

Dr Foster Population Health Analytics - Risk Stratification and Segmentation Tools

G-Cloud 14 Service Description Document

Risk Stratification Tool



What is risk stratification?

Risk stratification is the concept of applying algorithms to patient data and using historic patterns in the population to make predictions about adverse outcomes at the individual patient level.

How do I access the risk stratification tool?

The risk stratification tool can be accessed through the Telstra Health' Health Information Portal.

What the tool is designed to do?

The tool is designed to support an organisation in the following ways:

- Allows users to determine the risk of an individual patient having an emergency admission within the following 12 months
- Allows users to determine the frailty score of an individual patient, and view monthly trend over time
- Allows users to save a list of patients that they want to 'follow' and will show a historical timeline of a patient's risk month by month
- Allows users to filter patients by ambulatory care sensitive conditions, QOF register entries, risk movement, and search by NHS number

Risk Stratification Tool – ICS or PCN view



The CCG/Federation view provides a high-level summary by CCG/Federation and GP to support decisions on an aggregate level. This is provided for both models within the risk stratification tool.

Current patients in risk bands and 12 month profile of associated admissions (data to 30/09/2021)

Band	No. Patients	No. patients who had an emergency admission	Emergency Admissions	Admitted indicative cost £ (where available)	Av. admissions per admitted patient	Av. cost (£) per person admitted (indicative)	Av. Admissions	Av. cost (£) per admission (indicative)
Very High Risk	1,187	1,050	3,549	12,174,445	3.38	11,595	2.99	3,430
High Risk	8,236	3,789	5,912	17,479,254	1.56	4,613	0.72	2,957
Moderate Risk	30,367	5,389	6,425	12,153,015	1.19	2,255	0.21	1,892
Low Risk	385,910	4,496	4,771	6,801,182	1.06	1,513	0.01	1,426
NA	4,657	0	0	0	0.00	0	0.00	0

Risk Stratification Tool – GP view



The GP view provides flexibility for the user to select patients that meet a specific criteria and provides a patient level view of their key demographics, risk score and frailty score.

Filters

- Risk of emergency admission (next year)
- Risk movement
- Frailty level
- Frailty movement
- Gender
- Age band
- Deprivation level
- ACS Condition
- QOF Registers
- A&E attendances in the last 12 months
- Emergency admissions in the last 12 months
- Long term care plan
- Care Home
- Patient cohort
- Number of LTCs (long term conditions)
- High alcohol consumption

Risk Overview

Risk Stratification

SEARCH

Search by NHS Number

FILTERS

Risk of emergency admission (next year)

All

Risk movement

All

Frailty level

All

Frailty movement

All

Gender

All

Age band

All

Deprivation level

All

ACS Conditions (SUS)

All

QOF Registers (primary care)

All

A&E attendances in the last 12 months

All

Emergency admissions in the last 12 months

All

Long term care plan

All

In care home

All

RESET

APPLY

Risks of emergency admission in the next 12 months

62

265

808

7660

61

Very High

High

Moderate

Low

NA

Frailty

76

184

383

564

7649

Severe

Moderate

Mild

Fit

NA

8856 patients found

First

Previous

1

2

3

4

5

...

1156

Next

Last

*****	▲ Female, age 90, Q4 Above average deprivation	Long term care plan	Severe frailty: 61% No change on last month	Very high risk of admission: 97% 3% increase on last month	⚙️
*****	Female, age 85, Q2 Below average deprivation	Long term care plan	Severe frailty: 47% No change on last month	Very high risk of admission: 89% 7% decrease on last month	
*****	▲ Female, age 90, Q5 Most deprived deprivation	Long term care plan	Severe frailty: 47% No change on last month	Very high risk of admission: 87% 6% increase on last month	⚙️
*****	Female, age 85, Q2 Below average deprivation	Long term care plan	Mild frailty: 17% No change on last month	Very high risk of admission: 77% 10% increase on last month	
*****	Female, age 90, Q2 Below average deprivation	Long term care plan	Moderate frailty: 28% No change on last month	Very high risk of admission: 77% 11% decrease on last month	
*****	▲ Male, age 90, Q2 Below average deprivation	Long term care plan	Severe frailty: 44% No change on last month	Very high risk of admission: 73% 16% increase on last month	⚙️
*****	Female, age 85, Q2 Below average deprivation	Long term care plan	Mild frailty: 17% No change on last month	Very high risk of admission: 73% 13% increase on last month	
*****	▲ Male, age 5, Unknown deprivation		N/A frailty N/A	Very high risk of admission: 70% 25% increase on last month	⚙️

Risk Stratification Tool – GP view



Contact History

Users are able to view a patient's timeline which shows a full linked history of their interactions with secondary and primary care data.



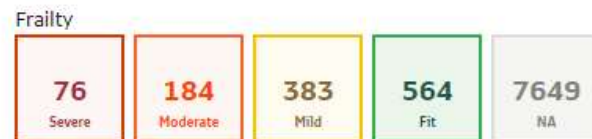
Risk History

Users have the ability to view a patient's risk history with the option to overlap both indicators or to select just one.



Electronic Frailty Index (EFI)

- We worked together with the author of the original algorithm and the Dr Foster Unit at Imperial College to improve the algorithm.
- The eFI score is calculated as the proportion of the total 36 deficits. All deficits are based on primary care data:
 - Diagnoses and procedures
 - Historical events
 - Medical tests
 - Medications
- Elderly patients (aged over 65 years) are stratified into four frailty groups:
 - Severe frailty - eFI score > 36%;
 - Moderate frailty - eFI score between 25% and 36%;
 - Mild frailty - eFI score between 13% and 24%;
 - Fit <= 12%.



Activity limitation
 Anaemia and haematinic deficiency
 Arthritis
 Atrial fibrillation
 Cerebrovascular disease
 Chronic kidney disease
 Diabetes
 Dizziness
 Dyspnoea
 Falls
 Foot problems
 Fragility fracture
 Hearing impairment
 Heart failure
 Heart valve disease
 Housebound
 Hypertension
 Hypotension/syncope
 Ischaemic heart disease

Memory and cognitive problems
 Mobility and transfer problems
 Osteoporosis
 Parkinsonism and tremor
 Peptic ulcer
 Peripheral vascular disease
 Polypharmacy
 Requirement for care
 Respiratory disease
 Skin ulcer
 Sleep disturbance
 Social vulnerability
 Thyroid disease
 Urinary incontinence
 Urinary system disease
 Visual impairment
 Weight loss and anorexia

Emergency admissions algorithm - overview



Overview:

- We have developed a model that allows GPs to identify patients with a high risk of having an emergency admission in the next 12 months
- It allows them to assess the needs of their local population and identify patients that would benefit from a targeted approach

Approach:

- Links primary and secondary care data to develop custom features that are likely to influence the risk of an emergency admission
- Uses a Machine Learning algorithm to predict patient-level risks and identify the most important factors from a large set of variables

Outputs:

- Predictions are obtained at patient-level and are aggregated into risk groups to provide system-level insights
- Feeds into a larger population health offering which surfaces patient-level risk scores and defines risk groups and their characteristics

Dr Foster Model – Feature engineering



Approach:

- **Developed features covering the following areas:**
 - Patient demographics
 - Utilisation variables
 - Clinical variables – data-driven
 - Clinical variables – knowledge-based
- **Features are calculated across different time periods (3 months, 1 year, 2 years, 3 years)**
- **Used an iterative approach to identify the features that are most relevant**

	SUS model	SUS and GP model
Initial model with no multiple lags	111	139
Model with no multiple lags reduced	76	70
Reduced model with multiple lags added	88	73
Model with multiple lags reduced	62	47

Demographic variables

Age
Gender
Deprivation

Utilisation variables - secondary care

Number of emergency spells
Number of emergency episodes
Total bed days
Total waiting time in A&E
Number of A&E visits arriving by ambulance
Number of outpatient appointments (attended, DNA)
...

Utilisation variables – primary care

Number of GP appointments
...

Clinical variables – primary care

Flag for QOF conditions (e.g. Asthma, COPD, Diabetes, Hypertension, Stroke)
Number of long-term conditions
Number of unique medications
Electronic Frailty Index (eFI)
...

Clinical variables – secondary care

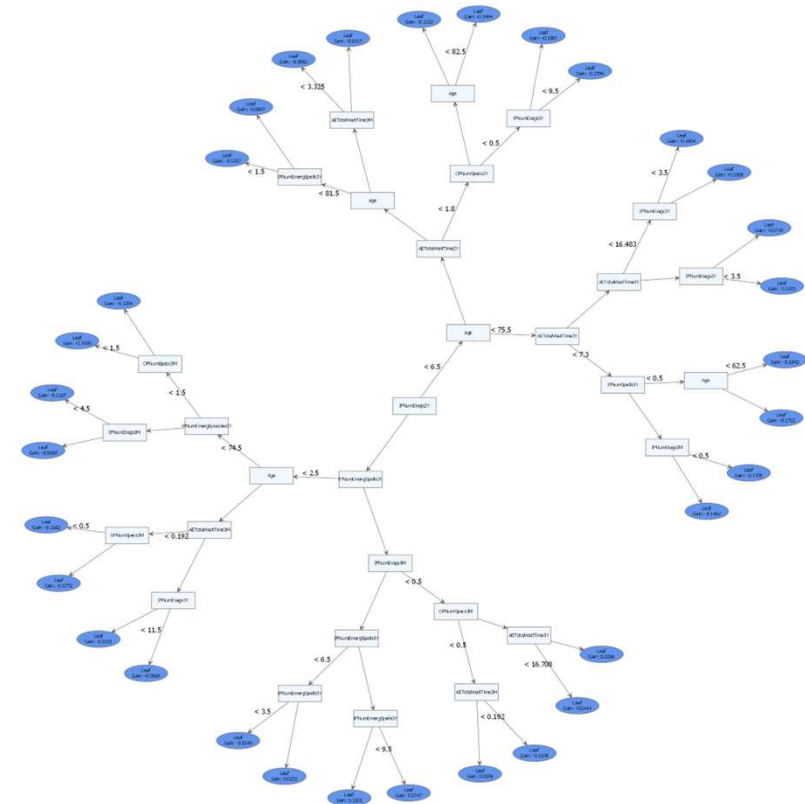
Number of distinct diagnoses
Number of distinct procedures
Flags for clinical groupings (e.g. Asthma, COPD, Diabetes, Stroke)
...

Dr Foster Model – Gradient Boosted Trees

- **Gradient boosted trees** is a tree-based machine learning algorithm that constructs multiple trees based on subsets of data
- With each iteration, it attempts to correct the errors from prior iterations, thus continuously **improving the overall accuracy** of the model
- Rather than averaging the results of decision trees (“bagging”) as in random forests, each tree is trained iteratively (“boosting”)

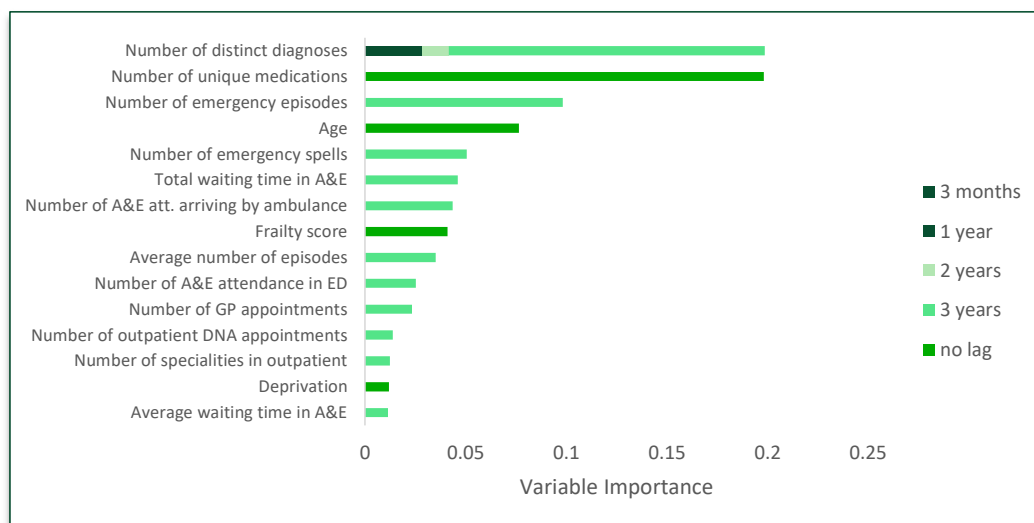
Gradient Boosted trees help us predict **more accurate risk scores for patients** by:

- Calculating scores on hundreds of models
- Identifying relevant input factors
- Determining sensible categories within a variable



Dr Foster model - Benefits

- Based on linked primary and secondary care data
- Healthcare domain expertise used to define features and clinical groupings
- Used a Machine Learning algorithm (Gradient Boosted Trees) to identify the most important features from a large set of variables
- Features are calculated across different time periods



Demographic variables
Age
Gender
Deprivation

Utilisation variables - secondary care
Number of spells
Number of emergency spells/episodes
Number of long LOS spells
Average number of episodes
Number of day cases
Total bed days/ bed days post-op
Total/average waiting time in A&E
Number of A&E visits/ arriving by ambulance/with incidence location public place
Number of A&E visits referred to other provider/admitted
Number of outpatient appointments (attended, DNA, first, face-to-face, proportion of first attendances)
Number of specialties in outpatient/inpatient

Clinical variables – primary care
Flag for QOF conditions (COPD, Dementia, Diabetes, Palliative Care)
Psychoactive substance misuse disorder diagnosis
Number of long-term conditions
Number of unique medications
Electronic Frailty Index (eFI)

Clinical variables – secondary care
Number of distinct diagnoses
Number of distinct procedures
Flags for clinical groupings (Diabetes, IBD, Peripheral Artery Disease)

Utilisation variables – primary care
Number of GP appointments

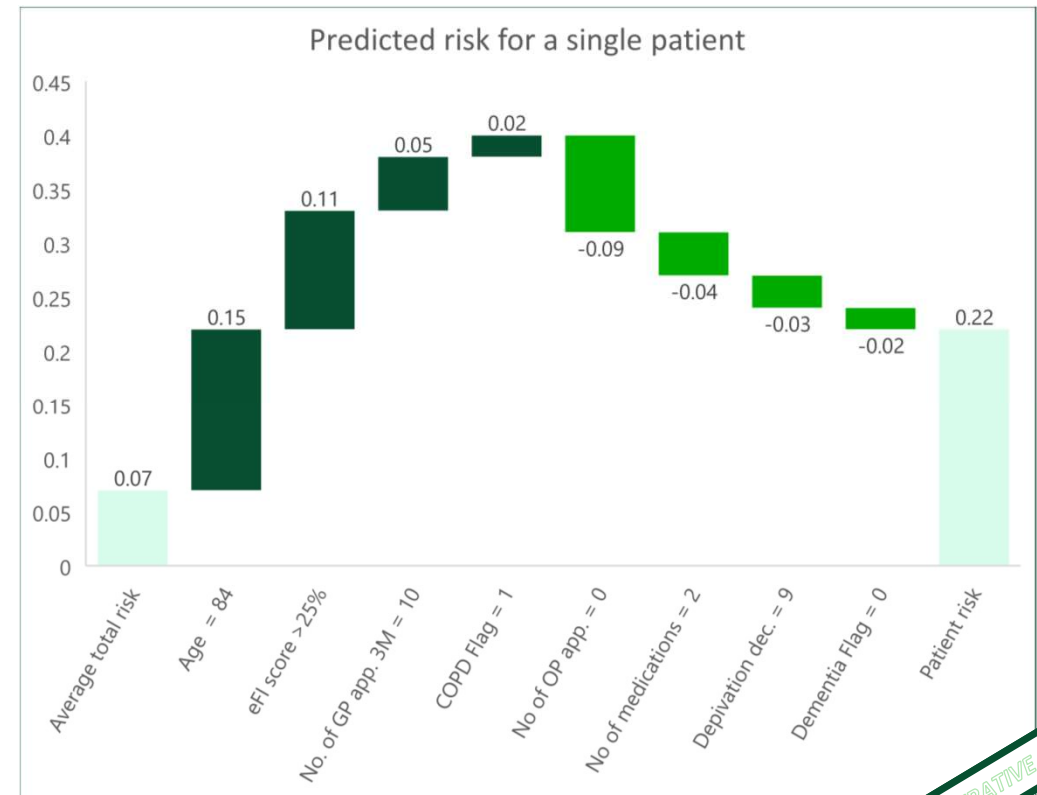
Dr Foster Model - Benefits



- Demonstrated improved model performance compared with traditional methods
- Model performance is improved across the full population
- Ability to visualise features that influence patient-level risks – actionable intelligence

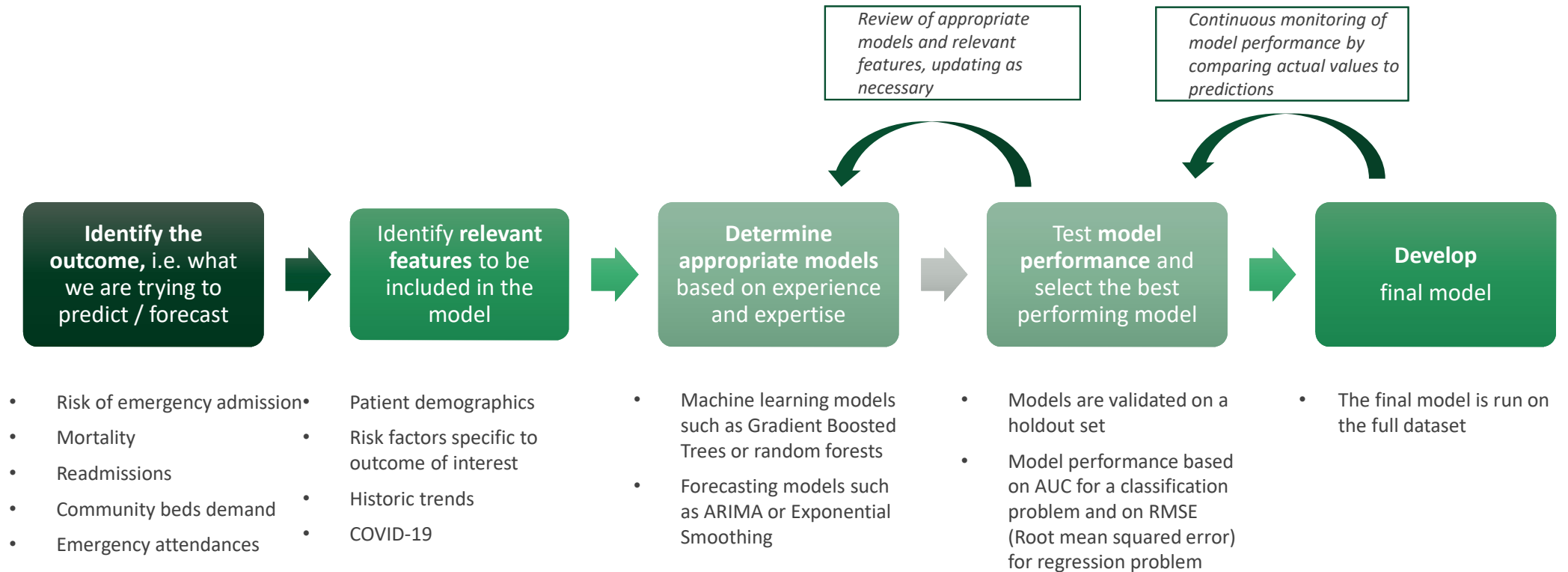
Percentile Rank %		Percentage of patients with an emergency admission in the next 12 months	
		Traditional approach	DF model
Highest risk ↑ ↓ Lowest risk	99.5 – 100	62.82%	65.27%
	95 – 99.5	30.02%	32.88%
	80 – 95	12.76%	13.61%
	50 – 80	6.01%	5.63%
0 – 50		2.71%	2.40%
Total		6.74%	6.74%

Area under the ROC curve	0.74	0.77
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ILLUSTRATIVE

Our modelling approach



Predictive Analytics - Further developments

Definition: Predictive Analytics is defined as the analysis of current and historical data to make predictions about future adverse outcomes.

Benefits:

- Link primary and secondary care data and other available data sets to predict future outcomes of interest.
- Advanced machine learning algorithms used to improve model performance and predictive accuracy

Falls algorithm:

- Falls are common for older people and are often preventable, with falls prevention schemes, including exercise classes and strength and balance training, known to reduce the likelihood of falls.
- Falls frequently result in fractures and expensive hospital admissions, so preventing falls not only improves patient outcomes, but also reduces costs to the NHS.

