Toy models - complex problems in small packages

Midlands Analyst Network huddle, 3rd April 2025

Lucy Morgan & Andy Hood | lucy.morgan48@nhs.net & andrewhood@nhs.net

Running Order

- Background
- What is risk stratification?
- Intervention ‘performance’
- Key terms in the IAPN framework
- The model theory
- Toy model demonstration…
- Other useful links:
- Questions?

Background

The New Hospitals Programme (NHP) have funded the development of some ‘toy models’ to:

- Support discussion of technical phenomonen
- Aid decision-making
- and Enhance learning & development

across the programme itself and for trusts involved in designing and delivering new hospital schemes. Understanding how and to what extent future acute demand pressures might be mitigated with preventive actions is a key part of system thinking.

The current suite of toy models includes the following:

- Bed pooling and occupancy
- Risk stratification
- Waiting list dynamics

The rest of this session focuses on the recent ‘Cost Effectiveness and Resource Allocation’ journal paper by colleagues at the Strategy Unit who explored the relationship and trade-off between the accuracy of risk stratification approaches, the effectiveness of targeted interventions and the resulting cost impacts.

What is risk stratification?

To paraphrase; risk stratification is the classification (of patients) into groups based on their likelihood of an adverse event occuring and for which preventive actions might be available and appropriate. Events could typically be emergency admission, death, disease onset, not adhering to treatment etc…

Factors routinely used in risk stratification approaches are demographic, lifestyle, historic and current clinical presentation.

There are many different methods for evaluating or predicting risk in individuals: - Logistic regression - Cox proportional hazards - Machine Learning & Neural networks (Decison trees, Support Vector Machines, XGBoost) - Clustering (k-means, LPA, DB scan)

Some at-scale examples from or used in England are:

- Framingham risk score
- PARR++
- Combined Predictive Model
- Covid vulnerability

Intervention ‘performance’

So you’ve created, refined (and validated) your risk-prediction algorithms, classified your patients, created some cool profiles, job done right…?

Well once a risk group has been identified, there (ethically) should be an intervention in place to offer those patients additional support to lower their risk or to prevent adverse events happening.

Typically this might be something like brief lifestyle interventions, screening & diagnosis, planned invasive or non-invasive treatments.

All these interventions will have associated costs and also associated success rates with interrupting the risk pathway.

So at the simplest level, an intervention would have a unit cost per patient and a number needed to treat in order to reverse or prevent an outcome at risk-group level.

Key terms in the IAPN framework

Risk stratification:

- Population size (n) - total size of your population e.g. GP surgery, ICB, Region etc…
- Cost of adverse event (a) - the average unit cost (£'s) of unplanned hospital admission.
- Positive Predictive Value (ppv) - the likelihood of the risk strat prediction correctly identifying adverse events.

Intervention:

- Percentage targeted (p) - the portion of the total population targeted for intervention.
- Unit cost (i) - average cost (£'s) to deliver the intervention to 1 patient.
- Number Needed to Treat (nnt) - Number of people need to receive the interventions in order to avoid 1 adverse event.

Other:

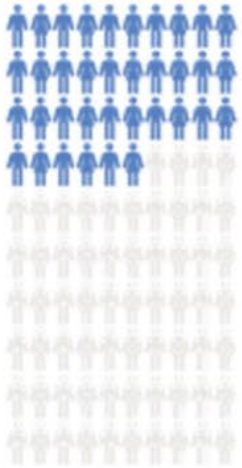
- iMax - the maximum unit cost value at which the intervention is cost effective *(given a, ppv and nnt)*.

The model theory

From a practice of 5,000, a risk tool identifies 100 individuals (top 2%) having the highest risk of unplanned admission in the next 12 months

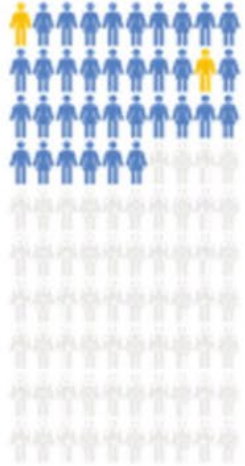
PPV = 0.36

36 would have experienced an emergency admission in the next 12 months



NNT = 18

For every eighteen people treated, one emergency admission is avoided



2 admissions avoided

Let's assume £2000 per admission

How much must your intervention cost per person to save money?

Toy model demonstration…

https://connect.strategyunitwm.nhs.uk/risk_stratification_tool/

Other useful links:

- Health Economics Unit guide
- Systematic review of risk stratification tools for health
- NHS England segmentation and stratification overview
- Approach to developing risk stratification models using logistic regression
- Overview of ML for epidemiology

Questions (and suggestions please)?