



The Nuffield Trust
FOR RESEARCH AND POLICY
STUDIES IN HEALTH SERVICES

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?



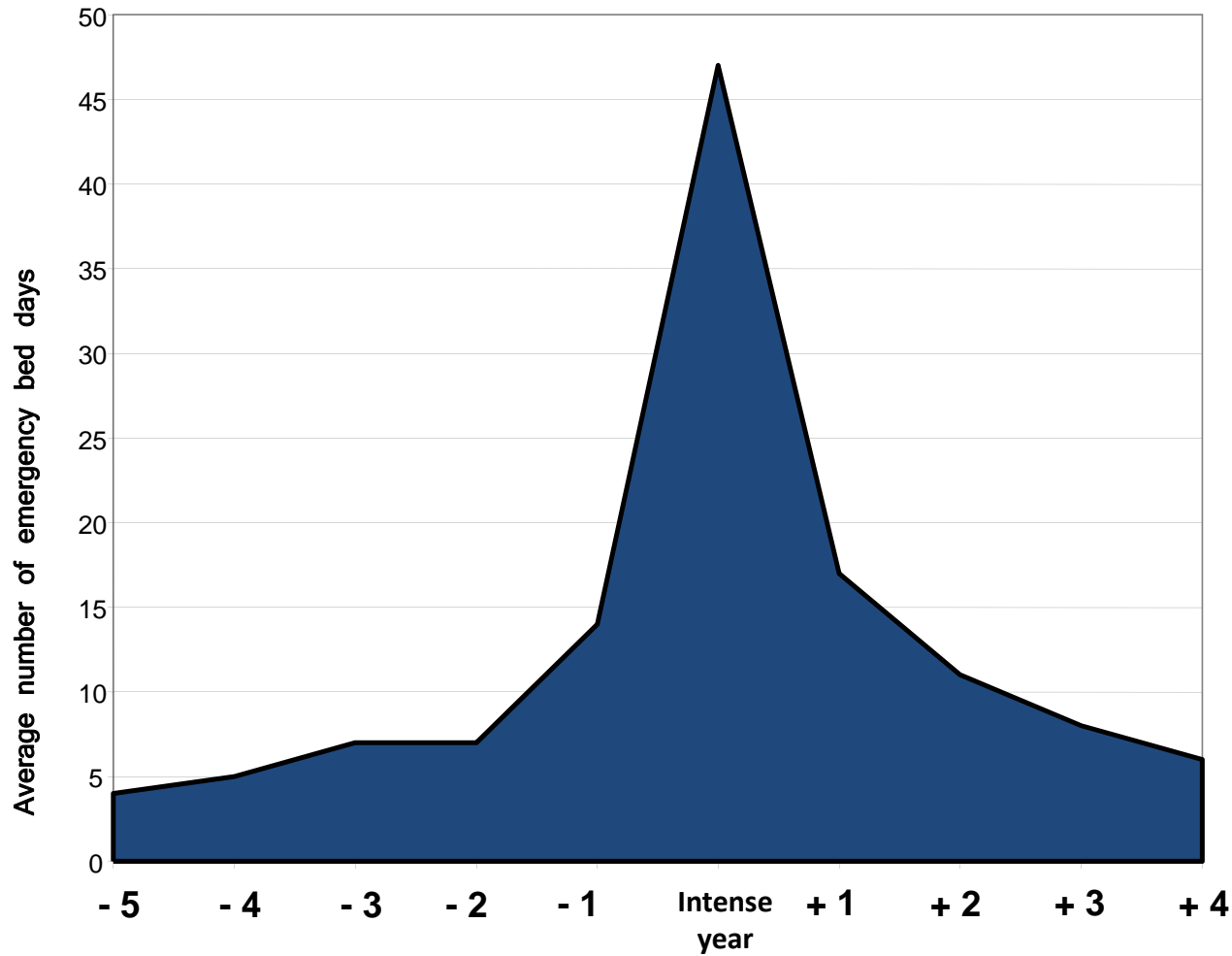
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- BMJ in paper* in 2002 showed *Kaiser Permanente* in California seemed to provide **higher quality** healthcare than the NHS at a **lower cost**

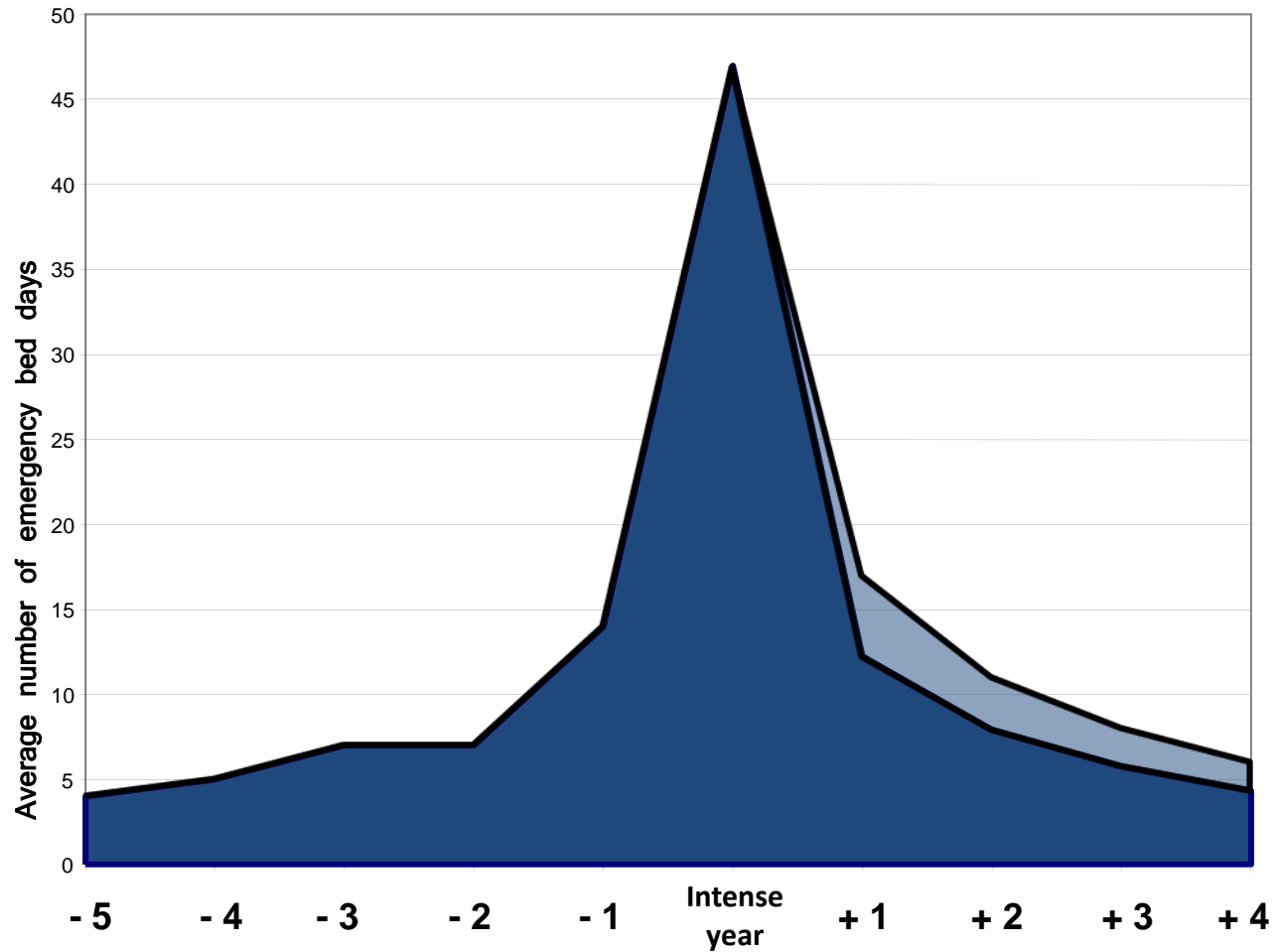
*Getting more for their dollar: a comparison of the NHS with California's Kaiser Permanente *BMJ* 2002;324:135-143

- 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)

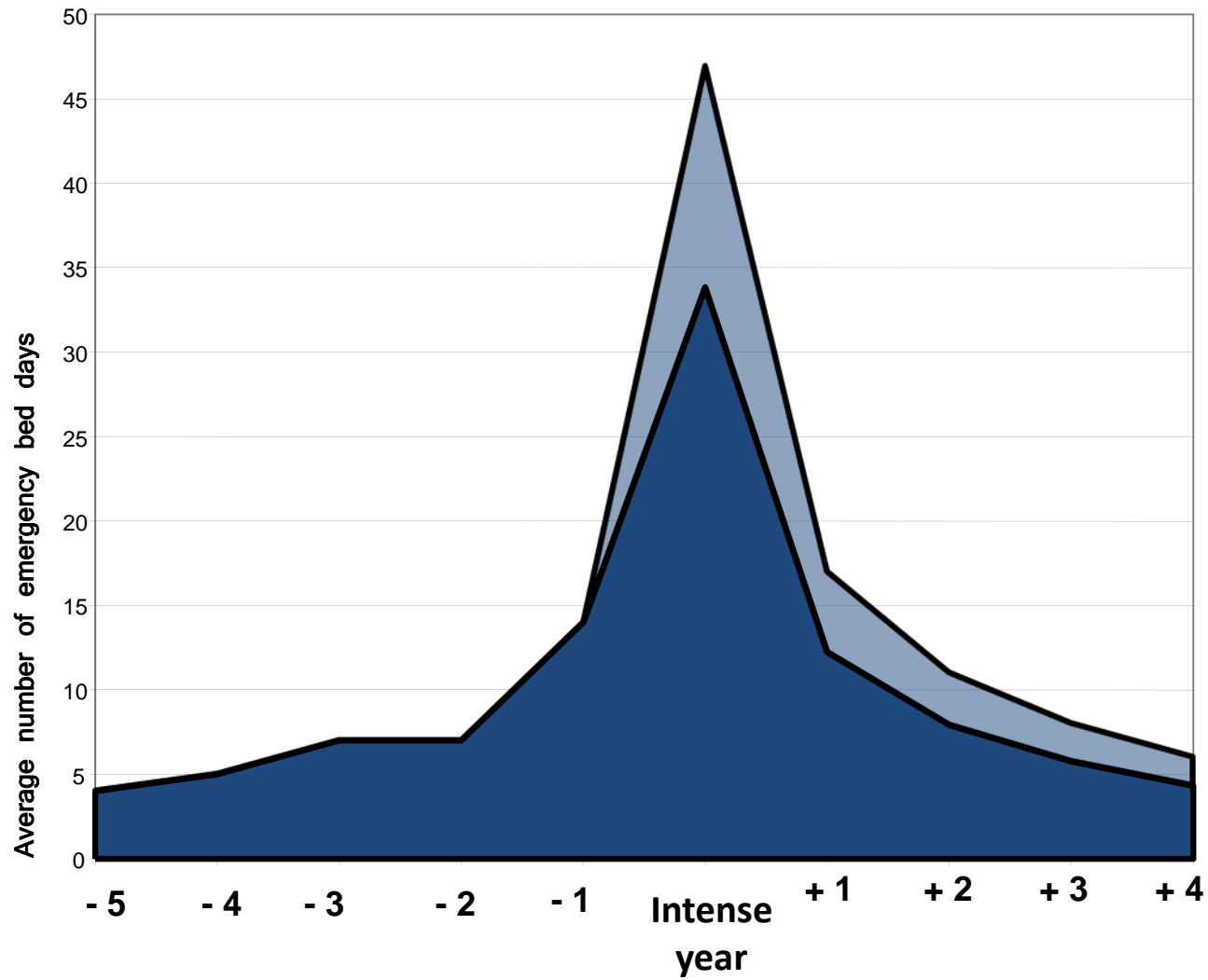
Frequently-admitted patients



Regression to the mean

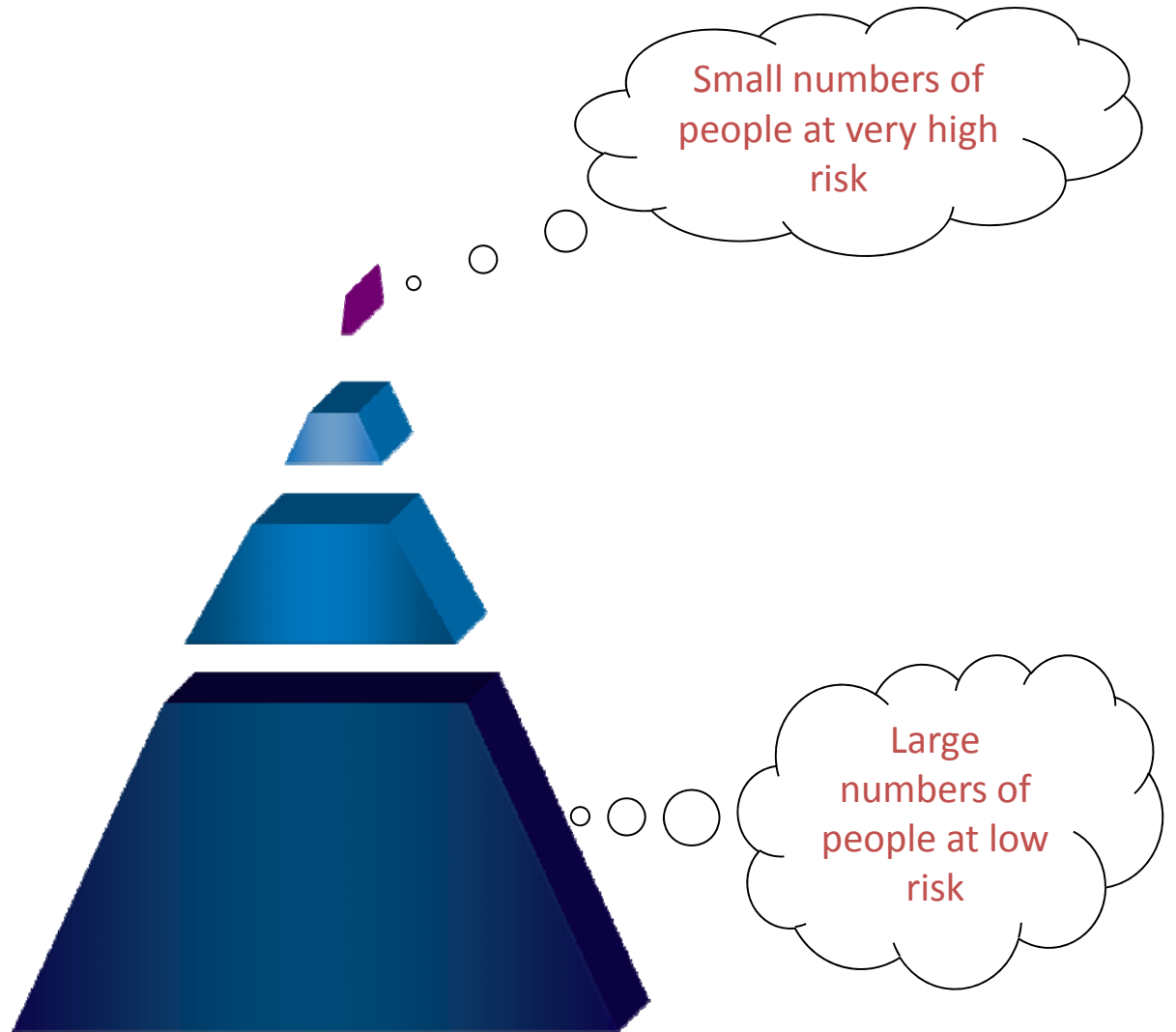


Emerging Risk



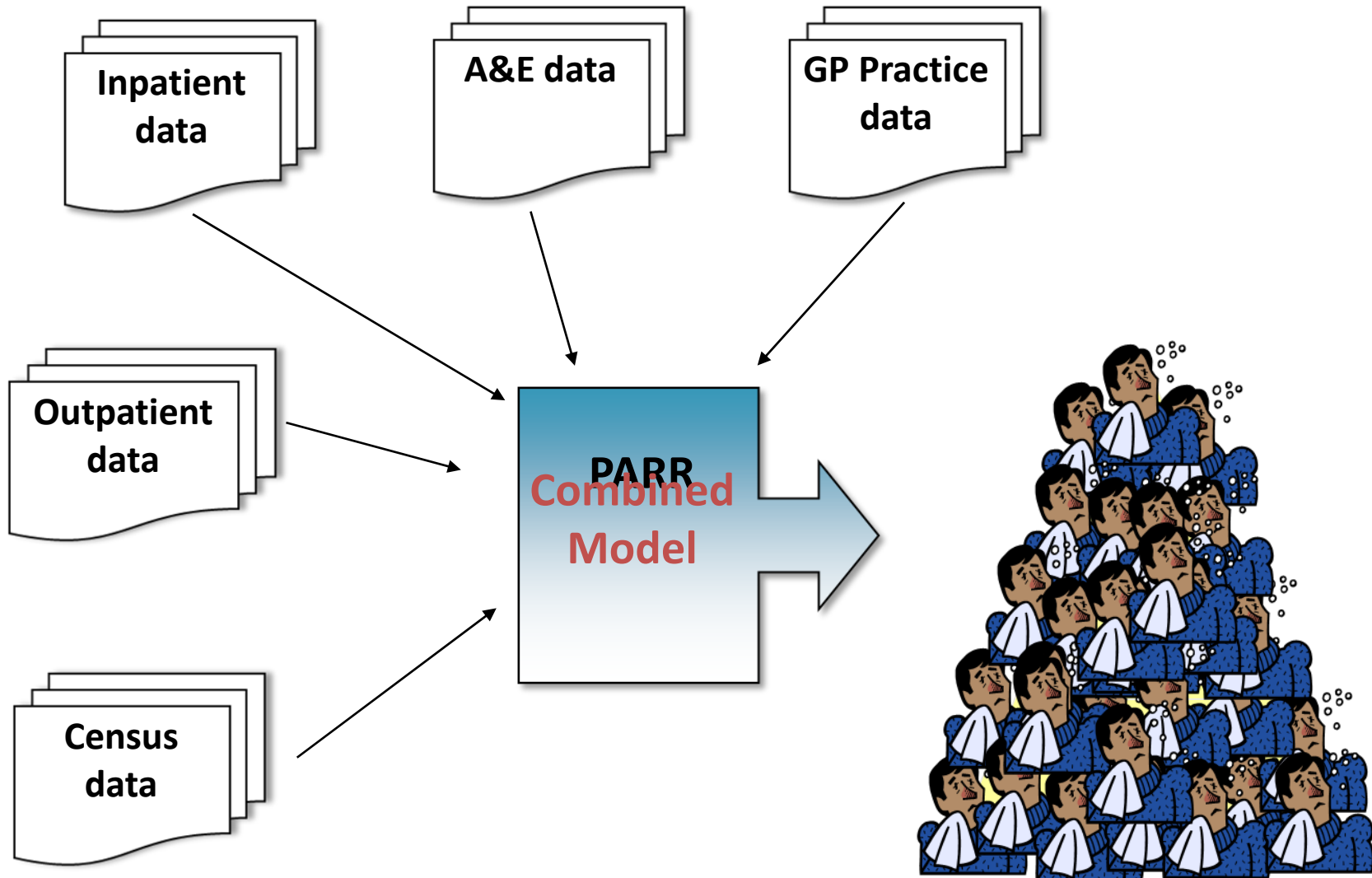
Kaiser Pyramid

The Pyramid represents the distribution of risk across the population



[Size of shape is proportional to number of patients]

Patterns in *routine* data





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Scotland

- SPARRA
- SPARRA-MD



Wales

- PRISM model
- Welsh Predictive Risk Service



Name, Address, DOB	131178	
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Name, Address, DOB	131178	
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Name, Address, DOB	131178	
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J7KA42	
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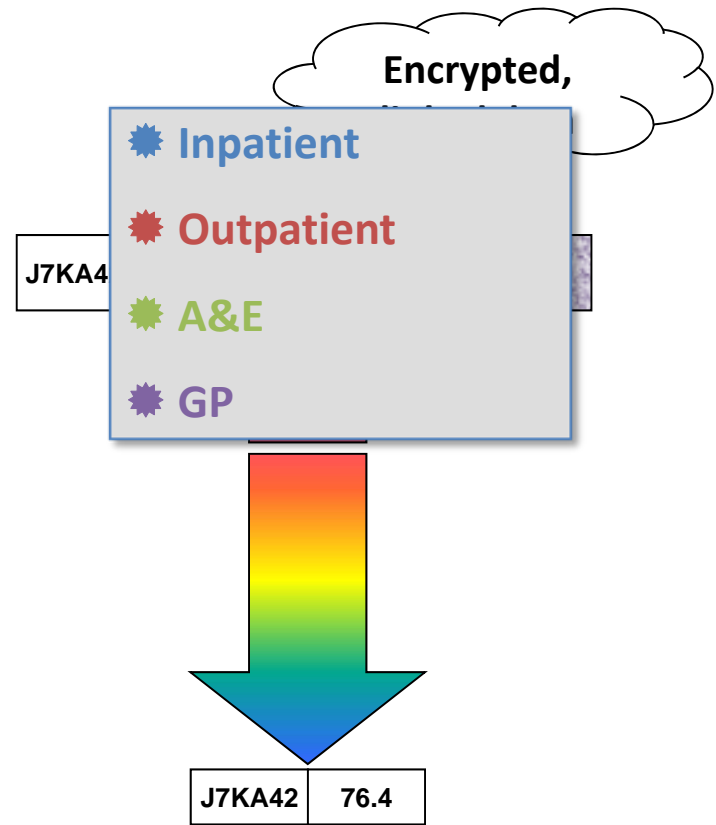
J7KA42	
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J7KA42	
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J7KA42	
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Decrypted data
with risk score
attached

131178	76.4
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**10 Million Patient-Years
of Data**

Randomised

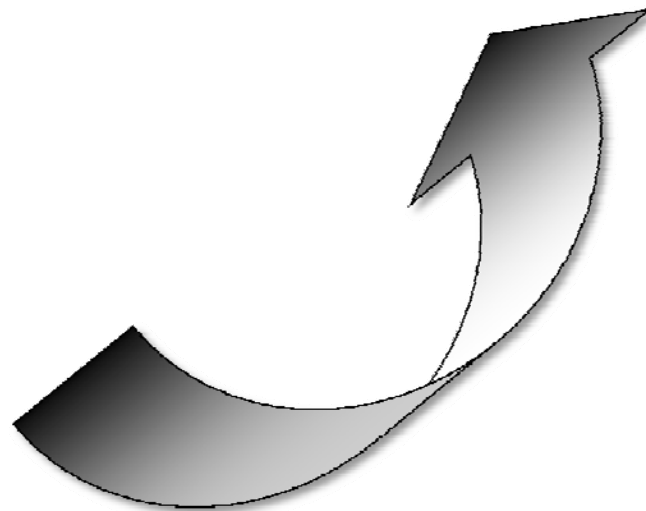
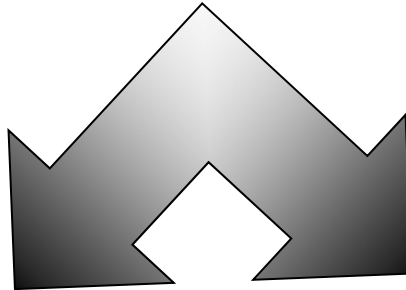
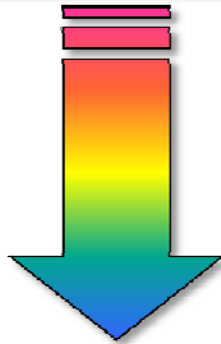
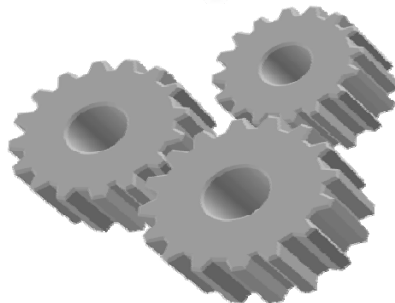
Development

**5 Million Patient-Years
of Data**

Validation

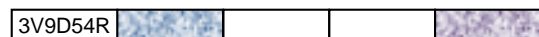
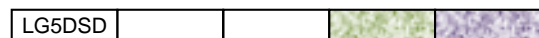
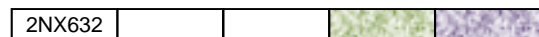
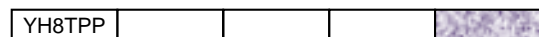
**5 Million Patient-Years
of Data**

**Predictive
Model**

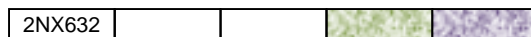




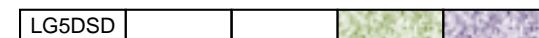
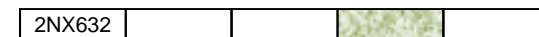
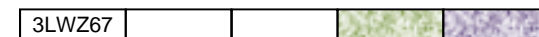
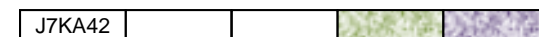
Development Sample



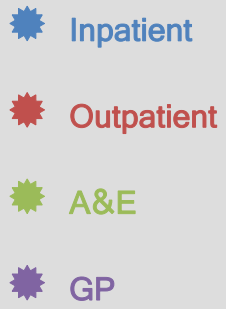
Year 1



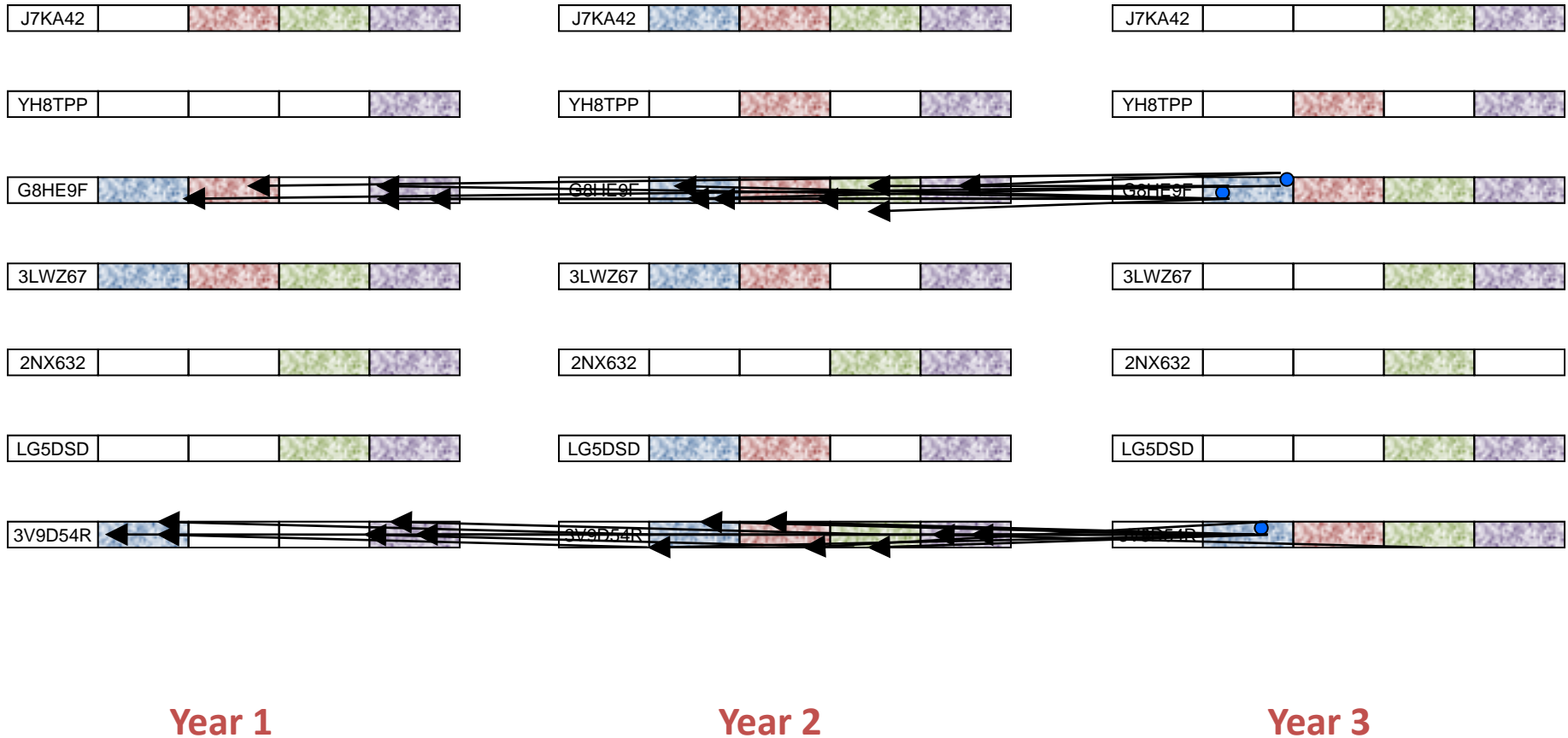
Year 2



Year 3

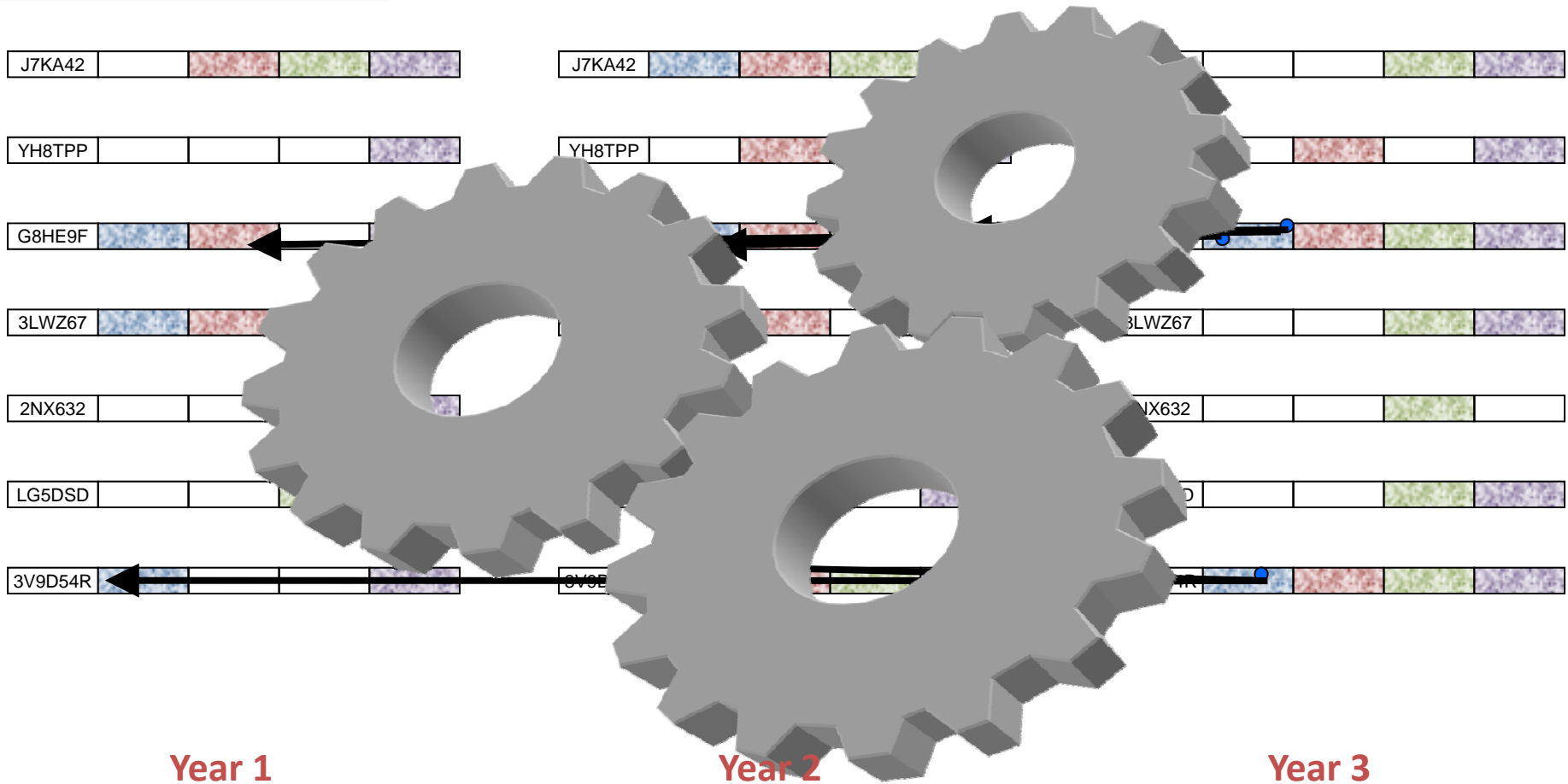


Development Sample



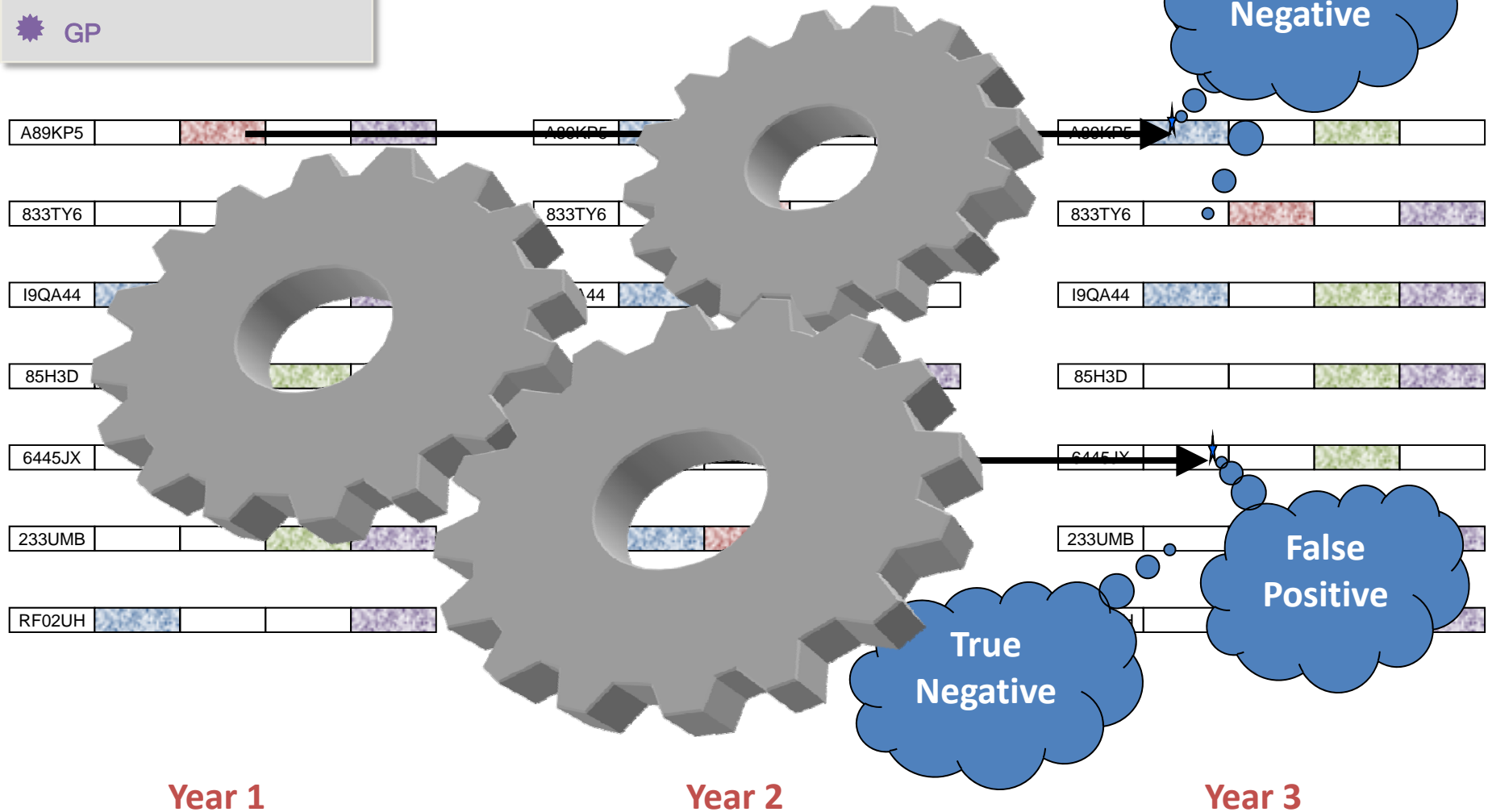
- Inpatient
- Outpatient
- A&E
- GP

Development Sample



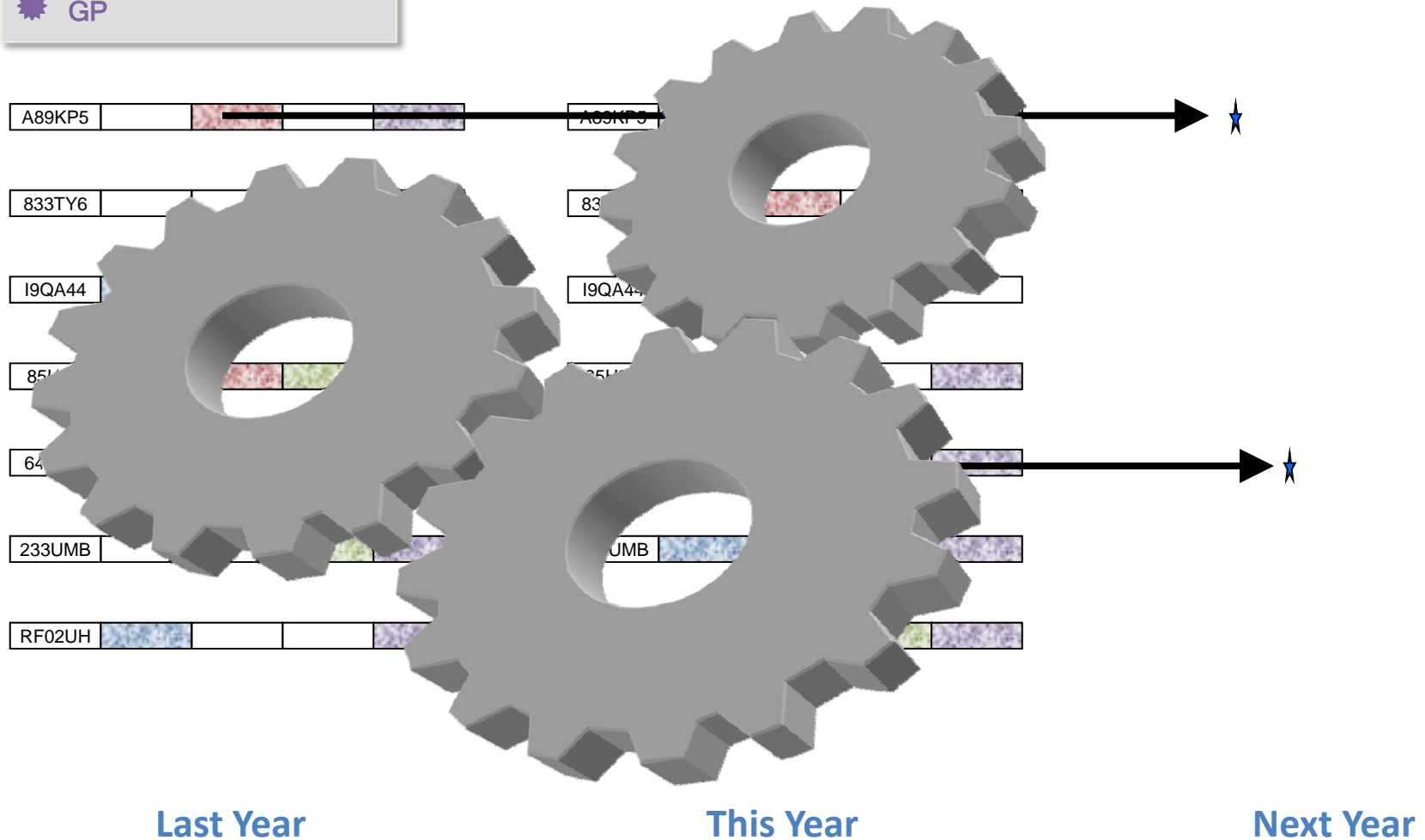
- Inpatient
- Outpatient
- A&E
- GP

Validation Sample

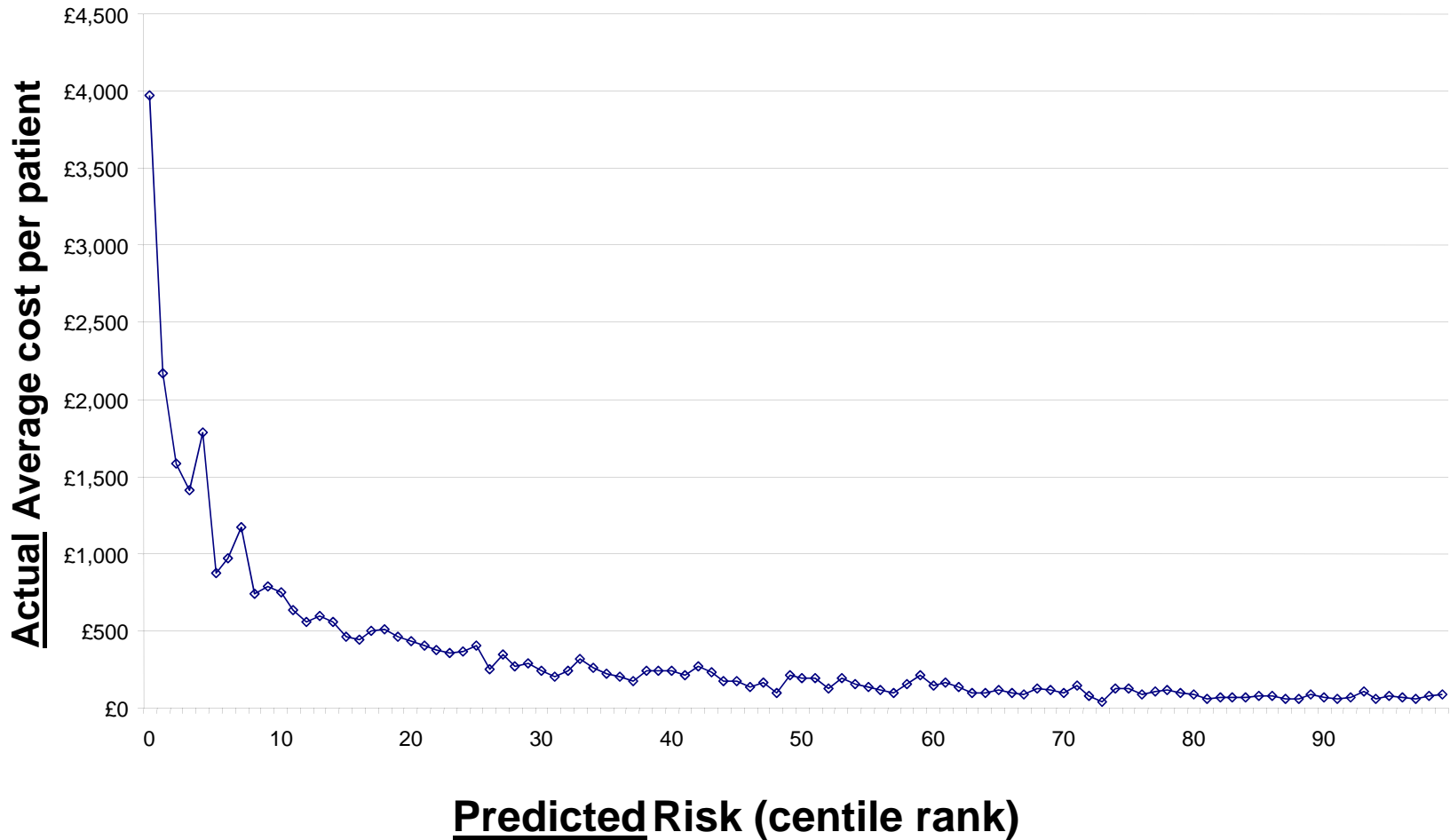


Using the Model

- Inpatient
- Outpatient
- A&E
- GP



Distribution of Future Utilisation





Risk Segmentation

The Kaiser pyramid can be divided into four segments:

Very High
(0 – 0.5%)

High
(0.5 – 5%)

Moderate
(5 – 20%)

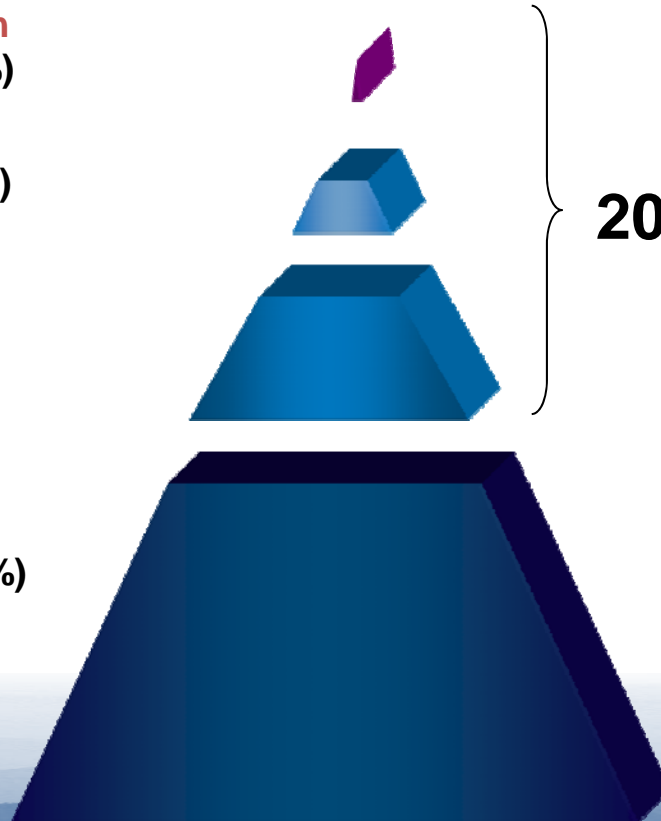
Low
(20 – 100%)

20%

Top three segments
combined make up
the top quintile

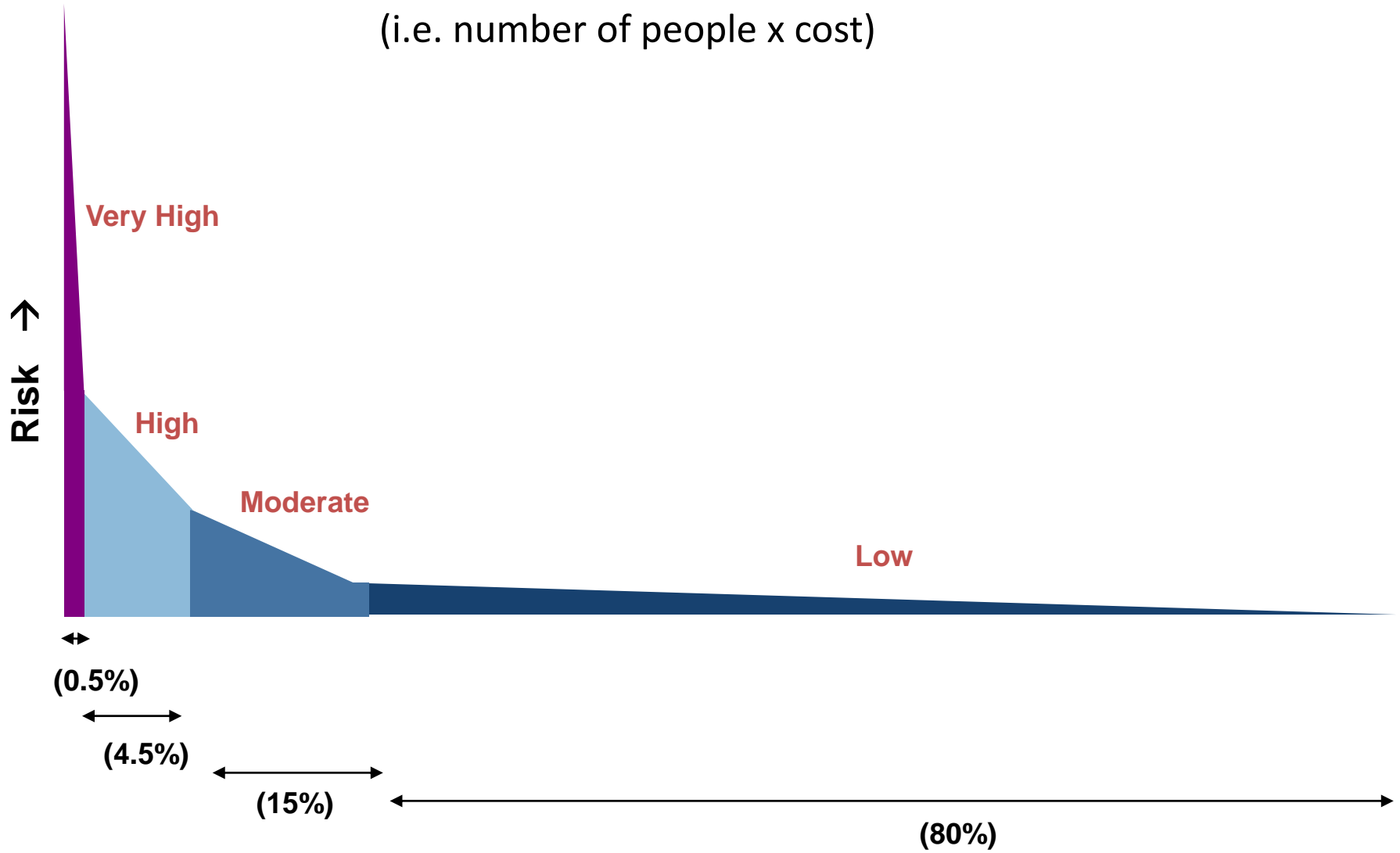
80%

Bottom
segment
represents
the bottom
four quintiles
combined

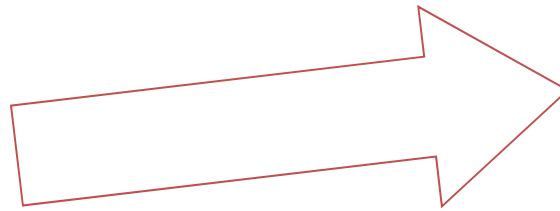
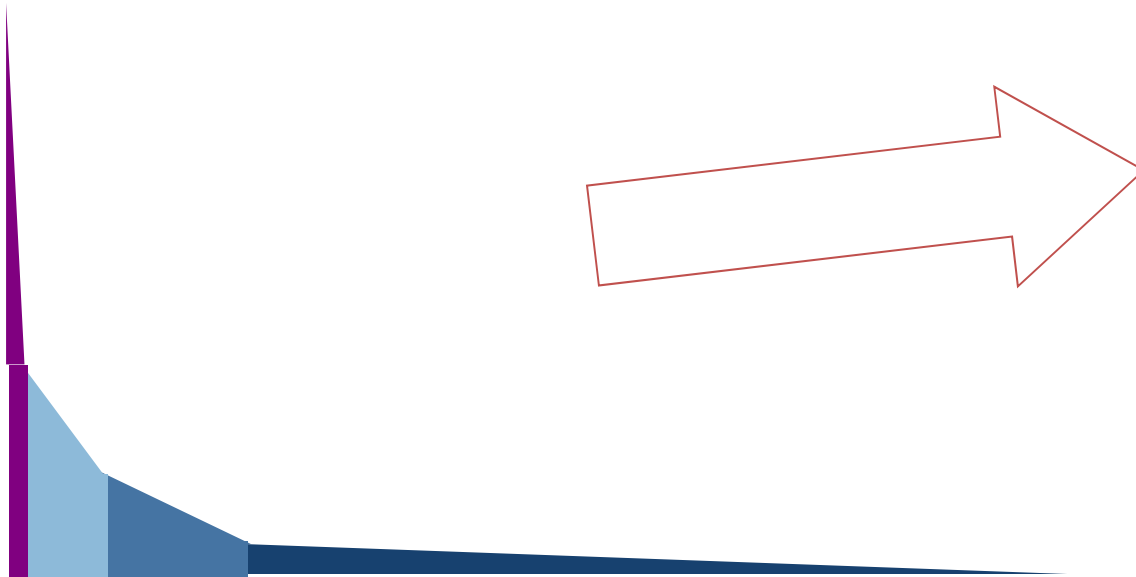


Burden of Future Utilisation is the Area Under the Curve

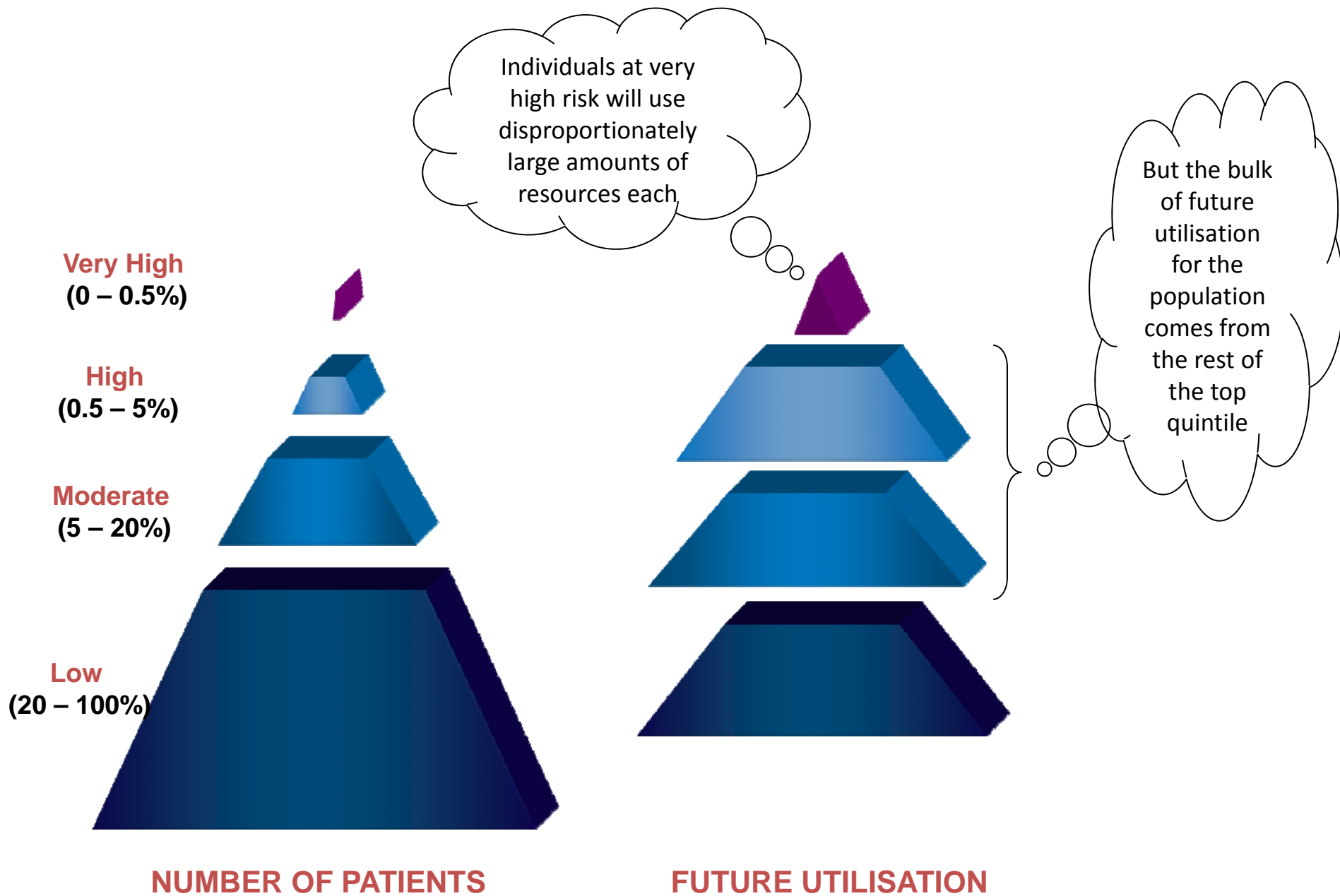
(i.e. number of people x cost)



Size of Shape is Proportional to Future Utilisation



**SIZE OF SHAPE IS
PROPORTIONAL
TO FUTURE UTILISATION**



NHS Combined Model

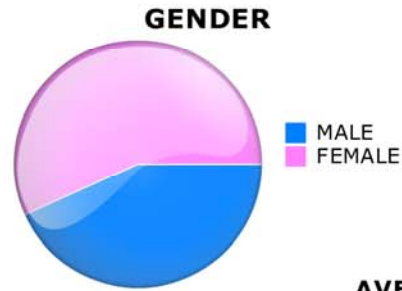
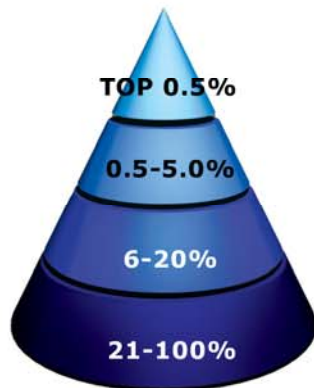
PATIENTS

TOTAL POPULATION	322518
RISK SEGMENT POPULATION	1612

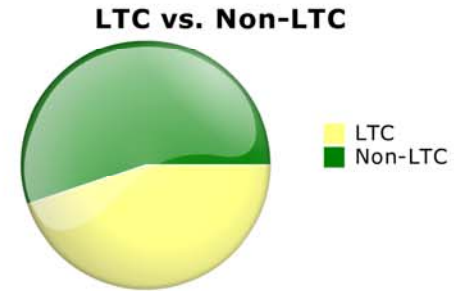


UTILISATION RATES PER 1000

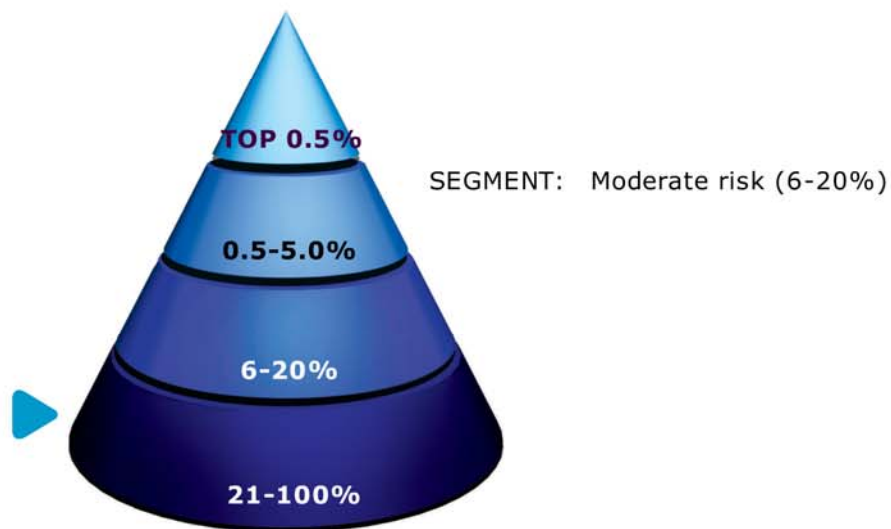
	Any IP admissions	Emergency IP admissions	OP visits	AE visits
OVERALL RATE	101	57	710	197
RISK SEGMENT RATE	1402	1094	5292	1563
INDEXED RATE(X OVERALL RATE)	13.9 X	19.3 X	7.5 X	7.9 X



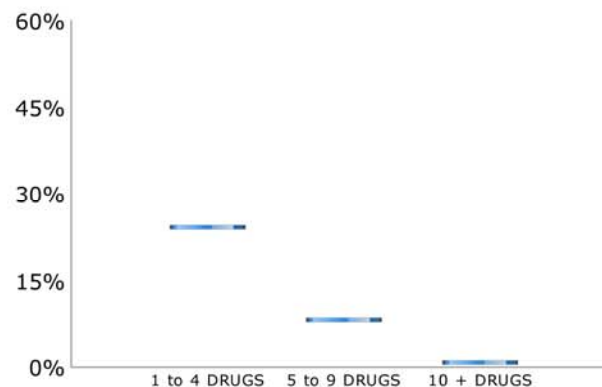
73
AVERAGE AGE



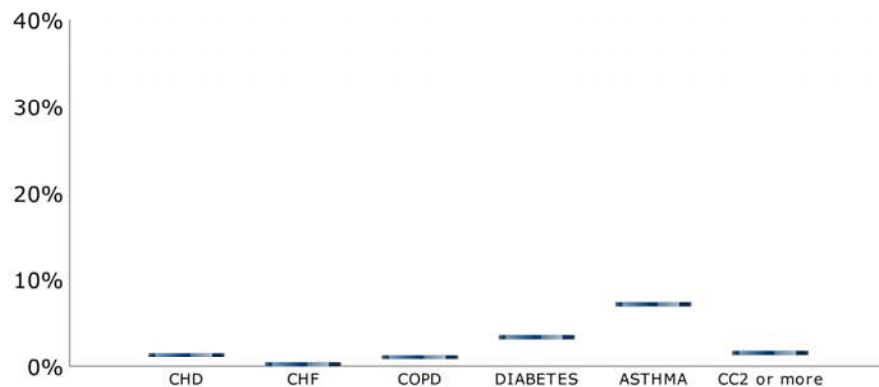
Clinical Profiles



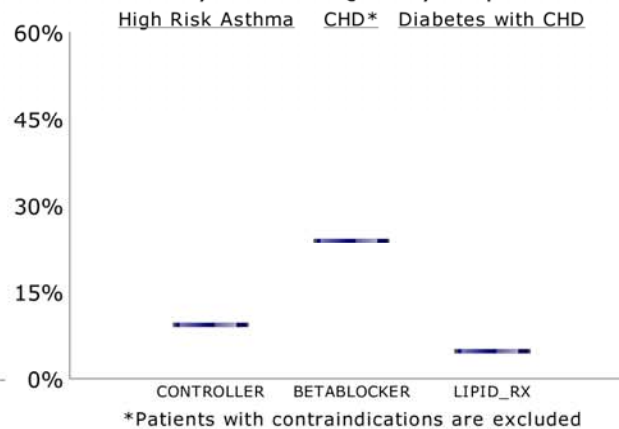
Polypharmacy in any One Month



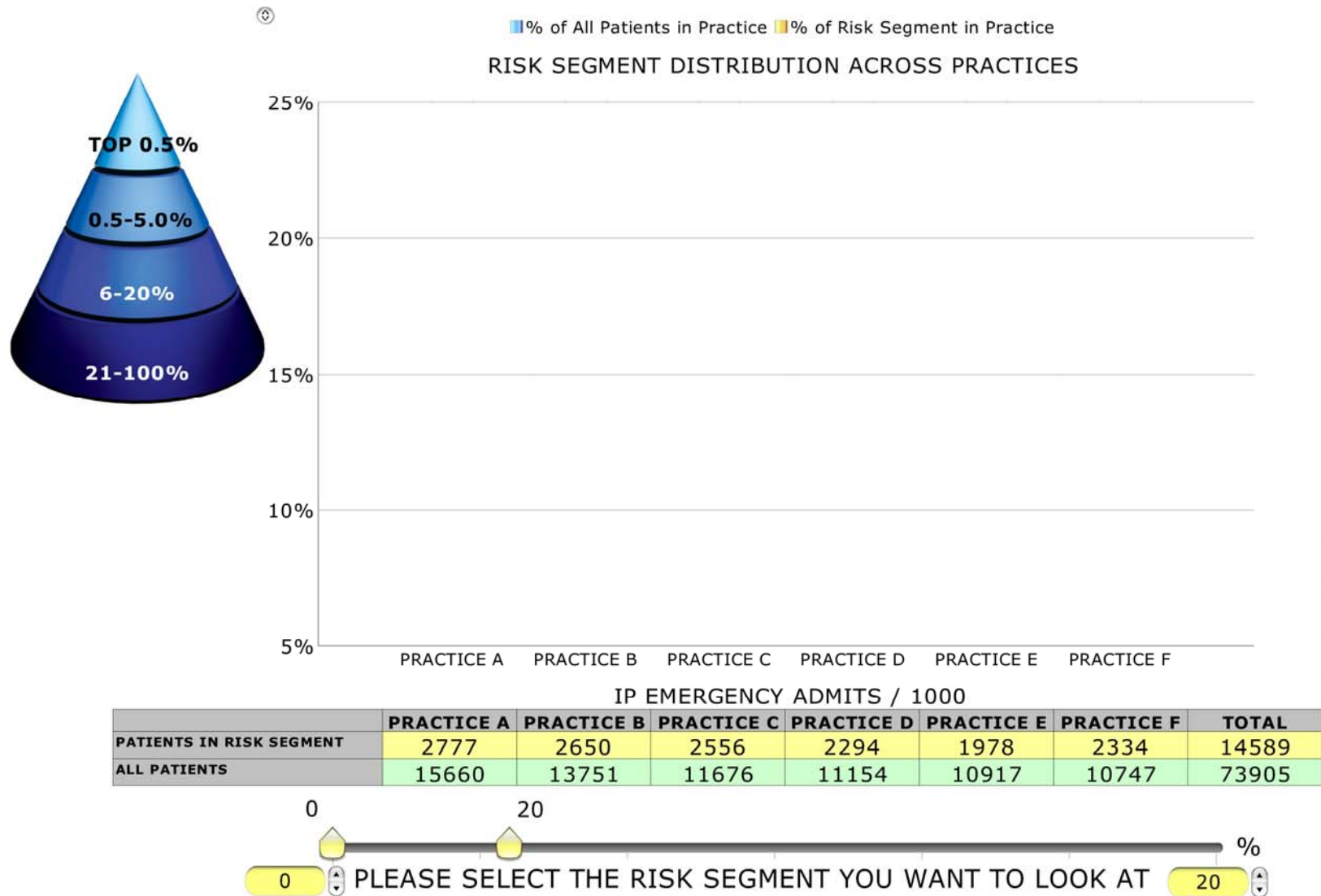
LTC Prevalence



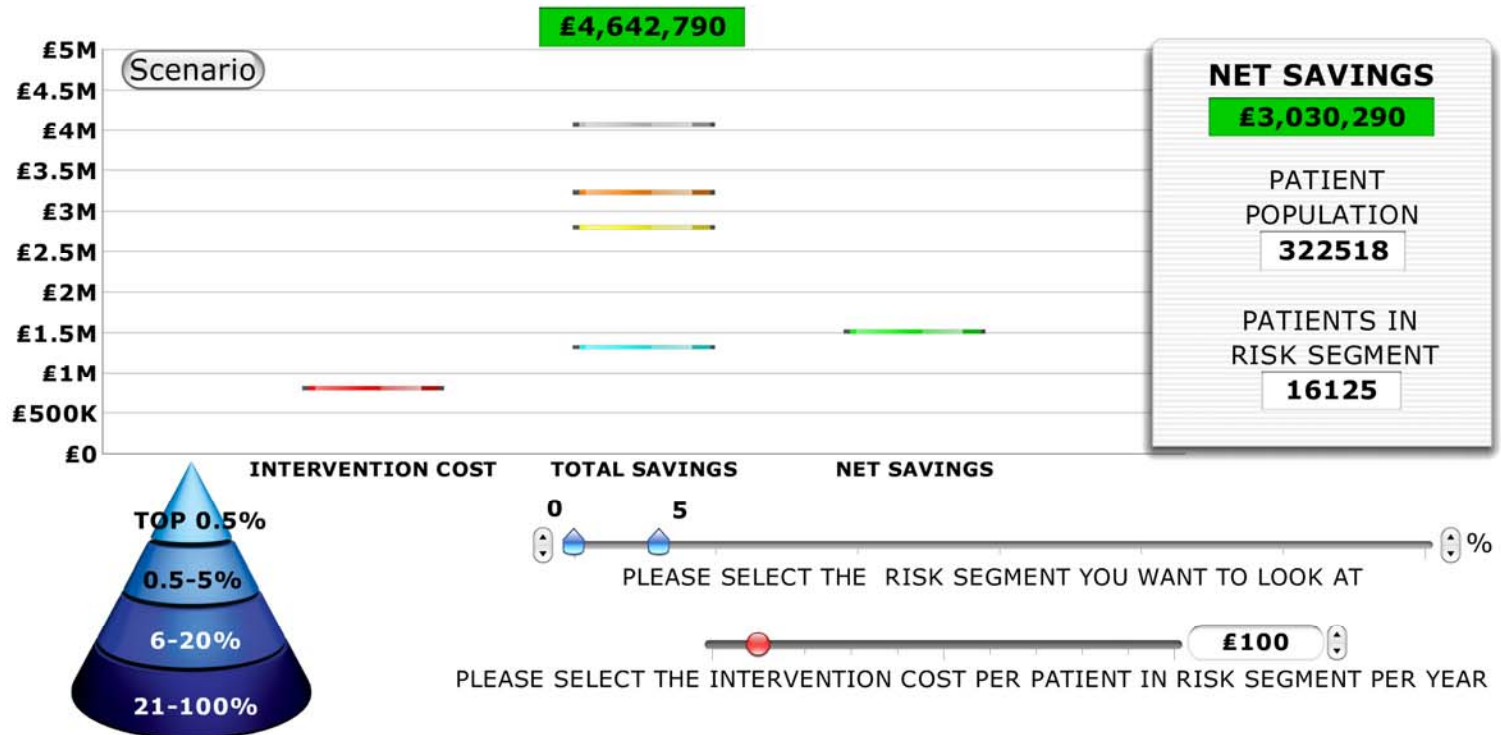
Key Clinical Quality Gaps



Tackling the *Inverse Care Law*



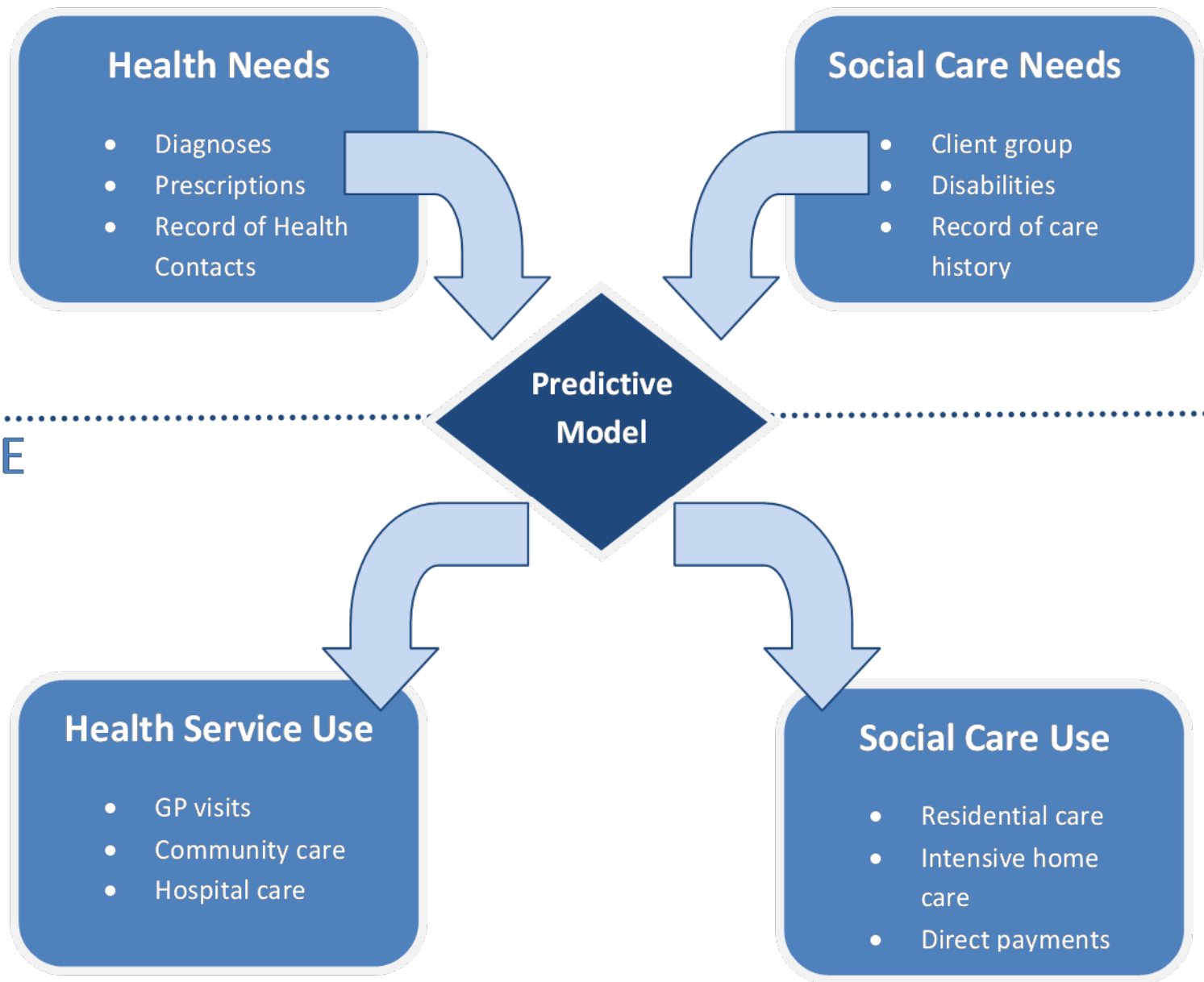
Developing Business Cases

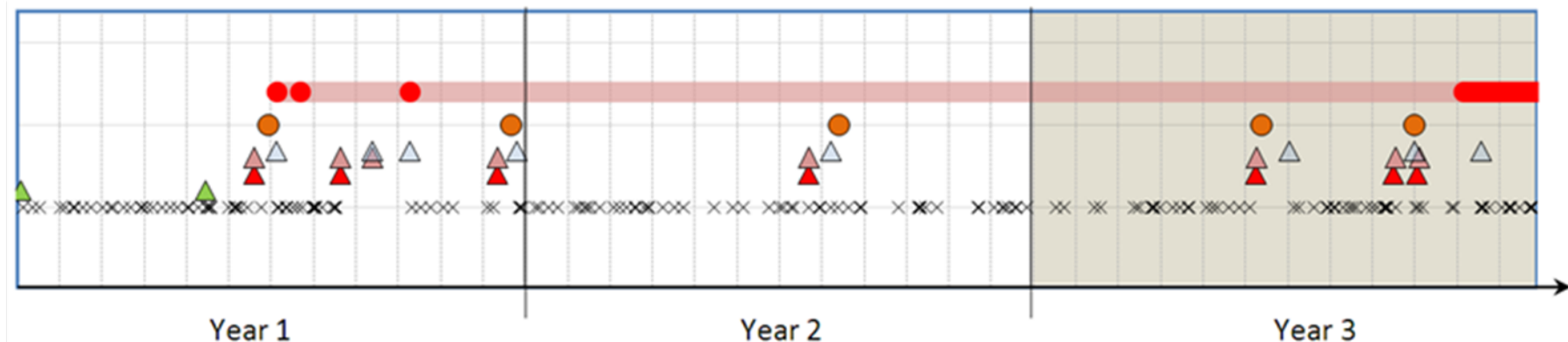


IP Emergency Admissions	6304	Intervention impact rate	0.20	Estimated cost of admission	£2,100
IP Other Admissions	3337	Intervention impact rate	0.10	Estimated cost of admission	£900
AE Visits	11152	Intervention impact rate	0.20	Estimated cost of visit	£250
OP Visits	56859	Intervention impact rate	0.20	Estimated cost of visit	£100

Note: Utilisation rates are for year following prediction

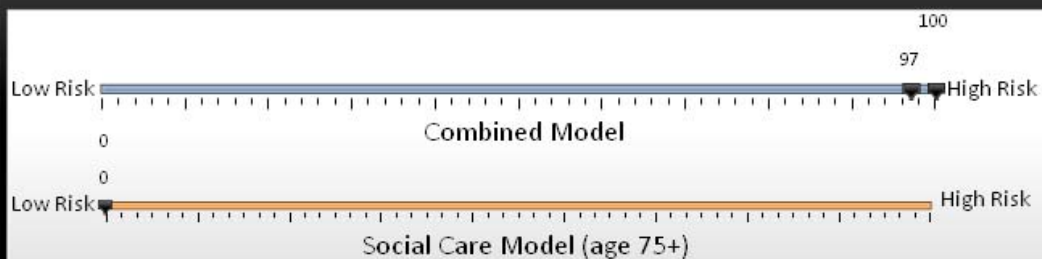
PAST
FUTURE





- High intensity social care service
- Other social care service
- Social care assessment
- △ Inpatient - discharge
- △ Inpatient - admission
- ▲ A&E visit
- ▲ Outpatient visit
- × GP visit

Choice of Patients



No. Combined Model Patients

1551

Overlap Individuals

0

No. Social Care Model Clients

0

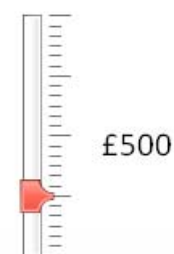
Individuals Selected

1551

NHS Costly Events

	No. of Events	Cost of Each Event	Total Cost	Effectiveness of Intervention	Saving
Emergency Admit	1526	£2500	£3.8M		£763k
Elective Admissions	1166	£1000	£1.2M		£233.2k
Outpatient Visits	1540	£200	£1.1M		£220.4k
A&E Visits	5509	£300	£462k		£92.4k

Intervention Cost



NHS Investment

£757.1k

Council Investment

£18.4k

Costly Social Services (Weeks)

	No. of Events	Cost of Each Event	Total Cost	Effectiveness of Intervention	Saving
Care Home	236	£250	£59k		£11.8k
Intense Home Care	201	£500	£100.5k		£20.1k

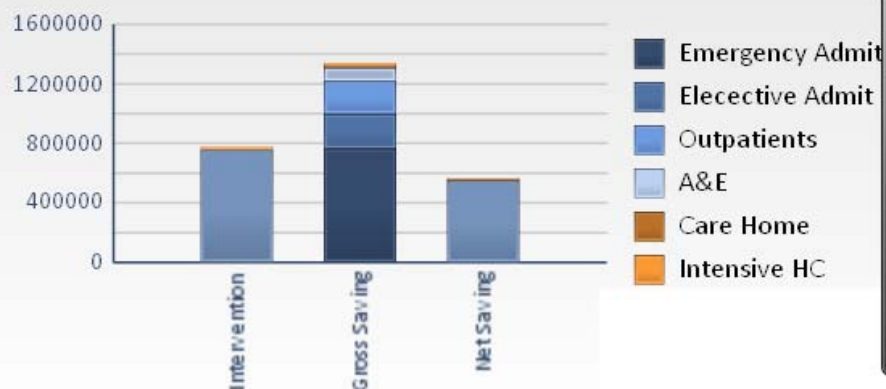
Pro-Rata Split

NHS

98%

Council

2%



Net Savings

Net NHS Savings

£538.8k

Net Council Savings

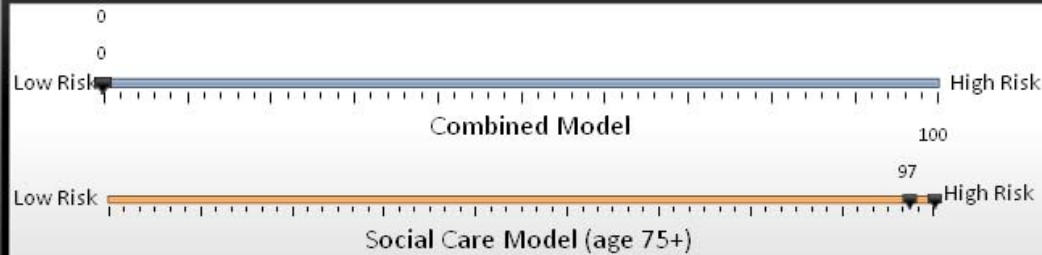
£13.1k

System Savings



+£551.9k

Choice of Patients



No. Combined Model Patients

0

Overlap Individuals

0

No. Social Care Model Clients

1551

Individuals Selected

1551

NHS Costly Events

	No. of Events	Cost of Each Event	Total Cost	Effectiveness of Intervention	Saving
Emergency Admit	1032	£2500	£2.6M		£516k
Elective Admissions	437	£1000	£437k		£87.4k
Outpatient Visits	1027	£200	£559.8k		£112k
A&E Visits	2799	£300	£308.1k		£61.6k

Intervention Cost



NHS Investment

£725.8k

Council Investment

£49.7k

Costly Social Services (Weeks)

	No. of Events	Cost of Each Event	Total Cost	Effectiveness of Intervention	Saving
Care Home	375	£250	£93.8k		£18.8k
Intense Home Care	345	£500	£172.5k		£34.5k

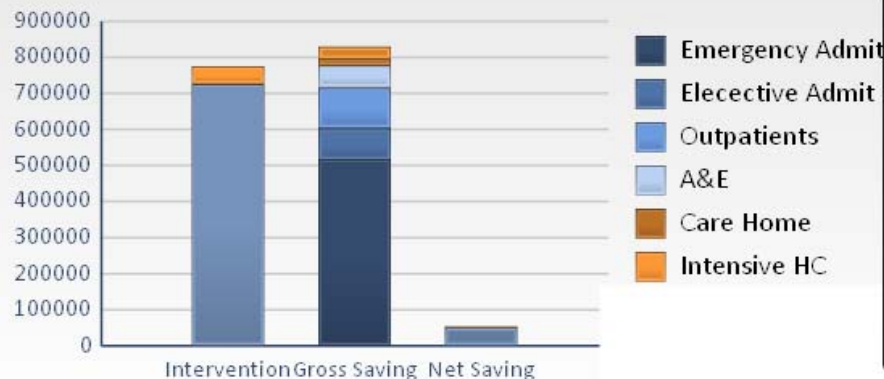
Pro-Rata Split

NHS

94%

Council

6%



Net Savings

Net NHS Savings

£47.9k

Net Council Savings

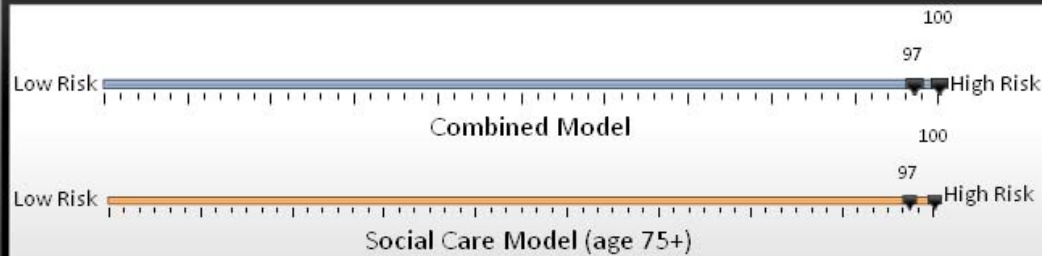
£3.3k

System Savings



+£51.2k

Choice of Patients



No. Combined Model Patients

1551

Overlap Individuals

578

No. Social Care Model Clients

1551

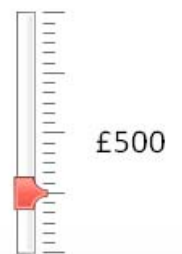
Individuals Selected

2524

NHS Costly Events

	No. of Events	Cost of Each Event	Total Cost	Effectiveness of Intervention	Saving
Emergency Admit	2064	£2500	£5.2M		£1M
Elective Admissions	1380	£1000	£1.4M		£276k
Outpatient Visits	2070	£200	£1.4M		£278.2k
A&E Visits	6955	£300	£621k		£124.2k

Intervention Cost



NHS Investment

£1.2M

Council Investment

£45.8k

Costly Social Services (Weeks)

	No. of Events	Cost of Each Event	Total Cost	Effectiveness of Intervention	Saving
Care Home	455	£250	£113.8k		£22.8k
Intense Home Care	416	£500	£208k		£41.6k

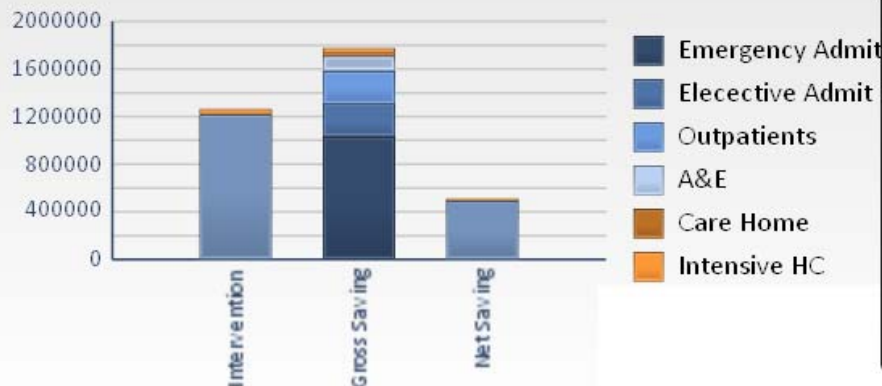
Pro-Rata Split

NHS

96%

Council

4%



Net Savings

Net NHS Savings

£476.2k

Net Council Savings

£17.9k

System Savings



+£494.2k



Model predicts:					
Details					
Examples					



Trend

Model predicts:	Cost				
Details	Model predicts which patients will <i>become</i> high-cost over next 6 or 12 months				
Examples	Low-cost patient this year will become high-cost next year				



Trend

Model predicts:	Cost	Event			
Details	Model predicts which patients will <i>become</i> 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			



Trend

Model predicts:	Cost	Event	Actionability		
Details	Model predicts which patients will <i>become</i> high-cost over next 6 or 12 months	Model predicts which patients will have an event that can be avoided	Model predicts which patients have features that can readily be changed		
Examples	Low-cost patient this year will become high-cost next year	Patient will be hospitalized Patient will have diabetic ketoacidosis	Patient has angina but is not taking aspirin Patient does not have pancreatic cancer (Ambulatory Care Sensitive)		



Trend

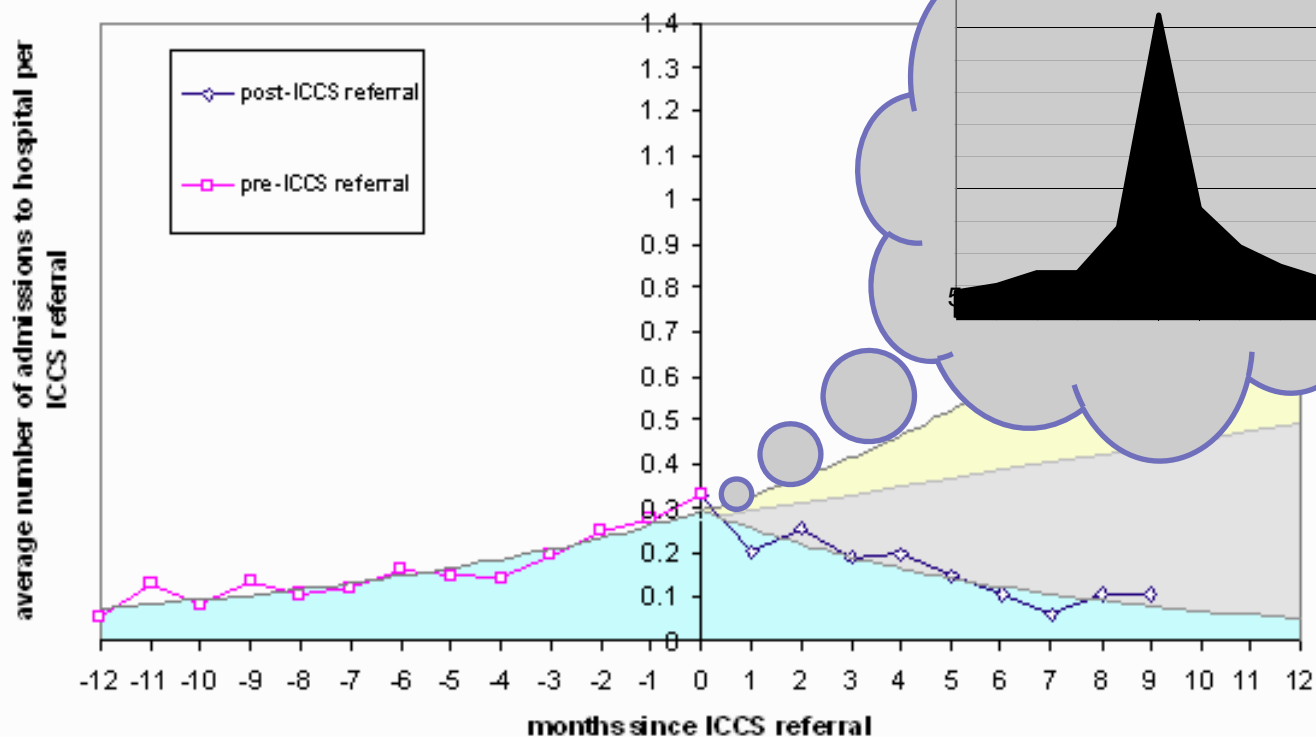
Model predicts:	Cost	Event	Actionability	Readiness to engage	
Details	Model predicts which patients will <i>become</i> high-cost over next 6 or 12 months	Model predicts which patients will have an event that can be avoided	Model predicts which patients have features that can readily be changed	Model predicts which patients are most likely to engage in upstream care	
Examples	Low-cost patient this year will become high-cost next year	Patient will be hospitalized Patient will have diabetic ketoacidosis	Patient has angina but is not taking aspirin Patient does not have pancreatic cancer (Ambulatory Care Sensitive)	Patient does not abuse alcohol Patient has no mental illness Patient previously compliant	



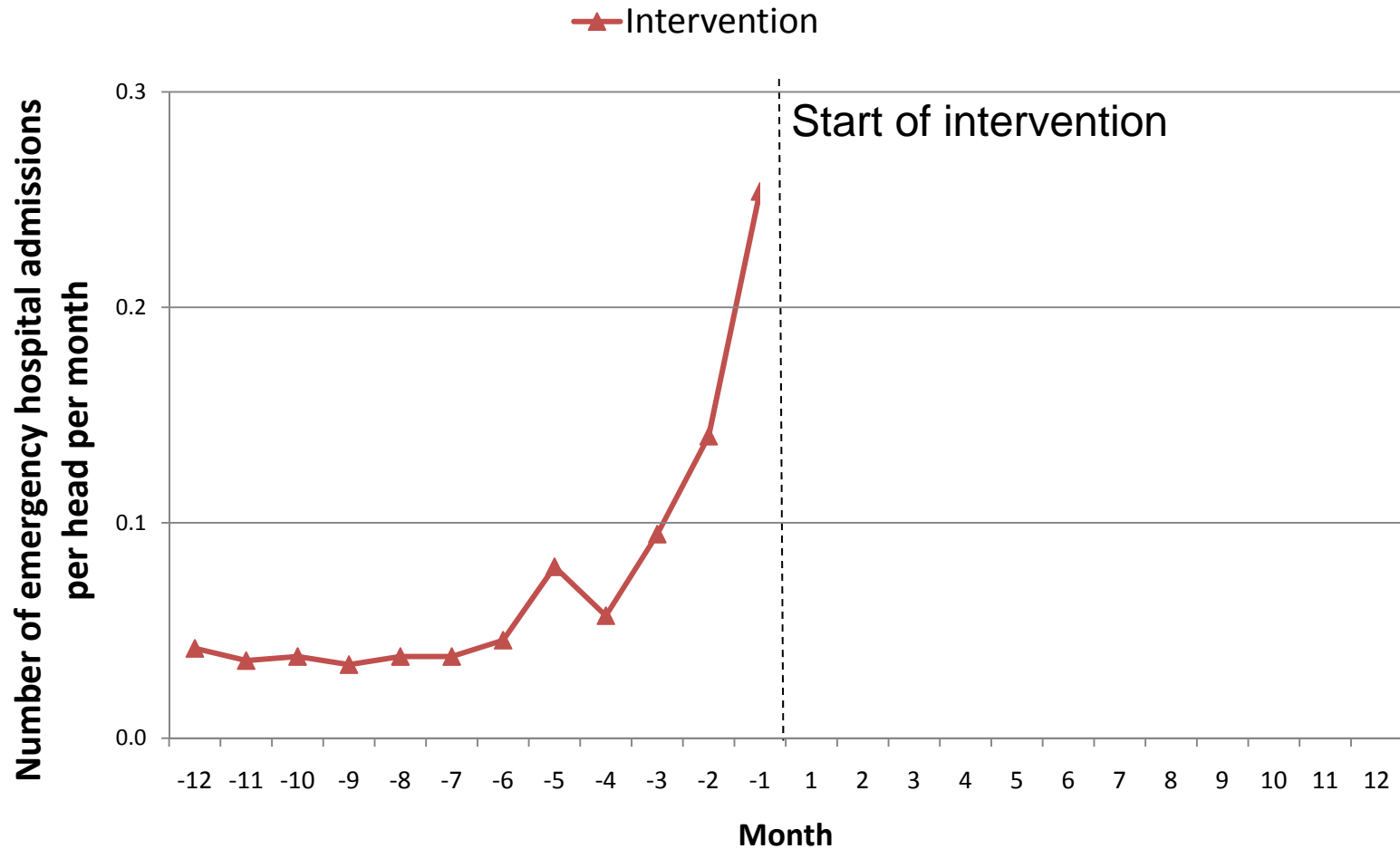
Trend

Model predicts:	Cost	Event	Actionability	Readiness to engage	Receptivity
Details	Model predicts which patients will <i>become</i> high-cost over next 6 or 12 months	Model predicts which patients will have an event that can be avoided	Model predicts which patients have features that can readily be changed	Model predicts which patients are most likely to engage in upstream care	Model predicts what mode and form of intervention will be most successful for each patient
Examples	Low-cost patient this year will become high-cost next year	<p>Patient will be hospitalized</p> <p>Patient will have diabetic ketoacidosis</p>	<p>Patient has angina but is not taking aspirin</p> <p>Patient does not have pancreatic cancer (Ambulatory Care Sensitive)</p>	<p>Patient does not abuse alcohol</p> <p>Patient has no mental illness</p> <p>Patient previously compliant</p>	<p>Patient prefers email rather than telephone</p> <p>Patient prefers male voice rather than female</p> <p>Readiness to change</p>

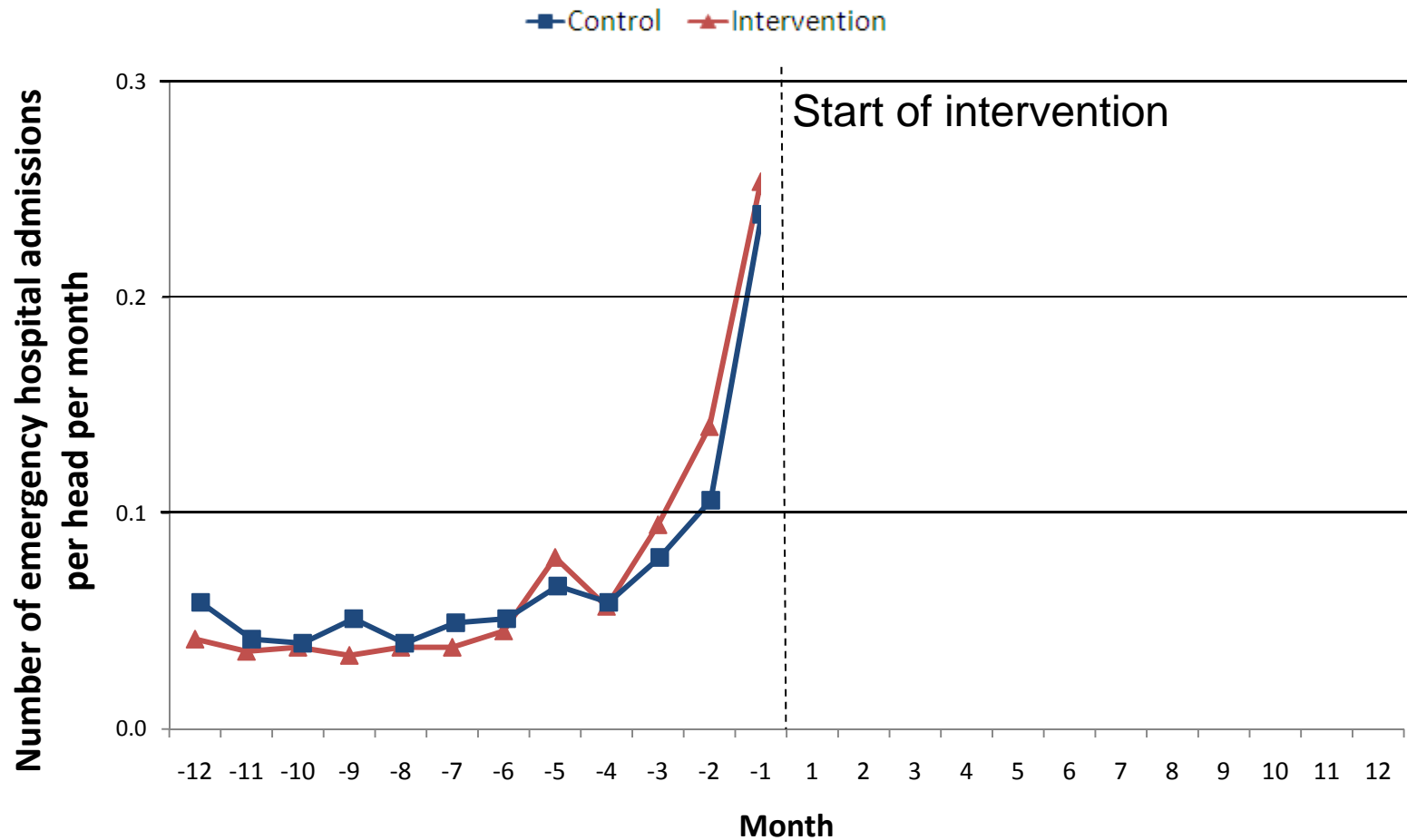
Evaluation of Integrated Care



Overcoming regression to the mean using a control group (1)

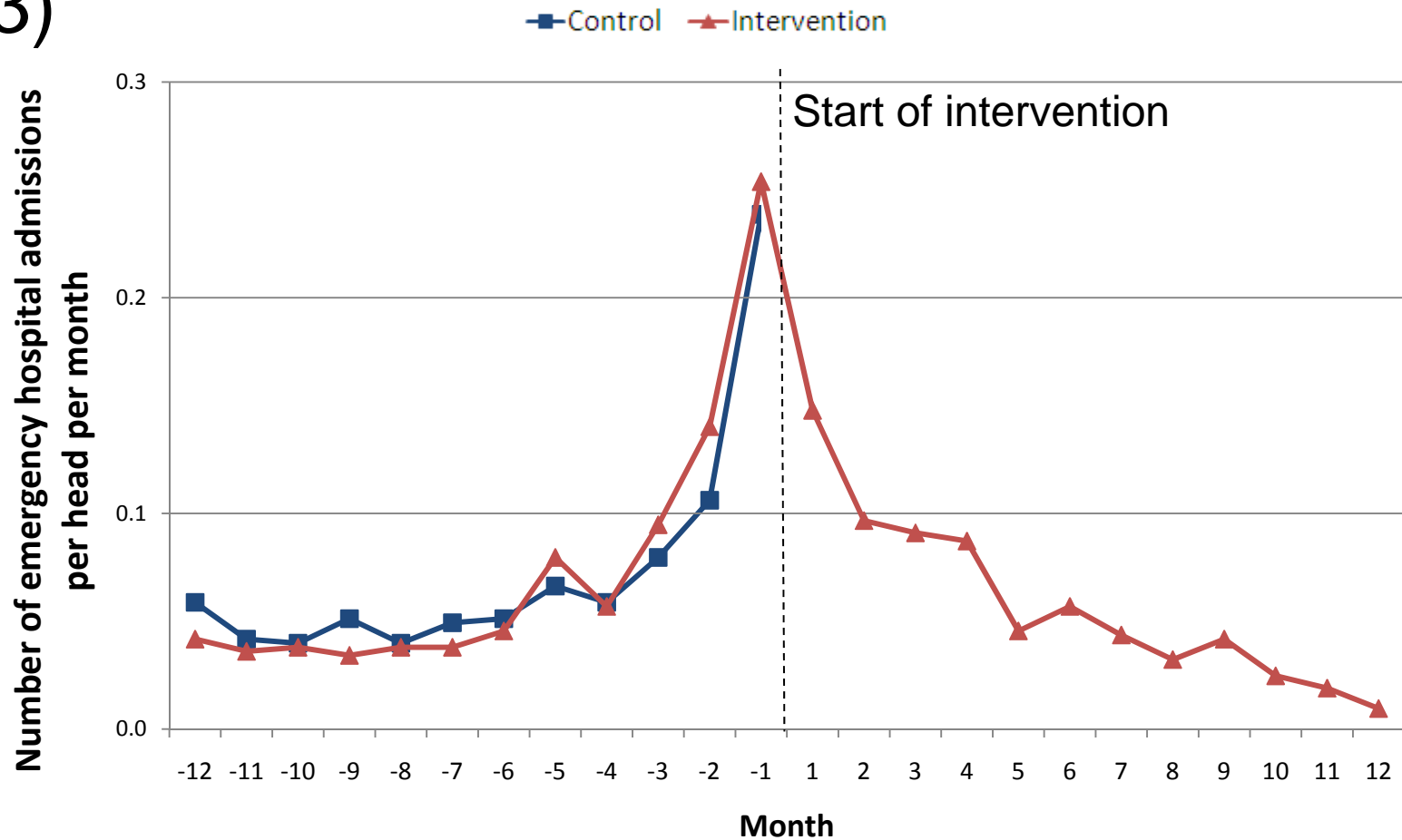


Overcoming regression to the mean using a control group (2)

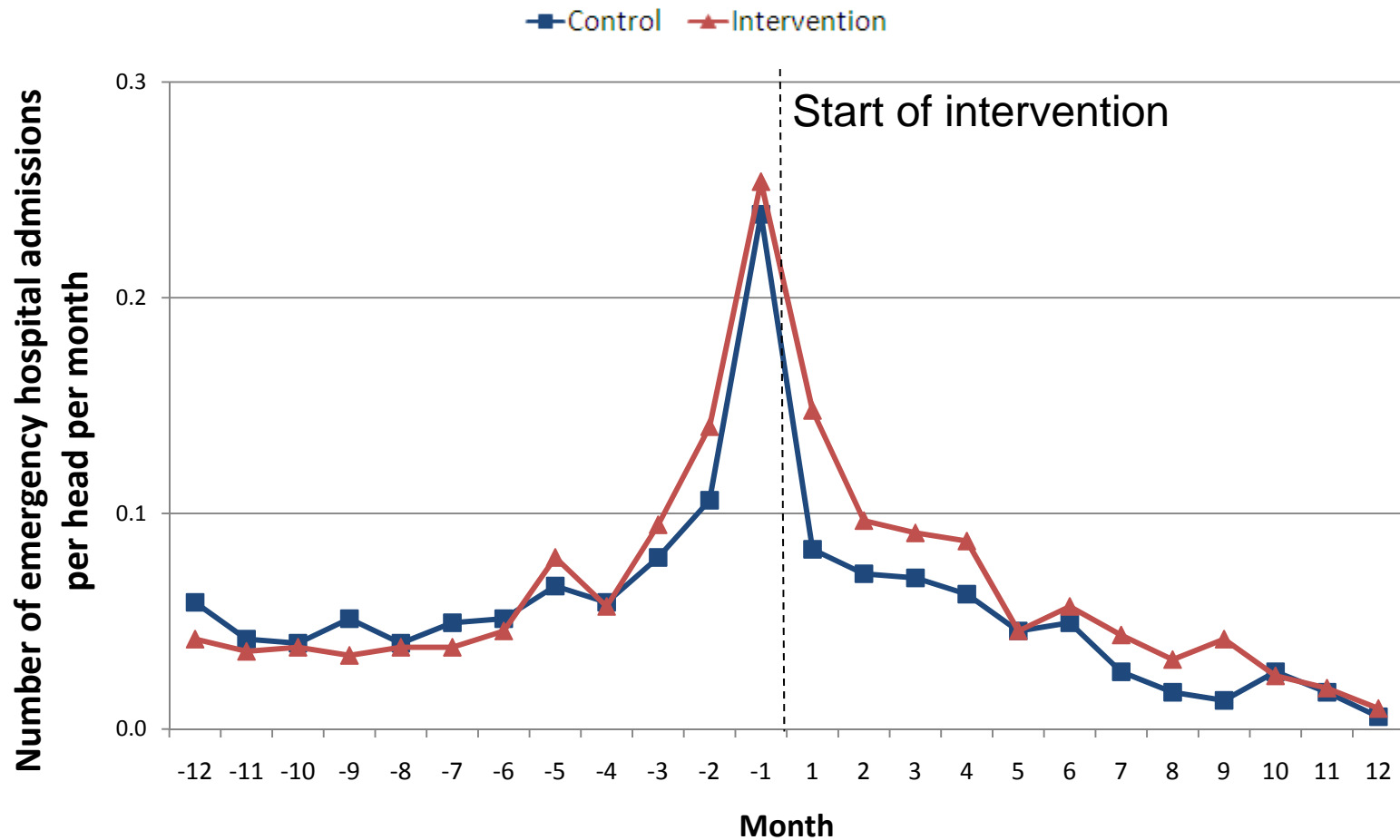


Overcoming regression to the mean using a control group

(3)



Overcoming regression to the mean using a control group (4)





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