**Intended use and implementation instructions for the eFI2 and eFalls**

**Contact info**

Prof Andrew Clegg

Academic Unit for Ageing and Stroke Research

Leeds Institute of Health Sciences

University of Leeds

Bradford Institute for Health Research

Bradford

BD9 6RJ

Email: [a.p.clegg@leeds.ac.uk](mailto:a.p.clegg@leeds.ac.uk)

Dr Kate Best (eFI2 lead)

Academic Unit for Ageing and Stroke Research

Leeds Institute of Health Sciences

University of Leeds

Bradford Institute for Health Research

Bradford

BD9 6RJ

Email: [k.e.best@leeds.ac.uk](mailto:k.e.best@leeds.ac.uk)

Dr Samuel Relton (eFI+ lead)

Health Services Research Division

Leeds Institute of Health Sciences

University of Leeds

Woodhouse Lane

Leeds

LS2 9JT

Email: s.d.relton@leeds.ac.uk

**Intended use**

The eFI2 is an algorithm and corresponding code list, developed by researchers. The eFI2 uses information on existing health deficit variables (signs, symptoms, diseases, disabilities, impairments) to predict the risk of an individual experiencing any of four frailty-related outcomes within the next 12 months (new home care requirement; emergency department attendance/hospitalisation with fall/fracture; care home admission; mortality). The level of risk of experiencing the outcomes is then transformed into an overall eFI2 score, which is used to construct frailty categories (fit; mild frailty; moderate frailty; severe frailty).

The intended use of the eFI2 is as a population risk stratification tool which identify groups of patients likely to be living with varying degrees of frailty or at risk of frailty-related outcomes. It is not designed to assign individual frailty diagnosis, which should be based on clinical assessment and judgement having been identified by the tool.

Additionally, compared with the original eFI, the changes made through the assignment of weights to individual variables, the addition of time constraints to some variables, the updated list of variables included and the refinement of category cutpoints means that clincians should expect differences between the eFI and eFI2 in terms of patients identified within the mild, moderate and severe frailty categories. Therefore, the eFI2 should be used in combination with clinical assessment and judgment to confirm a diagnosis or treatment plan, aligned with earlier guidance developed in collaboration with NHS England on use of the original eFI. Specifically the eFI2 should not be used to automatically assign a frailty ‘diagnosis’ (mild frailty, moderate frailty, severe frailty), including through the use of ‘batch coding’.

The eFI+ in an incorporated set of four algorithms that separately predict the risk of each of the individual frailty-related outcomes:

1. New home care requirement
2. Emergency department attendance/hospitalisation with fall/fracture
3. Care home admission
4. Mortality.

The absolute risk of experiencing each outcome, expressed as a percentage, is calculated by each eFI+ algorithm.

The intended use of the eFI+ risk prediction models is to identify people at increased risk of experiencing the four outcomes so that they can be identified for consideration for particular interventions (e.g. referral for falls prevention intervention for people identified as at increased risk of falling). Pre-specified thresholds for low, medium and high risk are not set – instead the risk thresholds for action should be agreed by local clinicians and commissioners based on local context. We recommend clinical judgement is used before deciding whether or not to offer intervention.

In these instructions, only the eFI+ falls alogorithm (known as eFalls) is provided. Please contact the authors for further information on the other eFI+ algorithms.

**Implementation instructions**

**The eFI2 and eFI+ code list**

The full eFI2 code list, used for both the eFI2 and separate eFI+ algorithms, contains 7555 unique SNOMED CT codes (or equivalent CTV3 or Read 2 codes) that are organised into 79 health deficit variables. Seventy-five of the variables are binary (e.g. asthma, ischaemic heart disease, dementia), three of the variables are ordinal categorical variables (Alcohol intake, BMI, smoking status) and one is numeric (polypharmacy). The full eFI2 code list is also available in Clinical Terms Version 3 (CTV3) and Read 2 versions. Examples of five rows from the eFI2 code list, corresponding to five different codes for five different deficits are shown in Table 1. We only recommend using the specified codes, and not any higher level parent codes as indicating all child codes should be included

A deficit is generally defined as being present if one or more of the eFI2 codes for that deficit are identified in the EHR. For example, Ischaemic Heart Disease would be defined as being present if the SNOMED CT code ‘810681000000101’ was recorded in a patients EHR. However, there are some variables that are additionally defined based on numeric values of lab results. For example, COPD should be coded as present if the number of exacerbations are recorded (SNOMED CT 41488207- see Table 1) and the numeric value corresponding to the code is >0. In general the thresholds for any numeric values are provided in the ‘Other instructions’ column of the eFI2 codelist.

For non-binary variables, ‘other instructions’ also shows which SNOMED (or CTV3/Read 2) codes should be assigned to categories (Alcohol, BMI, smoker deficits),

The eFI2 code list also features columns detailing additional rules for certain deficits/ codes: ‘Time constraint’, ‘Age limit’ (See Table 1). The ‘Time constraint’ column should be used to restrict the code to those that have occurred with the listed number of years prior to the date of estimating the eFI2 score or eFI+ risk. The ‘Age limit’ should be used to restrict the codes to those that occurred only after the patient was the listed number of years old.

Table 1 Example rows from the eFI2 code list

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Deficit variable** | **SNOMED CT code** | **CTV3 code** | **Text description** | **Time Constraint (years)** | **Age limit (years)** | **Other instructions** |
| Alcohol | 160577002 |  | Heavy drinker - 7-9u/day | 5 |  | Harmful drinking |
| Anaemia & haematinic deficiency | 161455008 | 145.. | H/O: blood disorder (& [anaemia]) | 5 |  | Anaemia deficit (i.e. all codes) resolve if there is a normal lab Hb following initial diagnosis |
| Asthma | 161527007 | 14B4. | H/O: asthma |  | 18 |  |
| Ischaemic heart disease | 810681000000101 | XaYYq | Coronary microvascular disease |  |  |  |
| COPD | 414882007 |  | Number of chronic obstructive pulmonary disease exacerbations in past year (finding) |  |  | If greater than 0 |

Note that not all variables are used in the eFI2 and eFI+ algorithms individually but they are all used in at least one algorithm. Some deficits are handled differently in the eFI2 compared to the eFI+**.**

**Some of the deficits have slightly complicated coding procedures, which are outlined below:**

***Please note that examples are given in reference to SNOMED CT codes, but the same rules will apply for READ v2 or CTV3 codes***

**Alcohol**

Alcohol is coded into six categories: (zero, previous harmful, lower, higher, harmful, missing). Alcohol intake is defined according to SNOMED CT codes (e.g. Harmful: SNOMED CT=420054005 corresponding to “Alcoholic cirrhosis of liver”) or according to a numeric value describing the number of units per week. The numeric weekly units should be coded as follows: 0 = code as zero alcohol; 1-20 = code as lower risk drinking; 21-48 = code as higher risk drinking; 49+ = code as harmful drinking. Where units per day (as opposed to per week) are recorded, these should be multiplied by 7 prior to categorisation. Where a SNOMED CT code is not present and there in no numeric value for units per week, the alcohol intake for the patient should be set to missing.

A patient’s final alcohol categorisation is taken as the highest intake category obtained over the last 5 years (as opposed to using only the latest value). For example, a patient with ‘higher’ intake coded on 10/9/20 and ‘zero’ intake on 10/9/23 will be coded as ‘higher’. Where a patient has a code representing previous harmful drinking (SNOMED CT= 160584005 corresponding to “Ex-moderate drinker - (3-6u/d)”), then this patient will be classed as a previous harmful drinker, unless they go on to have a ‘harmful’ code recorded thereafter.

**Hypertension and Hypotension**

Hypertension should be coded as present if any of the Hypertension SNOMED CT codes are recorded (ever) in the medical records of a patient (e.g. SNOMED CT= 302192008- “On treatment for hypertension”). Hypertension should also be coded based on numeric blood pressure recordings, but only if there are three or more values (ever) recorded that exceed 140 systolic or 90 diastolic. Note that the three readings cannot be a combination of diastolic OR systolic readings over the threshold. For example a patient with only two systolic measurements >140 and one diastolic measurement >90, should not be coded as having hypertension.

Additionally, hypertension should still be coded as present even if there was a ‘normal’ reading at some point between the three abnormal readings. However, SNOMED CT codes that represent average blood pressure readings (e.g. 24 hour average) can be recorded as hypertension based on one average, there do not need to be three average measurements recorded to code as hypertension.

Hypotension should be coded as above where blood pressure measures fall below 90 systolic or 60 diastolic on three occasions (ever).

**Body mass index (BMI)**

BMI should be coded as underweight, recommended weight, overweight, obese or missing. Coding can be based either on recorded SNOMED CT codes (e.g. underweight= SNOMED CT 310252000- “Body mass index less than 20”) or via classification of a numeric recorded value of BMI: underweight (<18.5kg/m2), recommended weight (18.5-24.9kg/m2), overweight (<25.0-29.9-kg/m2), obese (≥30kg/m2). The category corresponding to the most recent measurement or SNOMED CT code entry should be used. Note that BMI can be calculated based on separate height and weight recording if necessary (Weight in Kg/ (Height in meters)2). Where there are no SNOMED CT codes recorded and no numeric values for BMI or height and weight, BMI should be categorised as missing.

**Smoking status**

Smoking status should be categorised as Ex, Current, None/missing, based on the presence or absence of SNOMED CT codes (i.e. no numeric information is used). A patient should be coded as none (smoking)/ missing if they have no smoking SNOMED CT codes recorded in their record. Note that a patient with a preceding Ex-smoking code followed by a current smoking code should be coded as a current smoker.

**Polypharmacy**

Polypharmacy should be calculated as a numeric variable, representing the number of medications from different BNF 2017-18 sub-sub-chapters prescribed in the previous 90 days (see separate BNF chapters table for further information on medication definition and included/excluded BNF chapters). As an example, if a patient is prescribed cimetidine (BNF 1.3.1), lansoprazole (BNF 1.3.5), bendroflumethiazide (BNF 2.2.1) and tiotropium (BNF 3.1.2) their polypharmacy should be coded as ‘4’. Note that the eFI+ used polypharmacy as a continuous numeric variable, whereas the eFI2 requires polypharmacy to be categorised as follows: 0-4, 5-9, 10+.

**Anaemia and haematinic deficiency**

Anaemia and haematinic deficiency should be coded based on the presence of a SNOMED CT code (e.g. SNOMED CT 310647000 – “Anaemia secondary to renal failure” or based on numeric Hb levels above the thresholds shown below (taken from Oxford Handbook of Clinical & Laboratory Investigations:

males use <13.0 g/dL or >25.0 g/dL; or <130 g/L

females use <11.5 g/dL or >25.0 g/dL, <115 g/L

Note that the thresholds should but used according to whether the measurement is specified as g/dL to g/L (or at least if the measurement is above 75 then it can be assumed the unit of measurement is g/L as opposed to g/dL

Most of the Anaemia codes have a 5 year time constraint. Additionally, for those with and without this time constraint, Anaemia should only be coded where is hasn’t resolved i.e. there is no recording of a ‘normal’ Hb level following the data of the anaemia code.

**Chronic kidney disease**

Chronic kidney disease should be coded as the presence of the relevant SNOMED CT code recorded ever (e.g. SNOMED CT 73211009- “[X]Unspec diab mel + ren compl” or the recording of an abnormal lab result defined below:

|  |  |
| --- | --- |
| Urine total protein measurement | >150mg/24hr |
| Urine protein/creatinine ratio | >50mg/mmol |
| Urine albumin level | >20mg/24hr |
| Urine albumin: creatinine ratio | >3mg/mmol |
| Urine microalbumin level | >3mg/mmol |
| Glomerular filtration rate | < 60 |
| Urine protein/creatinine index | >50mg/mmol |

**Memory problems, Cognitive impairment and Dementia**

An individual cannot have Memory problems, Cognitive impairment and Dementia as active conditions simultaneously. Dementia supersedes Cognitive impairment, and the latter should be set to False for those individuals with Dementia codes in their EHR. Dementia and Cognitive impairment supersede Memory problems, and the latter should be set to false if either Dementia or Cognitive impairment is subsequently coded.

**Additional variables requiring extraction**

For the eFI+ algorithms, information on age (years) and gender will also need to be extracted. In the eFI2, alcohol is dichotomised into harmful vs non-harmful/missing and similarly BMI is dichotomsed into underweight vs not underweight/ missing.

**Target demographics for eFI2 and eFI+**

The statistical models within eFI2 and eFI+ were developed and tested on specific subsets of the population – using the models in other subsets of the population may give unreliable results.

For eFI2, our target demographic is those aged 65 years or older.

For the eFI+ models we have the following target demographics:

* Mortality model – aged 65 years or older
* Falls model – aged 65 years or older
* Home care requirement model – aged 65 years or older with no previous home care package
* Care home admission model – aged 65 years or older with no previous care home admission

**The eFI2 algorithm**

Once the deficits for each patient are identified using the code list, the eFI2 algorithm can be applied to calculate an eFI2 score. Essentially, the eFI2 score is the sum of the transformed coefficients assigned for each deficit (shown in Table 2), where that deficit is present:

**A screenshot of a test

Description automatically generated**

For example, a patient with atrial fibrillation, COPD and Weight loss, zero alcohol intake, recommended BMI, who has been prescribed 4 different medications and is a non-smoker would have their eFI2 frailty score calculated as follows:

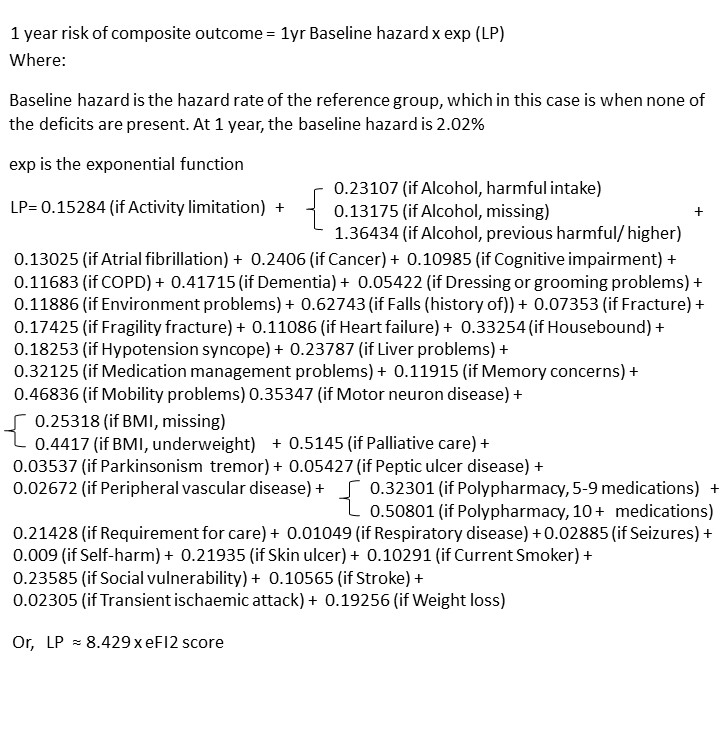
eFI2 score = 0.015 + 0.014 + 0.023

= 0.052

This hypothetical patient with an eFI2 score would be categorised as being robust using the categorisations described in Table 3.

Note that the eFI2 algorithm is derived from a Cox regression model, built to predict time until either hospital admission for a fall or fragility fracture, new/ increased homecare package, admission to a nursing home or mortality. The coefficients were extracted from the model and transformed so that the possible eFI2 score lies between 0 (no deficits) and 1 (all possible deficits). The transformation ensures the new eFI2 has a similar interpretation to the original eFI, which also lies between 0 and 1. Each transformed coefficient was calculated as the original coefficient divided by the highest sum of coefficients possible.

The eFI2 coefficients below are summed up for each individual into a so-called linear predictor (LP) which can be used along with the estimate of baseline hazard, to estimate the risk of the composite outcome occurring by one year:

****

For example, our hypothetical patient a patient with atrial fibrillation, COPD and Weight loss, zero alcohol intake, recommended BMI, who has been prescribed 4 different medications and is a non-smoker their one year risk would be calculated as follows:

1 year risk = 1yr Baseline hazard x exp (LP)

= 0.0202 x exp(0.13025 + 0.234 +0.091)

= 0.031

Meaning the hypothetical patient has a 3.1% risk of the composite outcome in the next 12 months.

More detail on the methodology used to develop and validate the eFalls are available in the published paper: Best K, Shuweihdi F, Alvarez JCB, Relton S, Avgerinou C, Nimmons D, Petersen I, Pujades-Rodriguez M, Conroy SP, Walters K, West RM, Clegg A. Development and external validation of the electronic frailty index 2 using routine primary care electronic health record data. Age Ageing. 2025 Mar 28;54(4):afaf077. doi: 10.1093/ageing/afaf077. PMID: 40163740; PMCID: PMC11957239.

Table 2 eFI2 coefficients and transformed coefficients

|  |  |  |
| --- | --- | --- |
| **Predictor** | **Coefficient** | **Transformed coefficient** |
| **Activity limitation** | 0.15284 | 0.018 |
| **Alcohol, harmful intake** | 0.23107 | 0.027 |
| **Alcohol, missing** | 0.13175 | 0.016 |
| **Alcohol, previous harmful/ higher** | 1.36434 | 0.162 |
| **Atrial fibrillation** | 0.13025 | 0.015 |
| **Cancer** | 0.2406 | 0.029 |
| **Cognitive impairment** | 0.10985 | 0.013 |
| **COPD** | 0.11683 | 0.014 |
| **Dementia** | 0.41715 | 0.049 |
| **Dressing or grooming problems** | 0.05422 | 0.006 |
| **Environment problems** | 0.11886 | 0.014 |
| **Falls (history of)** | 0.62743 | 0.074 |
| **Fracture** | 0.07353 | 0.009 |
| **Fragility fracture** | 0.17425 | 0.021 |
| **Heart failure** | 0.11086 | 0.013 |
| **Housebound** | 0.33254 | 0.039 |
| **Hypotension syncope** | 0.18253 | 0.022 |
| **Liver problems** | 0.23787 | 0.028 |
| **Medication management problems** | 0.32125 | 0.038 |
| **Memory concerns** | 0.11915 | 0.014 |
| **Mobility problems** | 0.46836 | 0.056 |
| **Motor neuron disease** | 0.35347 | 0.042 |
| **BMI, missing** | 0.25318 | 0.030 |
| **BMI, underweight** | 0.4417 | 0.052 |
| **Palliative care** | 0.5145 | 0.061 |
| **Parkinsonism tremor** | 0.03537 | 0.004 |
| **Peptic ulcer disease** | 0.05427 | 0.006 |
| **Peripheral vascular disease** | 0.02672 | 0.003 |
| **Polypharmacy, 5-9 medications** | 0.32301 | 0.038 |
| **Polypharmacy, 10+ medications** | 0.50801 | 0.060 |
| **Requirement for care** | 0.21428 | 0.025 |
| **Respiratory disease** | 0.01049 | 0.001 |
| **Seizures** | 0.02885 | 0.003 |
| **Self-harm** | 0.00900 | 0.001 |
| **Skin ulcer** | 0.21935 | 0.026 |
| **Smoker current** | 0.10291 | 0.012 |
| **Social vulnerability** | 0.23585 | 0.028 |
| **Stroke** | 0.10565 | 0.013 |
| **Transient ischaemic attack** | 0.02305 | 0.003 |
| **Weight loss** | 0.19256 | 0.023 |

An eFI2 frailty category is also identified based on the eFI2 score, using the cut-points listed in Table 3.

Table 3 eFI2 cut-points for calculating frailty category (applied to sum of transformed coefficients)

|  |  |
| --- | --- |
| **Frailty category** | **Cut-points** |
| Robust | 0 ≤ eFI2 score < 0.0857 |
| Mild frailty: | 0.0857 ≤ eFI2 score < 0.1624 |
| Moderate frailty: | 0.1624 ≤ eFI2 score < 0.2392 |
| Severe frailty: | 0.2392 ≤ eFI2 score ≤1 |

**The eFI+ algorithms**

The eFI+ algorithms are applied in a similar way to the eFI2. However, the eFI+ also uses information on age and sex, and also includes number of medications as a numeric variable. Age and number of medications are modelled using fractional polynomials.

Each model is a logistic regression. The coefficients below are summed up for each individual into a so-called linear predictor which is then transformed into a probability using the sigmoid function: s(x) = 1/(1+exp(-x)).

For example, let us imagine a female individual aged 70 with 5 medications, who is underweight, never smoked, a lower risk drinker, and has back pain. We can calculate their risk of a fall using Table 4 as follows. The linear predictor is:

L = -5.954459 + 70 \* 0.0415506 + 0.3296295 \* ln((5+1)/10) -0.303708 + 0.4896735+ 0.0498699

L = -3.023169

The resulting probability is:

P = 1/(1+exp(-L)) = 0.0464

The same general approach is used for all four eFI+ prediction models, substituting the relevant coefficients that correspond to each individual predictor (including the intercept term).

More detail on the methodology used to develop and validate the eFalls are available in the published paper and supplementary materials: Lucinda Archer, Samuel D Relton, Ashley Akbari, Kate Best, Milica Bucknall, Simon Conroy, Miriam Hattle, Joe Hollinghurst, Sara Humphrey, Ronan A Lyons, Suzanne Richards, Kate Walters, Robert West, Danielle van der Windt, Richard D Riley, Andrew Clegg, The eFI+ investigators, Development and external validation of the eFalls tool: a multivariable prediction model for the risk of ED attendance or hospitalisation with a fall or fracture in older adults, *Age and Ageing*, Volume 53, Issue 3, March 2024, afae057, <https://doi.org/10.1093/ageing/afae057>

Please contact the authors for further information on the eFI+ alogirthms for mortality, care home admission and new home care requirement.

Table 4 eFI+ falls model (eFalls) coefficients

|  |  |
| --- | --- |
| Predictor | Coefficient |
| Intercept term | -5.954459 |
| Age | 0.0415506 |
| Age^2 |  |
| Age^3 |  |
| Age^(-2) |  |
| Polypharmacy |  |
| Polypharmacy^2 |  |
| Polypharmacy^3 |  |
| ln((Polypharmacy + 1)/10) | 0.3296295 |
| ((Polypharmacy+1)/10)^2 |  |
| Sex – Male |  |
| Sex - Female | -0.303708 |
| BMI - Underweight | 0.4896735 |
| BMI - Normal | 0.2394177 |
| BMI - Overweight | 0 |
| BMI - Obese | -0.0411134 |
| BMI - Missing | -0.1451981 |
| Smoking - Never |  |
| Smoking - Ex |  |
| Smoking - Current | 0.0684529 |
| Alcohol - Harmful | 0.4164064 |
| Alcohol - Higher risk | 0.1549725 |
| Alcohol - Lower risk | 0 |
| Alcohol - Previous higher/harmful | 0.0849676 |
| Alcohol - Zero | 0.0070124 |
| Alcohol - Missing | -0.0679367 |
| Abdominal pain | -0.0641861 |
| Activity limitation | 0.0475092 |
| Anaemia and haematinic deficiency | 0.1733029 |
| Anxiety |  |
| Asthma | 0.0816046 |
| Atrial fibrillation | 0.1519654 |
| Back pain | 0.0498699 |
| Bone disease | -0.0267845 |
| Cancer | 0.0301854 |
| Chronic kidney disease |  |
| Cognitive impairment | 0.1472251 |
| COPD | 0.039956 |
| Dementia | 0.1038111 |
| Depression | 0.1633415 |
| Diabetes Mellitus | 0.0373911 |
| Dizziness | 0.0198363 |
| Dressing and grooming problems | 0.4532777 |
| Dyspnoea |  |
| Environment problems |  |
| Faecal incontinence | -0.071791 |
| Falls | 0.3009161 |
| Fatigue | -0.0635057 |
| Foot problems | 0.0282736 |
| Fracture | 0.1957923 |
| Fragility fracture | 0.2031303 |
| General mental health | 0.0991068 |
| Headache | -0.0149365 |
| Hearing impairment | -0.0168728 |
| Heart failure | -0.0190399 |
| Heart valve disease |  |
| Housebound | 0.2549983 |
| Hypertension | -0.0318888 |
| Hypotension or syncope | 0.0778591 |
| Inflammatory arthritis | 0.0586785 |
| Inflammatory bowel disease | 0.0145135 |
| Ischaemic heart disease |  |
| Liver problems | 0.3803626 |
| Meal preparation problems | -0.140024 |
| Medication management problems | 0.8030273 |
| Memory concerns | 0.2601186 |
| Mobility problems | -0.1310067 |
| Mono or hemiparesis | 0.1020457 |
| Motor neuron disease | -0.1209976 |
| Musculoskeletal problems | 0.0419361 |
| Osteoarthritis | 0.0634073 |
| Osteoporosis | 0.1276254 |
| Palliative care | -0.2353552 |
| Parkinsonism and tremor | 0.2312839 |
| Peptic ulcer disease | 0.0056687 |
| Peripheral neuropathy | 0.0335789 |
| Peripheral vascular disease | 0.0173065 |
| Problems managing finances |  |
| Requirement for care | -0.2177301 |
| Respiratory disease | 0.0132757 |
| Seizures | 0.2571899 |
| Self-harm | 0.1461241 |
| Severe mental illness | 0.0676153 |
| Shopping problems |  |
| Skin ulcer | 0.0746926 |
| Sleep problems | 0.0056967 |
| Social vulnerability | 0.0495075 |
| Stress | -0.0200494 |
| Stroke | 0.0788542 |
| Thyroid problems | -0.0273864 |
| Toileting problems |  |
| Transient ischaemic attack |  |
| Urinary incontinence | 0.0345173 |
| Urinary system disease | 0.0119309 |
| Visual impairment | 0.02332 |
| Washing and bathing problems | -0.1118824 |
| Weakness | -0.0589464 |
| Weight loss | 0.0301414 |