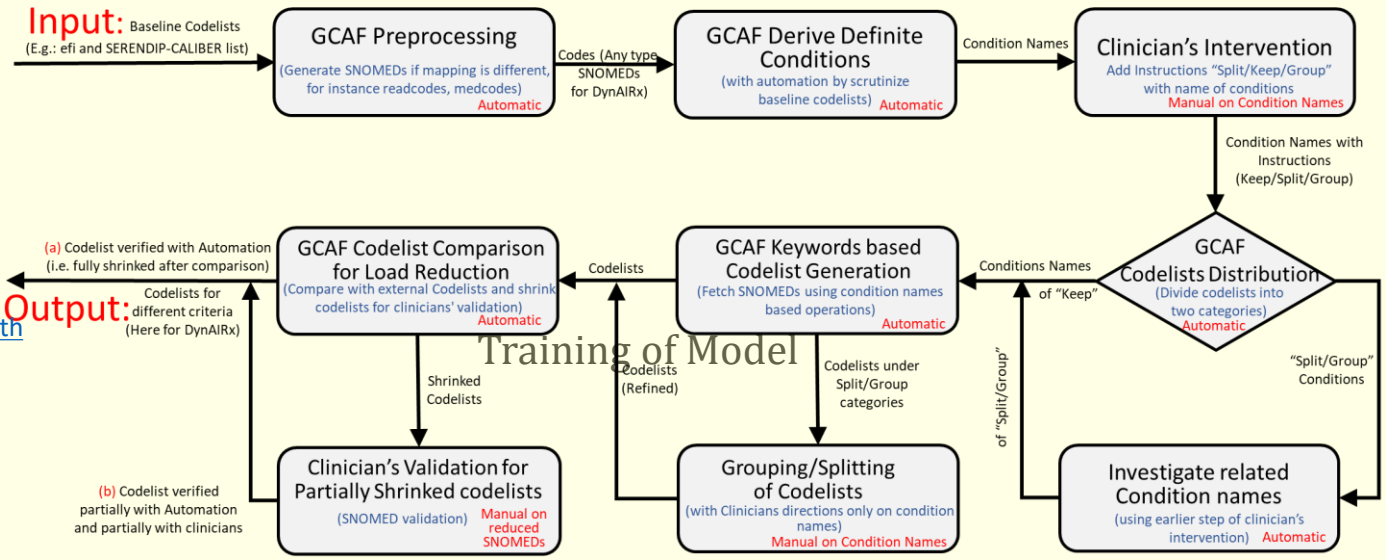
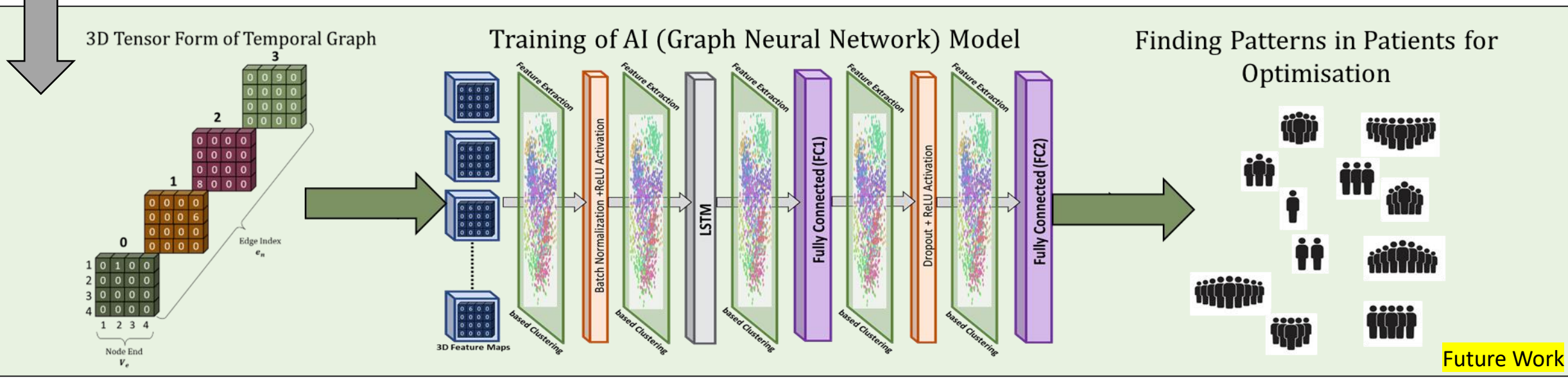
Generalised Codelist Automation Framework (GCAF)

Links:

- Codelist Generation Framework: https://github.com/DynAIRx/GCAF_DynAIRx
- DynAIRx Codelists https://github.com/DynAIRx/Codelists_DynAIRx
- Paper: An Automation Framework for Clinical Codelist Development Validated with UK Data from Patients with Multiple Long-term Conditions | medRxiv



Pre-processed Data using Generated Codelists



- Documented Codelists on GitHub:

https://github.com/DynAIRx/Codelists_DynAIRx

Codelists_DynAIRx Public

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main | 2 Branches | Tags | Go to file t | Add file | Code

AsraAslam7 bmi obesity updated 27e3fb5 · 2 weeks ago 7 Commits

codelists	bmi obesity updated	2 weeks ago
LICENSE	Initial commit	last month
README.md	codelists updated	last month

README | BSD-3-Clause license

Codelists DynAIRx

Introduction

These **codelists** are part of DynAIRx Project. DynAIRx has been funded by the National Institute for Health and Care Research (NIHR) Artificial Intelligence for Multiple Long-Term Conditions (AIM).

Collaboration This NIHR Funded project is collaboration of University of Manchester, University of Leeds, University of Liverpool, Merseycare NHS, Wales Powys Teaching Health Board, and University of Glasgow, UK.

About DynAIRx DynAIRx (Artificial Intelligence for dynamic prescribing optimisation and care integration in multimorbidity) aims to develop new, easy to use, artificial intelligence (AI) tools that support General Practitioners (GPs) and pharmacists to find patients living with multimorbidity (two or more long-term health conditions) who might be offered a better combination of medicines.

Pleaase use this link to know more about DynAIRx.

Codelists

This repository contains codelists (consisting of SNOMEDs) of ~260 coditions. Mappings from SNOMEOs to ReadCode, MedCode or any other codes are avaliable in DynAIRx framework. These lists are compiled mainly with

About

No description, website, or topics provided.

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- Documented Codelist Generation Framework on GitHub:

https://github.com/DynAIRx/GCAF_DynAIRx

GCAF_DynAIRx Public

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AsraAslam7 format a bit — 34b1233 · last month — 30 Commits

Input	renaming	2 months ago
Intermediate_Input_Output	almost completed	2 months ago
Output	almost completed	2 months ago
helper codes additional	image relocation	2 months ago
others	image relocation	2 months ago
Clincians_Intervention_Split_Keep_Group.xlsx	module 4 added	2 months ago
GCAF_Codelist_Comparison_for_Load_Reducti...	shrinking added completed	2 months ago
GCAF_Derive_Definite_Conditions.ipynb	almost completed	2 months ago
GCAF_Investigate_Related_Condition_Names.ip...	completed all codes	2 months ago
GCAF_Keywords_based_Codelist_Generation.ip...	almost completed	2 months ago
GCAF_Preprocessing.ipynb	almost completed	2 months ago
GCAF_codelist_Distribution.ipynb	almost completed	2 months ago
LICENSE	Create LICENSE	last month
README.md	format a bit	last month

README | BSD-3-Clause license

GCAF_DynAIRx

Introduction

This repository is designed for Generalised Codelist Automation Framework (GCAF). It is part of DynAIRx Project

About

No description, website, or topics provided.

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Languages

Jupyter Notebook 100.0%

- Documented Codelist Generation Framework on GitHub: https://github.com/DynAIRx/GCAF_DynAIRx

GCAF_DynAIRx

Introduction

This repository is designed for Generalised Codelist Automation Framework (GCAF). It is part of DynAIRx Project (NIHR funded). It consist of multiple Python Jupyter Notebooks that perform specific tasks of modules of GCAF shown Figure below:

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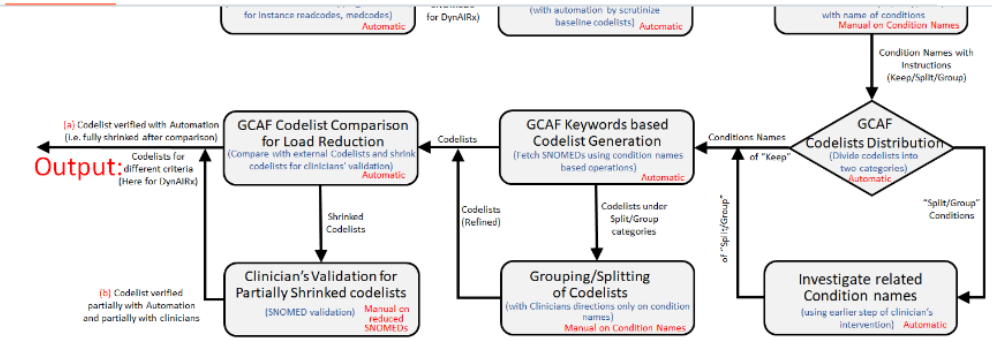

Requirements

- Python (for development). If you dont have Python, you can install using https://www.python.org/downloads/
- Jupyter Notebook (for practice / run directly)

How do I run these scripts?

- Run Jupyter Notebooks directly for conversions (For example CVT_to_SNOMED). You will be able to see results (expected) of each cell just by clicking on Run button

Modules

- `GCAF_Preprocessing.ipynb` This file is performas task of module GCAF Preprocessing. It is performing ReadCode to SNOMED for baseline-1 codelist.
- `GCAF_Derive_Definite_Conditions.ipynb` This file is performas task of module GCAF Derive Definite Conditions. The purpose of this module is to scan all input codelist, perform text operations on condition names, and generate a list of definitive conditions.
- `Clincians_Intervention_Split_Keep_Group.xlsx` This file is for module Clinical Intervention. Tis fiel consist of guidance comments on which clinical concepts in the codelist need to be split and which to be grouped or merged based on the specific usecase of the project.
- `GCAF_codelist_Distribution.ipynb` This file is performas task of module GCAF Codelists Distribution. On the basis of the clinicians' comments, this module distribute conditions into different types: keep comments type and Group/Split type comments.
- About `GCAF_Investigate_Related_Condition_Names.ipynb` This file is performas task of module Investigate related condition names. This module focuss on concepts where the clinical team indicated the need for merging or splitting to produce a potential list of concepts we need to capture.
- About `GCAF_Keywords_based_Codelist_Generation.ipynb` This file is performas task of module GCAF Keywords based Codelist Generation. This automated phase performs a keyword search across the preprocessed codelists (using terms from the previous step), fetching the associated SNOMED codes, and generating draft codelists for
- About `GCAF_Codelist_Comparison_for_Load_Reduction.ipynb` This file is performas task of module GCAF Codelist Comparison for Load Reduction. This module automatically validate codes using a trusted source (CALIBER for DynAIRx) and reduce loads for clinicans for reducing need to validate all codes. I produce Fully shrunk or partially shrunk codelists to validate.
- Please note Modules Grouping/Splitting of Codelists, Clinician's Validation of Partially Shrunken codelists, and Clinician's Validation of Partially Shrunken codelists are manual, detailed in paper.

Useful Files

- About `Multimorbidity_Codelist_16.11.2021.xlsx` Mapping file for ReadCode to SNOMED used in abaseline codelists. Mapping file downloaded by Asra using website `NHS Data Migration - TRUD (digital.nhs.uk)`
- About `Baseline1_Codelist.csv` The LW codelists are from previous CPRD-based projects at Liverpool (details TBC). These appear to be in CTV3 (aka Read Code v3) format so they gets translated to SNOMED using a mapping file avaliable on the NHS TRUD website.
- About `Baseline2_Codelist.csv` The eFI refers to the electronic Frailty Index - a very successful clinical tool that has been deployed in all major GP systems. Sam Relton and Andy Clegg are currently finishing off the eFI2 project which expands upon this initial work to build prediction models. The SNOMED codes here are the basis of that work, used to define 80 long-term conditions that are used to predict mortality, hospitalisation with a fall, requirement for a homecare package, and nursing home admission (all measured as binary outcomes within the next 12 months).

Codelists

- **Where can I find generated codelists?**
  As this is Generalized framework which can be used for any project to generate codelists, we uploaded DynIARx generated codelists in separate repository. Please use this link for downloading all DynAIRx Codelists.

Citation

Thank you for listening!

Questions?

Publicly Available GitHub Repositories:

1. Codelist Generation Framework: https://github.com/DynAIRx/GCAF_DynAIRx
2. DynAIRx Codelists https://github.com/DynAIRx/Codelists_DynAIRx
3. Paper Link: An Automation Framework for Clinical Codelist Development Validated with UK Data from Patients with Multiple Long-term Conditions | medRxiv

1	Abdominal Aortic Aneurysm	COPD: Chronic Obstructive Pulmonar	Hyposplenism	Renal and Bladder Stones
2	Abdominal Hernia	Chronic Pancreatitis	Hypotension_syncope	Renal Stones
3	Acne	Chronic Sinusitis	Immunodeficiencies	Requirement for care
4	Actinic keratosis	Chronic Tinnitus	Inflammatory arthritis	Respiratory failure
5	Activity limitation	Chronic Urticaria	Interstitial lung disease	Rheumatic heart disease
6	Alcohol Problems Others	chronic_constipation	Ischaemic Heart Disease History	Rheumatoid Arthritis
7	Alcohol Problems	CKD	Ischaemic Heart Disease	Rosacea
8	Alcohol-related Brain Injury	Coeliac Disease	Learning Disability	Sarcoidosis
9	Alcoholic Liver Disease	Colonic polyp	Liver Disease - Other	Schizoaffective
10	Allergic And Chronic rhinitis	Complex pain syndrome	Liver Disease - Unknown	Scoliosis
11	Alopecia Areata	Cystic fibrosis	Liver Disease - Viral	Secondary Polycythaemia
12	Alopecia	Dementia	Lupus Erythematosus	Seizure Disorders
13	Anaemia B12 Deficiency	Depression	Macular Disorders	Self-harm
14	Anaemia Folate Deficiency	Dermatitis atopic contact	Meal preparation problems	Shopping problems
15	Anaemia Haemolytic	Diabetes Mellitus	Medication management problems	Sick sinus Syndrome
16	Anaemia Iron Deficiency	Diabetes Neuropathy and Peripheral	Memory concerns	Sickle cell anaemia
17	Anaemia Other	Diabetic Eye Disease	Meniere Disease	Sjogren Disease
18	Angina	Diabetic Renal Complications	Menorrhagia and Polymenorrhea	Skin ulcer
19	Ankylosing Spondylitis	Dilated Cardiomyopathy	Migraine	Sleep apnoea
20	[illegible]rectal Prolapse	Diverticular Disease	Mobility problems	Sleep problems
21	[illegible]	[illegible]ess	Motor Neurone Disease	Smoking
22	[illegible]	[illegible]e	Multiple Sclerosis	Social vulnerability
23	[illegible]	[illegible] problems	Musculoskeletal problems	Spina bifida
24	Asbestosis	Dysmenorrhoea	Myasthenia Gravis	Spinal stenosis
25	Asthma	Dyspnoea	Myocardial Infarction	Splenomegaly
26	Atrial Fibrillation History and Monitoring	End Stage Renal Disease	Obesity	Spondylolisthesis
27	Atrial Fibrillation	Endometrial Hyperplasia and Hyperti	Obstructive Sleep Apnoea	Spondylosis
28	Attention Deficit Hyperactivity Disorder	Endometriosis	Occupational lung diseases	Stress
29	Autism and Asperger Syndrome	Environment problems	OCD	Stroke - Haemorrhagic Traumatic
30	Autoimmune liver Disease	Erectile Dysfunction	Oesophageal varices	Stroke - Haemorrhagic
31	Autonomic dysfunction	Faecal incontinence	Osteoarthritis	Stroke - Ischaemic and Haemorrhagic
32	Back pain	Falls	Osteoporosis	Stroke - Ischaemic
33	Barrett Oesophagus	Fatty Liver	Palliative care	Stroke - Subarachnoid Haemorrhage
34	Benign	Female genital Prolapse	Parkinson_and_Tremor	Stroke - Subarachnoid Traumatic
35	Bipolar	Fibroids	Peptic ulcer Disease	Stroke - Transient Ischaemic Attack
36	Bladder Dysfunction	Foot problems	Peripheral Neuropathies Excluding C	Subdural Haematoma no-traumatic
37	Body mass index	Fracture	Personality Disorder	Systemic Sclerosis
38	Bone disease	Fragility fracture	Pituitary adenoma	Thalassaemia
39	Bronchiectasis	Gastritis and Duodenitis	Polycystic Ovarian Syndrome	Thrombophilia
40	Cancer Haematological	Gastrooesophageal Reflux Disease	Polycythaemia vera	Thyroid Problem
41	Cancer Solid organ	Glaucoma	Polymyalgia Rheumatica	Toileting problems
42	Cancer	Gout	Primary Idiopathic Thrombocytopae	Tuberculosis
43	Carcinoma in situ_Cervical	Headache	Primary Pulmonary hypertension	Urinary system disease
44	Cataract	Hearing Loss	Problems managing finances	Urinary_Incontinence
45	Cerebral palsy	Heart Failure	Prostate Disorder	Urolithiasis
46	Cholelithiasis	Heart_block	Psoriasis	Uterovaginal Genital Prolapse
47	cholesterol	HIV	Psoriatic Arthropathy	Vitiligo
48	cholesterol_hdl	Housebound	Psychoactive Substance Misuse	Washing & bathing problems
49	cholesterol_hdl_ratio	Hyperparathyroidism	Pulmonary Fibrosis	Weakness
50	cholesterol_ldl	Hypertension	Pulmonary hypertension	Weight loss
51	Chronic Dermatitis Eczema	Hypertrophic Cardiomyopathy	Raynaud Syndrome	