Risk Stratification: an introduction

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Chief Data Officer
Risk Stratification

• BMJ in paper* in 2002 suggested *Kaiser Permanente* in California was providing higher quality healthcare than the NHS at a lower cost. Kaiser identify high risk people in their population and manage them intensively to avoid admissions

• Modelling aims to identify people at risk of a future Triple Fail event (i.e. low quality, poor patient experience, high cost)

• In health sector a number of predictive models available PARR; PARR++; combined model, ACG tool etc.

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

Risk of the event

Small numbers of people at very high risk

Large numbers of people at low risk

↔ number of patients ↔
Bottom Line

• A risk stratification tool estimates for each person in a population:
  
  • their *individual risk* of experiencing *adverse event x* during *future time period y*

• (e.g. Mrs. Smith’s risk of unplanned hospital admission during the next 12 months)
Patterns in *routine* data

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

Combined Model: PARR
10 Million Patient-Years of Data

Development

Randomised

Validation

Predictive Model

Regression analysis or decision tree or machine learning

5 Million Patient-Years of Data
Development Sample

- Inpatient
- Outpatient
- A&E
- GP

Year 1

Year 2

Year 3
Validation Sample

Year 1  Year 2  Year 3

Inpatient  Outpatient  A&E  GP

A89KP5  A89KP5  A89KP5
833TY6  833TY6  833TY6
I9QA44  I9QA44  I9QA44
85H3D  85H3D  85H3D
6445JX  6445JX  6445JX
233UMB  233UMB  233UMB
RF02UH  RF02UH  RF02UH

Validation Sample

True Positive
False Negative
False Positive
True Negative
False Positives

- Intervention “wasted”
- Needless anxiety
- Over-investigation
- Over-treatment

False Negatives

- Unwarranted reassurance
- Delayed presentation

Next Steps for Risk Stratification in the NHS

Using the Model

Inpatient
Outpatient
A&E
GP

Last Year

This Year

Next Year
Measuring predictive accuracy

- **r-squared** and **c-statistic** (single values ranging between 0 and 1)

- **Positive predictive value** (proportion of patients who are identified by the model as being ‘high risk’ that will truly experience the outcome being predicted)

- **Sensitivity** (proportion of the population who will experience the outcome of interest that the model successfully identifies.)
Accuracy of the PARR model

Area under the ROC curve ("c-statistic") = 0.685

<table>
<thead>
<tr>
<th>Cut-off score</th>
<th>Positive predictive value</th>
<th>Sensitivity</th>
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<tbody>
<tr>
<td>50</td>
<td>0.65</td>
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<tr>
<td>70</td>
<td>0.77</td>
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<td>80</td>
<td>0.84</td>
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% of people identified by the model as high risk who will be admitted

% of people in the population who will be admitted that are identified by the model as high risk

Billings et al. Case finding for patients at risk of readmission to hospital: development of algorithm to identify high risk patients. BMJ 2006;333:327
# Business case modelling scenarios

1. Risk score threshold

2. Effectiveness of intervention

3. Cost of intervention

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<th>Assumed reduction in admissions (%)</th>
<th>No (%) admitted patients identified</th>
<th>No (%) patients flagged incorrectly (not admitted)</th>
<th>Total cost (£) of intervention</th>
<th>Admissions within 12 months for correctly flagged patients</th>
<th>Intervention savings (£) (E2100/admission)</th>
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### Other Examples of ‘Triple Fail’ Events

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<th>Event</th>
<th>Quality of care</th>
<th>Patient experience</th>
<th>Cost</th>
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<td>Unplanned hospital readmission within 30 days</td>
<td>A readmission may indicate complications, a premature discharge, a failure to coordinate and reconcile medications, inadequate communication, or poor discharge planning(^\text{1})</td>
<td>Higher 30-day risk-standardized hospital readmission rates are associated with lower patient satisfaction(^\text{2})</td>
<td>A 2009 study found that 30-day rehospitalizations cost Medicare $17.4 billion annually(^\text{3})</td>
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<td>Nursing home admission</td>
<td>Predictors of nursing home admission include low self-rated health status and functional and cognitive impairment(^\text{4})</td>
<td>Loss of independence and nursing home admission are two of the major fears of older people(^\text{5})</td>
<td>The cost of long-term care in the United States in 2009 was estimated to be $203–$243 billion(^\text{6})</td>
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<td>Inappropriate initiation of hemodialysis</td>
<td>Peritoneal dialysis patients experienced a lower adjusted relative risk of death compared with those beginning hemodialysis(^\text{7}); late and early dialysis initiation appear to be associated with equal outcomes(^\text{8})</td>
<td>Peritoneal dialysis patients reported better quality of life and better satisfaction with dialysis care(^\text{9})</td>
<td>Median annual health care costs in 2004 were $43,510 higher for hemodialysis patients than peritoneal dialysis patients(^\text{10})</td>
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<td>Wrong-site surgery</td>
<td>Wrong-site surgery is one of the National Quality Forum’s ‘never events’(^\text{11})</td>
<td>Wrong-site surgery can be a devastating experience for the patient(^\text{12})</td>
<td>A 2010 study found that the average compensation paid to victims of wrong-site surgery was $47,216(^\text{13})</td>
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<td>Intentional injury or maltreatment of a child</td>
<td>Child maltreatment involving physical abuse is the leading cause of infant death from injury(^\text{14})</td>
<td>Child abuse has been associated with a wide range of psychological symptoms in the victim(^\text{15})</td>
<td>A 2012 study found the annual acute medical costs and annual societal costs of childhood abuse in the United States were $2.9 billion and $80 billion, respectively(^\text{16})</td>
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<td>Overly invasive treatment for a preference-sensitive condition</td>
<td>Patients offered a decision aid for a preference-sensitive condition reported significantly improved outcomes(^\text{17})</td>
<td>Patients offered a decision aid reported significantly greater satisfaction with their selected treatment(^\text{18})</td>
<td>Patients offered a decision aid were 21–44% less likely to choose costly, aggressive surgery(^\text{19})</td>
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Predictive Risk Model

Whole Population

People at Risk

Impactability Model

People at Risk who will benefit

People at Risk
Ethical Considerations

- Predictive Modelling is a form of population screening
- Any screening test has the potential to cause more harm than good

Prerequisites for the Stratified Approach to the Triple Aim

1. The Triple Fail event should be an important health problem.
2. There should be an intervention that can mitigate the risk of the Triple Fail event.
3. There should be resources and systems available for timely risk stratification and preventive interventions.
4. There should be sufficient time for intervention between stratification and the occurrence of the Triple Fail event.
5. There should be a sufficiently accurate predictive risk model for the Triple Fail event.
6. The predictive risk model and impactibility model should be acceptable to the population.
7. The natural history of the Triple Fail event (i.e., the practices and processes that typically lead to the event) should be adequately understood by the organization offering the preventive intervention.
8. There should be an accepted policy about who should be offered the preventive intervention.
9. The cost stratification should be “economically balanced” (i.e., it should not be excessive in relation to the cost of the program as a whole).
10. Stratification should be a continuous process, not just a "once and for all" occurrence.