Predictive Modelling in the UK

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Senior Fellow
The Nuffield Trust
The Nuffield Trust

• Charitable Organization founded in 1940
• Formerly a grant-giving organization
• Since 2008 we have been conducting in-house research and policy analysis
• Promote independent analysis and informed debate on healthcare policy across the UK
Outline

• Rationale
• Building a Predictive Model
• NHS Combined Predictive Model
• Predictive Models for Social Care
• Impactability Models
Why Predictive Modelling?

• BMJ in paper* in 2002 showed *Kaiser Permanente* in California seemed to provide high quality healthcare than the NHS at a lower cost

*Getting more for their dollar: a comparison of the NHS with California’s Kaiser Permanente BMJ 2002;324:135-143

• Kaiser identify high risk people in their population and manage them intensively to avoid admissions

• Inaccurate Approaches:
  – Clinician referrals
  – Threshold approach (e.g. all patients aged >65 with 2+ admissions)
Frequently-admitted patients

[Graph showing the average number of emergency bed days from -5 to +4 years, with a peak in the intense year (+1).]
Regression to the mean
Emerging Risk

Average number of emergency bed days

Intense year

-5 -4 -3 -2 -1 +1 +2 +3 +4
Kaiser Pyramid

The Pyramid represents the distribution of risk across the population.

Small numbers of people at very high risk

Large numbers of people at low risk

[Size of shape is proportional to number of patients]
Patterns in *routine* data

- Inpatient data
- A&E data
- GP Practice data
- Outpatient data
- Census data

**PARR Combined Model**
Scotland

- SPARRA
- SPARRA-MD

Wales

- PRISM model
- Welsh Predictive Risk Service
<table>
<thead>
<tr>
<th>Type</th>
<th>Data</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inpatient</td>
<td>131178</td>
<td>76.4</td>
</tr>
<tr>
<td>Outpatient</td>
<td>131178</td>
<td></td>
</tr>
<tr>
<td>A&amp;E</td>
<td>131178</td>
<td></td>
</tr>
<tr>
<td>GP</td>
<td>131178</td>
<td></td>
</tr>
</tbody>
</table>

Encrypted, linked data with risk score attached.

Decrypted data with risk score attached.
10 Million Patient-Years of Data

Randomised

Development

Predictive Model

Validation

5 Million Patient-Years of Data

5 Million Patient-Years of Data
Development
Sample

Year 1

Year 2

Year 3
Development
Sample

Year 1  Year 2  Year 3
## Development Sample

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inpatient</td>
<td>Outpatient</td>
<td>A&amp;E</td>
</tr>
<tr>
<td>GP</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Validation Sample

Year 1
Year 2
Year 3

Inpatient
Outpatient
A&E
GP

Validation Sample

False Negative

False Positive

True Negative
Using the Model

- Inpatient
- Outpatient
- A&E
- GP

<table>
<thead>
<tr>
<th>Last Year</th>
<th>This Year</th>
<th>Next Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>A89KP5</td>
<td>A89KP5</td>
<td>A89KP5</td>
</tr>
<tr>
<td>833TY6</td>
<td>833TY6</td>
<td>833TY6</td>
</tr>
<tr>
<td>I9QA44</td>
<td>I9QA44</td>
<td>I9QA44</td>
</tr>
<tr>
<td>64</td>
<td>64</td>
<td>64</td>
</tr>
<tr>
<td>233UMB</td>
<td>233UMB</td>
<td>233UMB</td>
</tr>
<tr>
<td>RF02UH</td>
<td>RF02UH</td>
<td>RF02UH</td>
</tr>
</tbody>
</table>
Distribution of Future Utilisation

Actual Average cost per patient

Predicted Risk (centile rank)
Risk Segmentation

The Kaiser pyramid can be divided into four segments:

- **Very High** (0 – 0.5%)
- **High** (0.5 – 5%)
- **Moderate** (5 – 20%)
- **Low** (20 – 100%)

Top three segments combined make up the top quintile.

Bottom segment represents the bottom four quintiles combined.
Burden of Future Utilisation is the Area Under the Curve
(i.e. number of people x cost)
Size of Shape is Proportional to Future Utilisation
Individuals at very high risk will use disproportionately large amounts of resources each.

But the bulk of future utilisation for the population comes from the rest of the top quintile.
NHS Combined Model

Patients

<table>
<thead>
<tr>
<th>Total Population</th>
<th>Risk Segment Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>322518</td>
<td>1612</td>
</tr>
</tbody>
</table>

Utilisation Rates per 1000

<table>
<thead>
<tr>
<th>Overall Rate</th>
<th>Any IP admissions</th>
<th>Emergency IP admissions</th>
<th>OP visits</th>
<th>AE visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>57</td>
<td>710</td>
<td>197</td>
<td></td>
</tr>
</tbody>
</table>

Risk Segment Rate

<table>
<thead>
<tr>
<th>Risk Segment Rate</th>
<th>Any IP admissions</th>
<th>Emergency IP admissions</th>
<th>OP visits</th>
<th>AE visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1402</td>
<td>1094</td>
<td>5292</td>
<td>1563</td>
<td></td>
</tr>
</tbody>
</table>

Indexed Rate (x Overall Rate)

<table>
<thead>
<tr>
<th>Indexed Rate (x Overall Rate)</th>
<th>Any IP admissions</th>
<th>Emergency IP admissions</th>
<th>OP visits</th>
<th>AE visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.9 X</td>
<td>19.3 X</td>
<td>7.5 X</td>
<td>7.9 X</td>
<td></td>
</tr>
</tbody>
</table>
Clinical Profiles

SEGMENT: Moderate risk (6-20%)

LTC Prevalence

Polypharmacy in any One Month

Key Clinical Quality Gaps

- High Risk Asthma
- CHD
- Diabetes with CHD

*Patients with contraindications are excluded
Tackling the *Inverse Care Law*

The image includes a diagram titled "RISK SEGMENT DISTRIBUTION ACROSS PRACTICES". The diagram shows the distribution of risk segments across different practices. Below the diagram, there is a table labeled "IP EMERGENCY ADMITS / 1000" with data for various practice segments. The table provides percentages and counts for different risk segments across practices. The table includes columns for "PRACTICE A", "PRACTICE B", "PRACTICE C", "PRACTICE D", "PRACTICE E", and "PRACTICE F". The table also includes rows for "PATIENTS IN RISK SEGMENT" and "ALL PATIENTS" with corresponding counts. The section below the table invites users to select a risk segment to look at.
Developing Business Cases

Please select the intervention cost per patient in risk segment per year.

<table>
<thead>
<tr>
<th>Description</th>
<th>Count</th>
<th>Intervention Impact Rate</th>
<th>Estimated Cost of Admission</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP Emergency Admissions</td>
<td>6304</td>
<td>0.20</td>
<td>£2,100</td>
</tr>
<tr>
<td>IP Other Admissions</td>
<td>3337</td>
<td>0.10</td>
<td>£900</td>
</tr>
<tr>
<td>AE Visits</td>
<td>11152</td>
<td>0.20</td>
<td>£250</td>
</tr>
<tr>
<td>OP Visits</td>
<td>56859</td>
<td>0.20</td>
<td>£100</td>
</tr>
</tbody>
</table>

Note: Utilisation rates are for year following prediction.
<table>
<thead>
<tr>
<th>Model predicts:</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
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<tbody>
<tr>
<td>Details</td>
<td></td>
<td></td>
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<td></td>
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### Model predicts:

<table>
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### Details

Model predicts which patients will *become* high-cost over next 6 or 12 months

### Examples

Low-cost patient this year will become high-cost next year
Model predicts: Cost | Event
--- | ---

Details
Model predicts which patients will become high-cost over next 6 or 12 months | Model predicts which patients will have an event that can be avoided

Examples
Low-cost patient this year will become high-cost next year | Patient will be hospitalized
Patient will have diabetic ketoacidosis
<table>
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<th>Cost</th>
<th>Event</th>
<th>Actionability</th>
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<td><strong>Details</strong></td>
<td>Model predicts which patients will become high-cost over next 6 or 12 months</td>
<td>Model predicts which patients will have an event that can be avoided</td>
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<td>Patient has angina but is not taking aspirin</td>
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<td></td>
<td>Patient will have diabetic ketoacidosis</td>
<td>Patient does not have pancreatic cancer (Ambulatory Care Sensitive)</td>
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Evaluation of Integrated Care
Overcoming regression to the mean using a control group (1)

Number of emergency hospital admissions per head per month

Month

Start of intervention
Overcoming regression to the mean using a control group (2)
Overcoming regression to the mean using a control group

(3)

![Graph showing number of emergency hospital admissions per head per month over months with control and intervention groups. The graph indicates a peak in admissions immediately before the start of the intervention, followed by a decline.]
Overcoming regression to the mean using a control group (4)