

# Predictive Risk Modelling Adverse Outcomes for Children: Case Studies from New Zealand

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# Today's Talk

1. Background
2. Outline two case studies of predictive risk modelling projects in New Zealand: (i) maltreatment; and (ii) hospitalisation

# Targeting Preventive Care

Home visitation to..

**prevent** maltreatment

Chronic disease management to..

**prevent** re-hospitalisation

How well do health and social care systems

choose children

for preventive services?

# Threshold Models

Recruit people on the basis of a

*list* of characteristics

observed by a frontline **clinician**

## FAMILY START Referral Criteria

List A sets out the main criteria for Family Start. Families need to experience challenges in one of these areas to be referred.

List B sets out other areas where families may have challenges. If you feel that a parent has high needs but does not 'fit' into the Family Start criteria then explain, using indicators in List B, why an exception should be made for this family.

LIST A. Family Start criteria	DESCRIPTION
Mental health issues	<p>Either parent/carer has a mental health problem, for example:</p> <ul style="list-style-type: none"><li>• Post-natal depression</li><li>• Anxiety</li><li>• Depression</li><li>• Self-harm or suicidal tendencies</li><li>• Other (specify)</li></ul> <p>Is this current or historic?</p> <p>Are they receiving any assistance or professional services for this?</p>
Difficulties with drugs, alcohol or gambling	<p>Either parent/carer has a problem with one of the following which affects parenting ability:</p> <ul style="list-style-type: none"><li>• Alcohol use</li><li>• Illicit drug use</li><li>• Gambling</li></ul> <p>Are they are receiving any assistance from other professional services for this?</p>
Childhood history of abuse	Either parent/carer experienced abuse as a child or young person.

Admissions criteria for a NZ home visiting program  
called "Family Start"

# Do they work?

- Qualitative evidence that frontline workers “distort” inputs to get the classification that they want
- “*FRET (an actuarial tool for ) is fairly useless as it always gives high or very high – they do not automatically open very high cases as they do not have the staff to do so*”

• [P Gillingham and Humphreys \(2010\)](#)(interview subjects quoted on p 9).

# Threshold models in hospital avoidance programs

“Aged over 65 years old and has 2 or more admissions in the past 12 months”

Admissions criteria for a US hospital avoidance program called Evercare



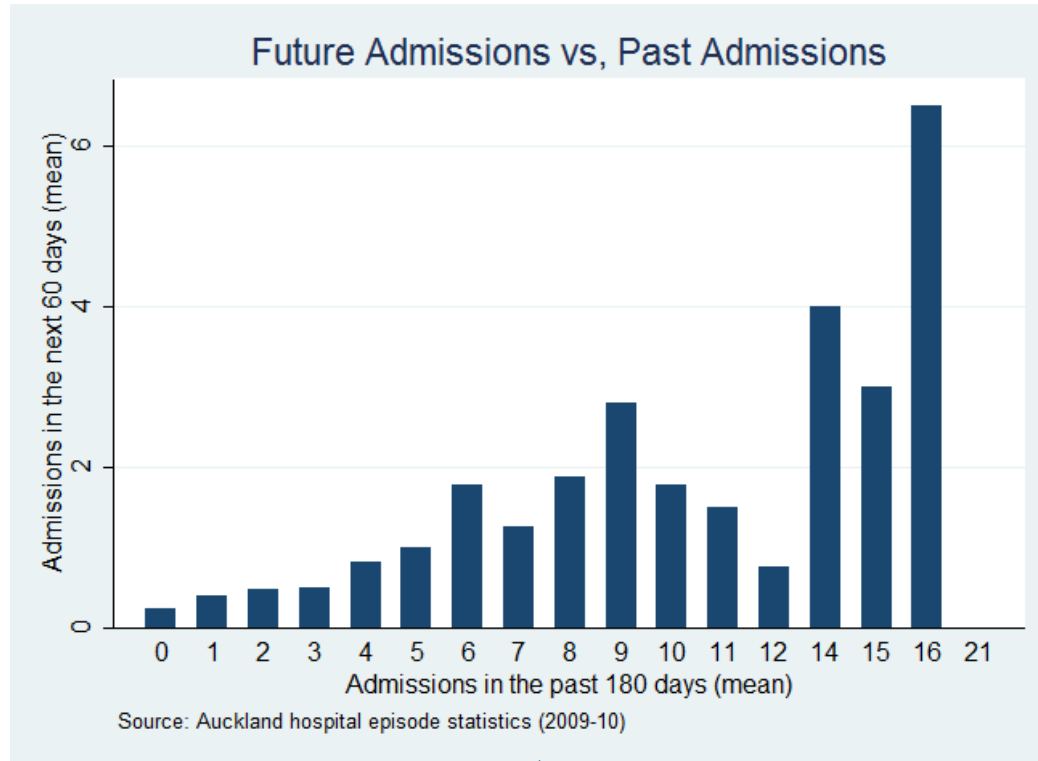
For hospitalisation,

past utilisation

is not a good measure

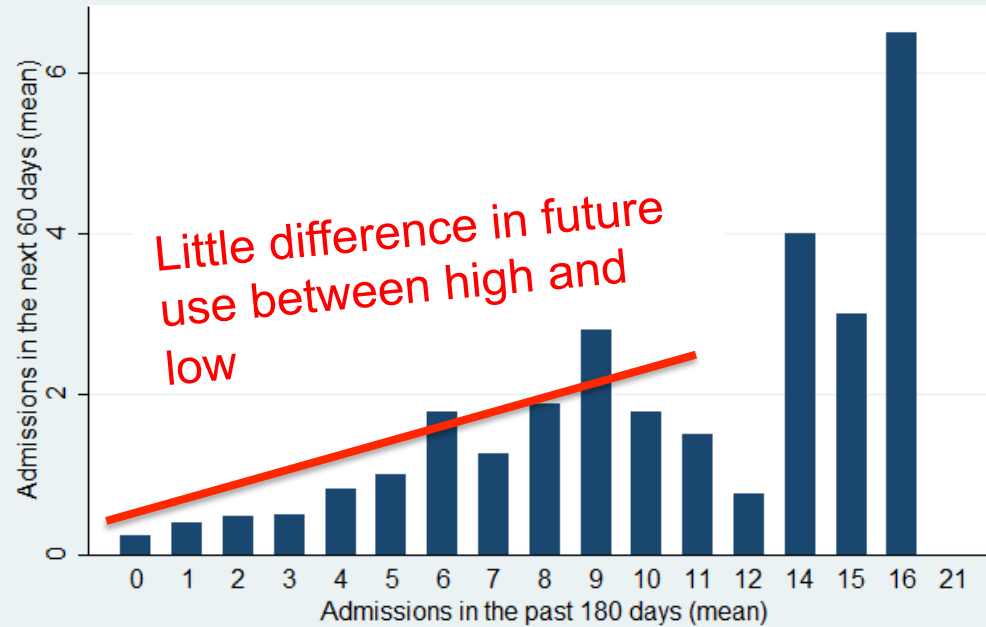
of future utilisation?

future  
admission  
s



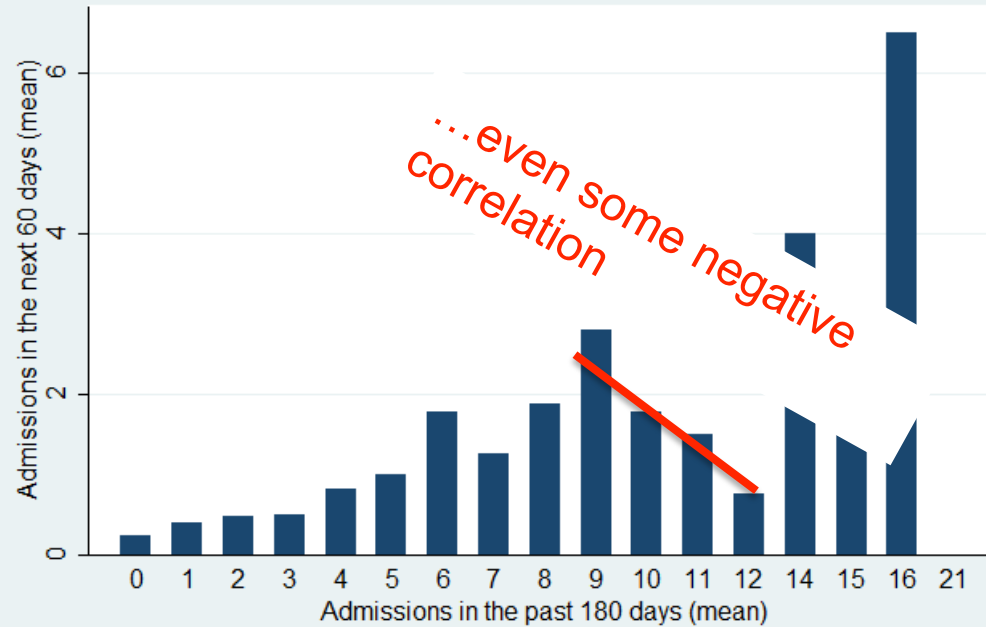
Past admissions

### Future Admissions vs, Past Admissions



Source: Auckland hospital episode statistics (2009-10)

## Future Admissions vs, Past Admissions



Source: Auckland hospital episode statistics (2009-10)

# What's wrong with threshold models?

- Operators distort inputs to get the outcomes they want
- Expensive to administer – so only a small population can be screened

# What's wrong with threshold models?

- Not developed or validated on the population
  - ODARA is used by the New Zealand police for family violence callouts but not validated on New Zealand population
  - LACE index is used in Ontario for readmission risk but found not to be valid for the NHS\*

\* See Cotter, Paul E., et al. "Predicting readmissions: poor performance of the LACE index in an older UK population." *Age and ageing* 41.6 (2012): 784-789.

# Predictive Risk Modeling (PRM)

Automatic risk scoring tool  
which generates a **risk score**  
for an adverse event based  
on **large administrative**  
**dataset**

# Use of PRM in Health and Social Care

- Most advanced in the prediction of re-hospitalisation risk\*
- Is known as “predictive analytics” – and routinely used in private firms

\* see Kansagara, Devan, et al. "Risk prediction models for hospital readmission: a systematic review." *JAMA* 306.15 (2011): 1688-1698



# Advantages

- Cost effective screening of large populations  
e.g. all hospital admissions or all births
- No human factor involvement
- Risk score is a “continuum”
- Built from the same data as the population

# Disadvantages

- “Black Box”
- Resistance by clinicians and frontline staff
- Only as good as the preventive intervention
- Risk is not the same as “amenability” to the intervention

# Case Study 1: Predicting Child Maltreatment in New Zealand

# Objective of this Project

Can PRM be used to identify children (and pre-births) at high risk of a finding of maltreatment?

What are the practical issues to doing this?

# Two Prototypes Developed

*Prototype I:* Using the Public Benefit system to identify children at risk\* (~ 33% of a birth cohort)

*Prototype II:* “Using birth registry or public benefit system to identify children at risk\*\* (~94% of a birth cohort by age 3 months, ~98% by age 6 months)

\*Vaithianathan, R., Maloney, T., Putnam-Hornstein, E., & Jiang, N. (2013). Children in the public benefit system at risk of maltreatment: Identification via predictive modelling. *American journal of preventive medicine*, 45(3), 354-359.

\*\*Ministry of Social Development (2013) The feasibility of using predictive risk modelling to identify new-born children who are at high risk of future maltreatment. Unpublished report. Wellington.

# Prototype I: How it would work

A family registers on to the public benefit system

→ there is a <2-year-old child in the family

That **night** the system harvests

Public benefit data set..

- ✓ Demographics of Primary Caregiver
- ✓ Demographics of Partner
- ✓ Previous benefits

Child Protection Data Sets...

Was Caregiver themselves abuse victim or known to CYF care and protection or youth justice services?

- ✓ Previous children with CYF contact?
- ✓ Previous children taken into care?

That **night** the system harvests

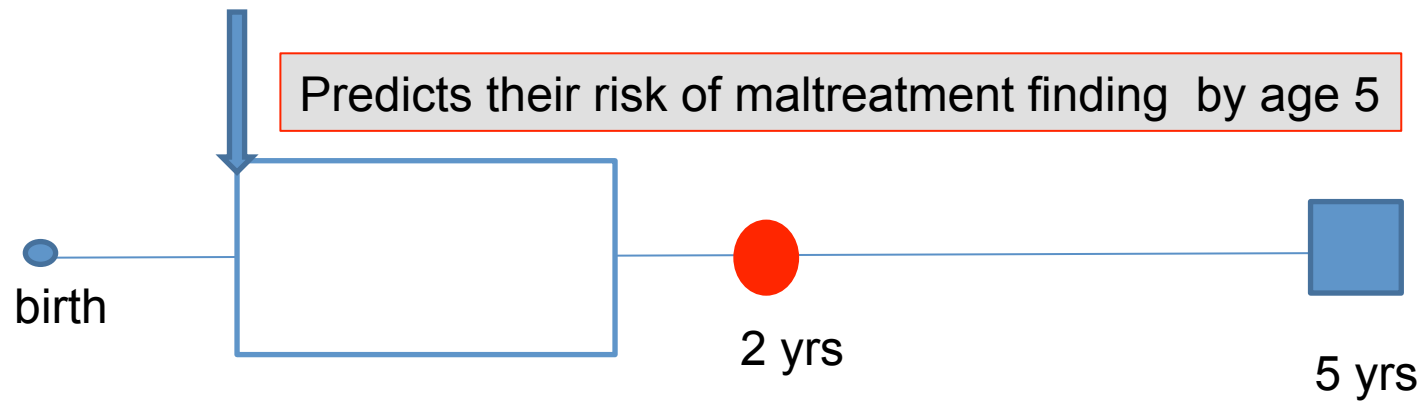
“SWIFTT” Data..

- ✓ Time since last prison spell of caregiver
- ✓ Caregiver is a refugee
- ✓ Foreign Born



## Core Risk Scoring Algorithm

Applied at start of a spell  
for child under 2 years



**Maltreatment** is a substantiated **finding** of

EMOTIONAL  
NEGLECT  
PHYSICAL or  
SEXUAL ABUSE

By age 5

Finding is only a subset of actual incidence due to under-reporting

# Data

- linkages between New Zealand's public benefit and child protection systems
- linked by the New Zealand Ministry of Social Development for the purposes of research
- Matched using a probabilistic algorithm that consisted of names, birth dates, and other personal identifiers

# Cohort Used to Develop Algorithm

- Born between January 1, 2003, and June 1, 2006 and observed in the public benefit system between the start of the mother's pregnancy and age 2.
- 103,397 public benefit spells, reflecting 57,986 unique children
- Used pseudonymised data – destroyed after use

# Baseline

5.4% of all children (born between 2003 and 2006) are maltreated by age 5

Of children **seen on a benefit** by age 2, 13% are maltreated by age 5

Of children **never seen** on a benefit by age 2, 1.5% are maltreated by age 5

# Baseline

Percentage neglected	Percentage emotionally abused	Percentage physically/sexually abused
5.6%	9.4%	1.7%

***10 times the  
risk of breast  
cancer in  
women aged  
50-60\****

# Baseline

Of all children born between 1/03 and 06/06  
who were **maltreated** by age 5

→ 83% are seen on benefits

before age 2



# Predictor Variables

The algorithm is a set of predictor variables and weights attached to each variable

We have a set of 224 predictor variable

We use stepwise probit to choose 132 variables

Develop model using 70% sample

Test on 30% sample

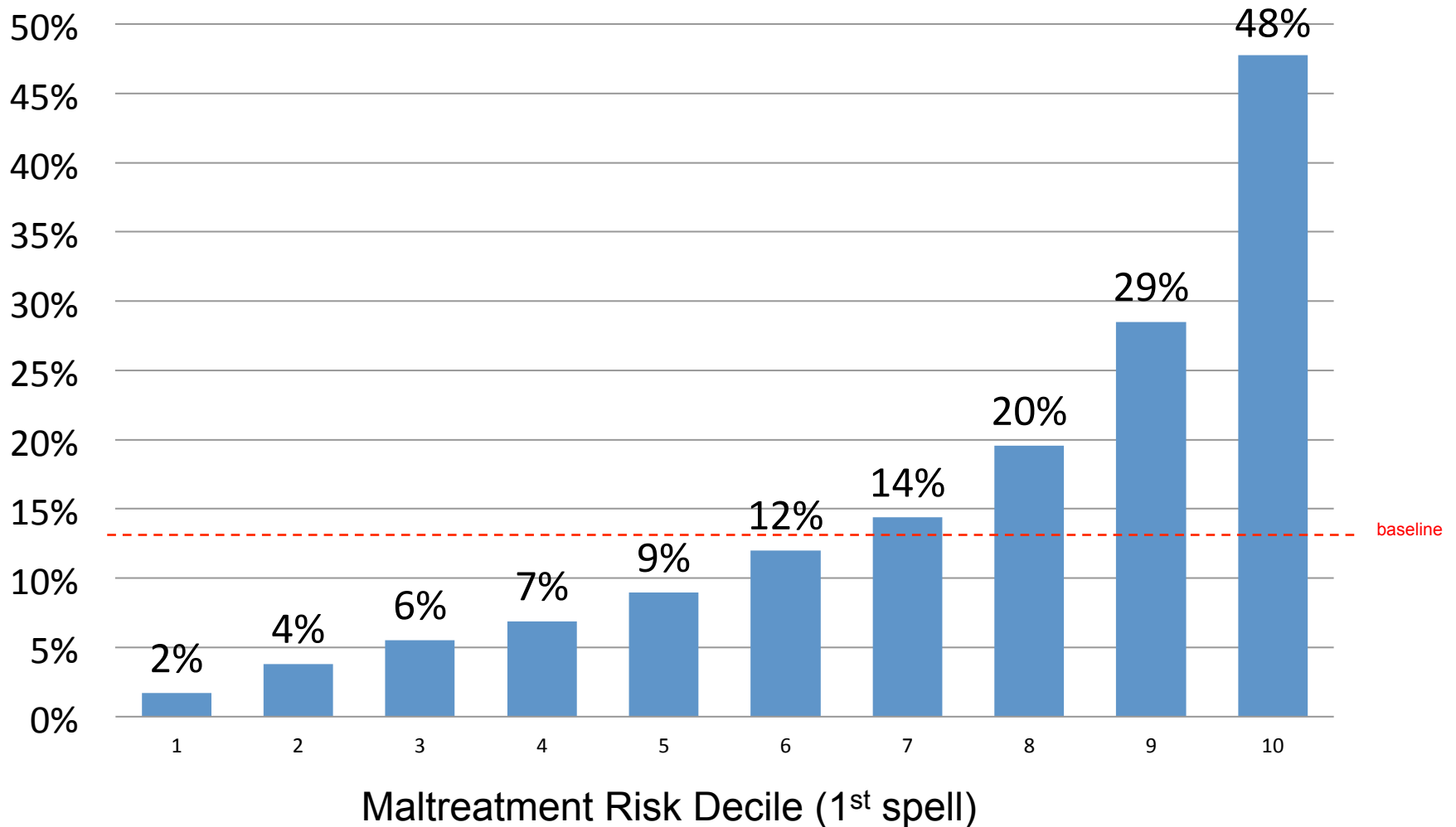


# Examples of variables with large estimated marginal effects

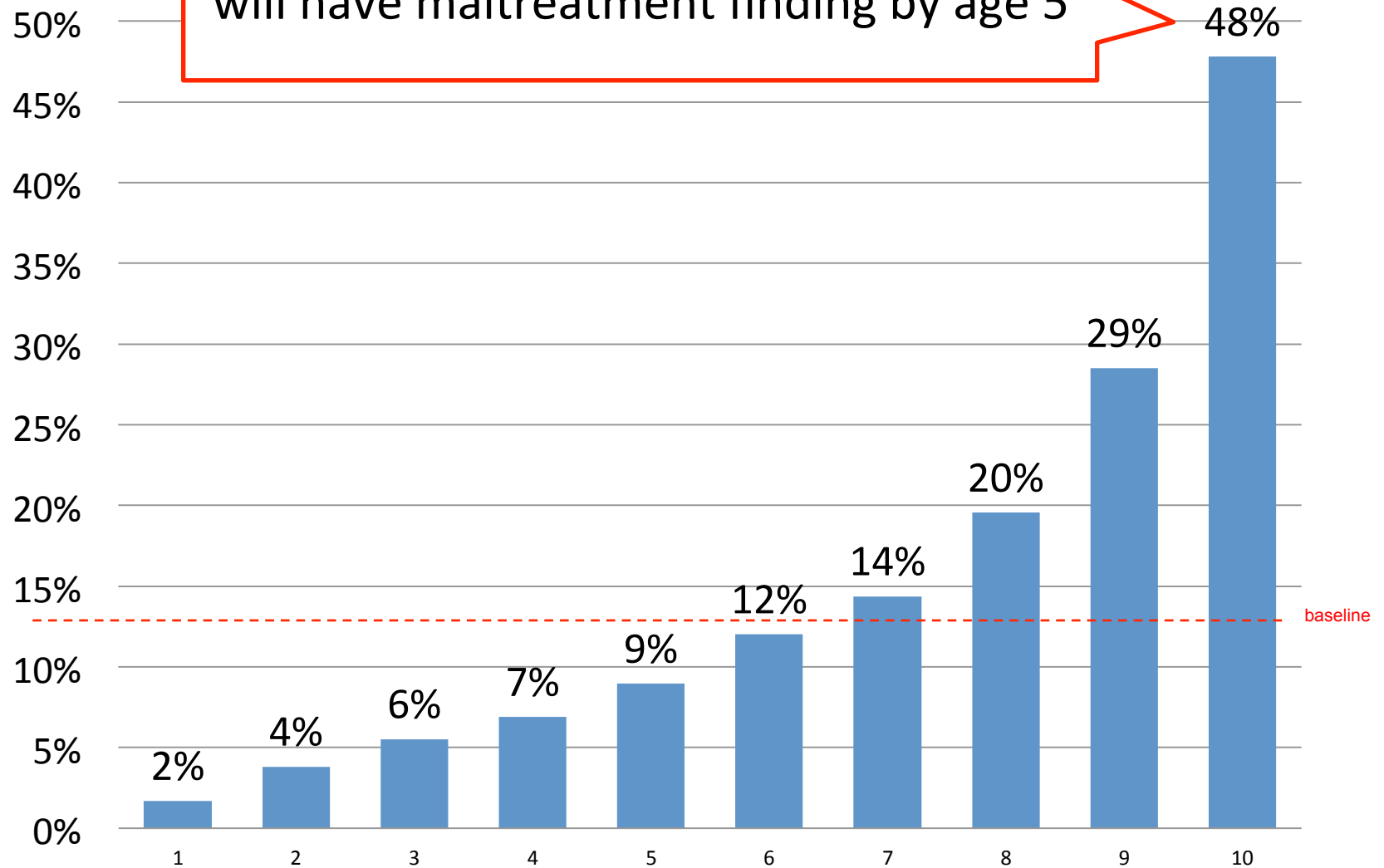
	Marginal Effect	P> z
Prior care and protection Police Family Violence notifications on child with primary CG (Count)	-4.3%	0.0020
Prior court order on child while included in benefit of primary CG (Count)	-4.3%	0.0140
Prior family group conference on child (Count)	-4.0%	0.0900
Primary CG is a refugee based on SWIFTT data (Dummy)	-4.0%	0.0000
Proportion of time of primary CG on incapacity benefit 6-10 years ago (0.00-1.00)	10.2%	0.0000
Proportion of time of primary CG on sickness benefit 6-10 years ago (0.00-1.00)	7.7%	0.0000
Prior care and protection notifications by courts on child with primary CG (Count)	7.2%	0.0640
Single and male primary CG (Dummy)	7.1%	0.0000
Prior care and protection Police Family Violence notifications on child (Count)	6.2%	0.0000

Using this model we can generate  
risk scores from 1 to 10 for each  
child ...

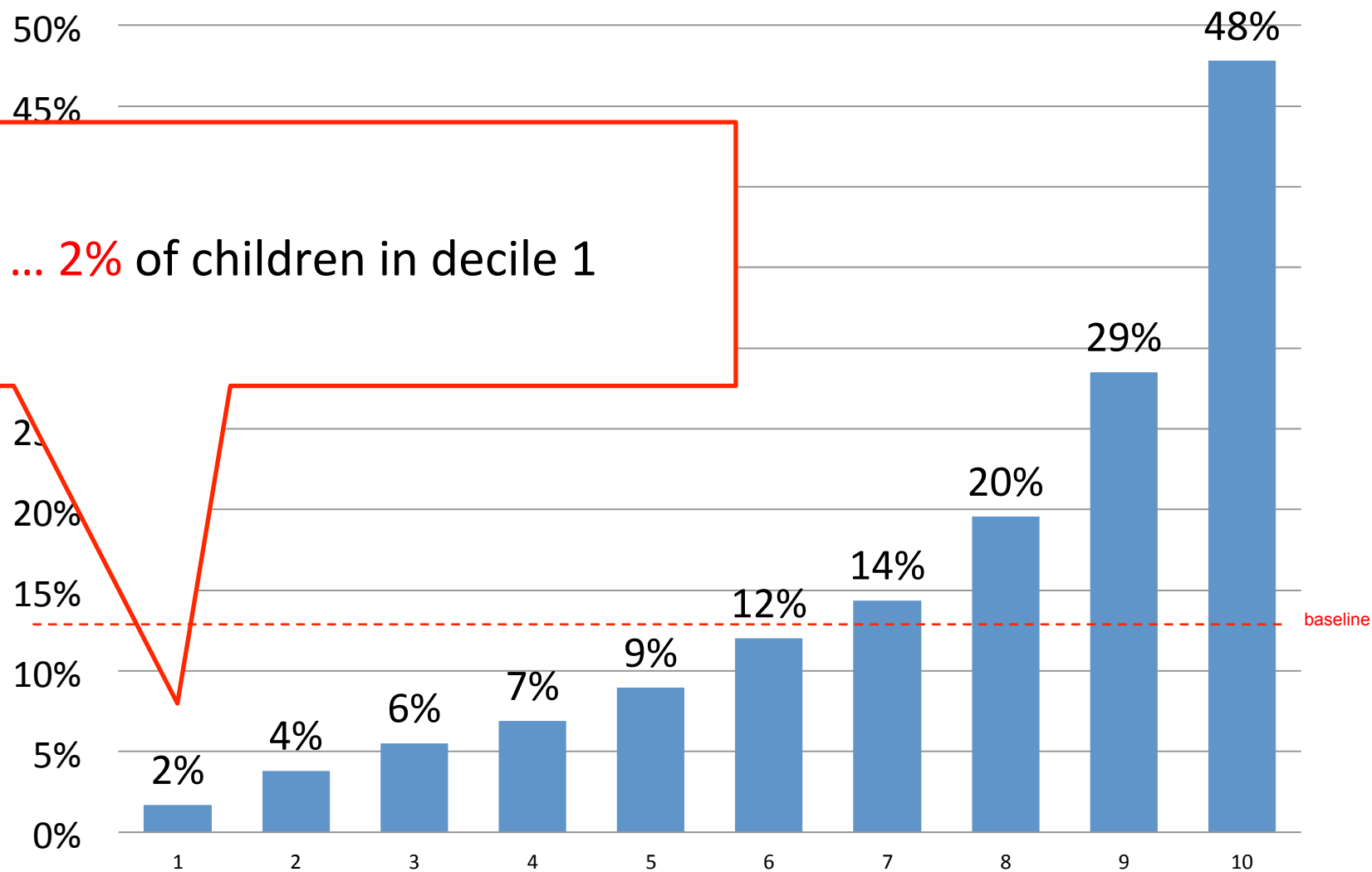
... predicts actual maltreatment rates well



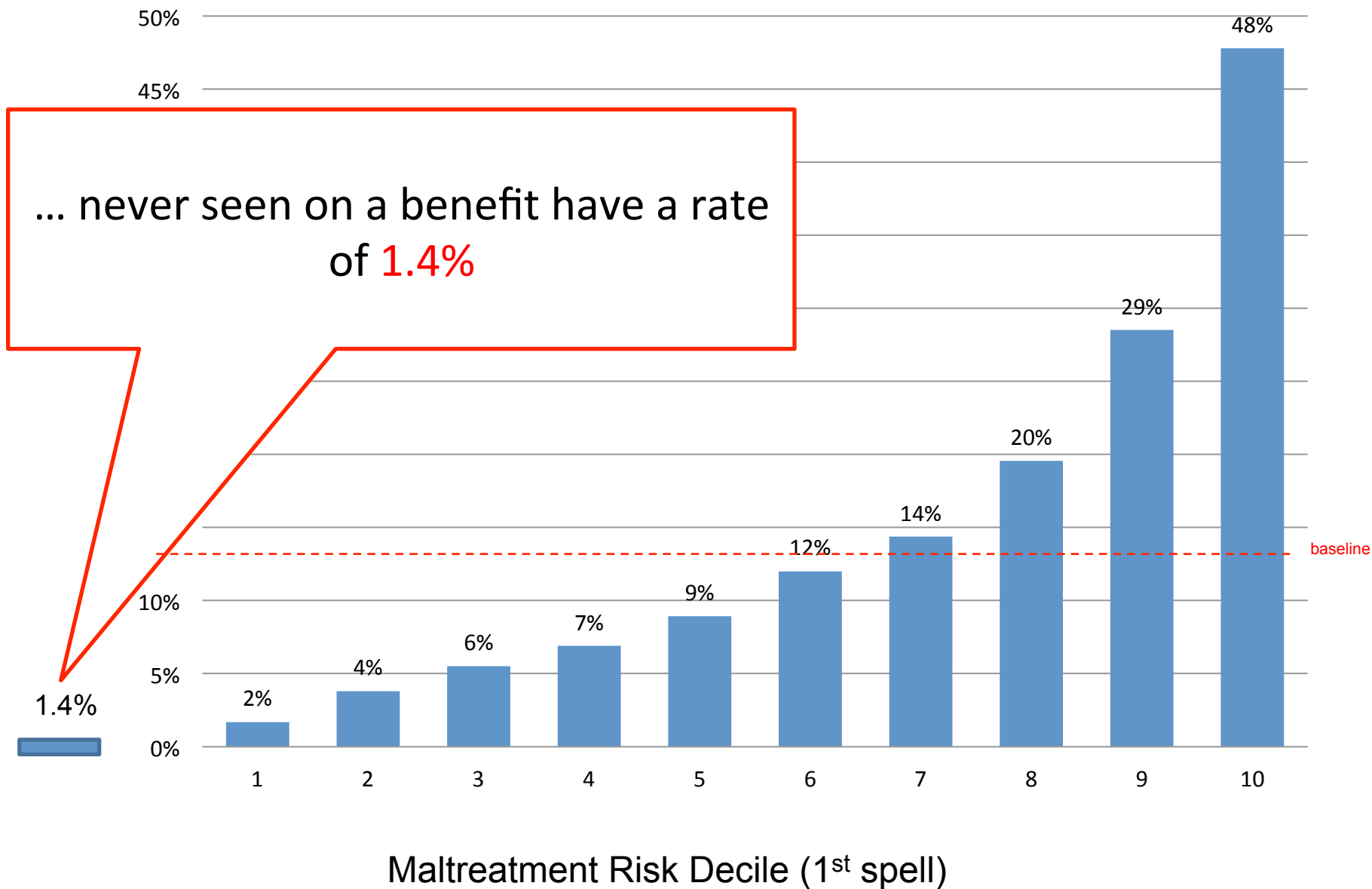
**Half** of children in decile 10  
will have maltreatment finding by age 5



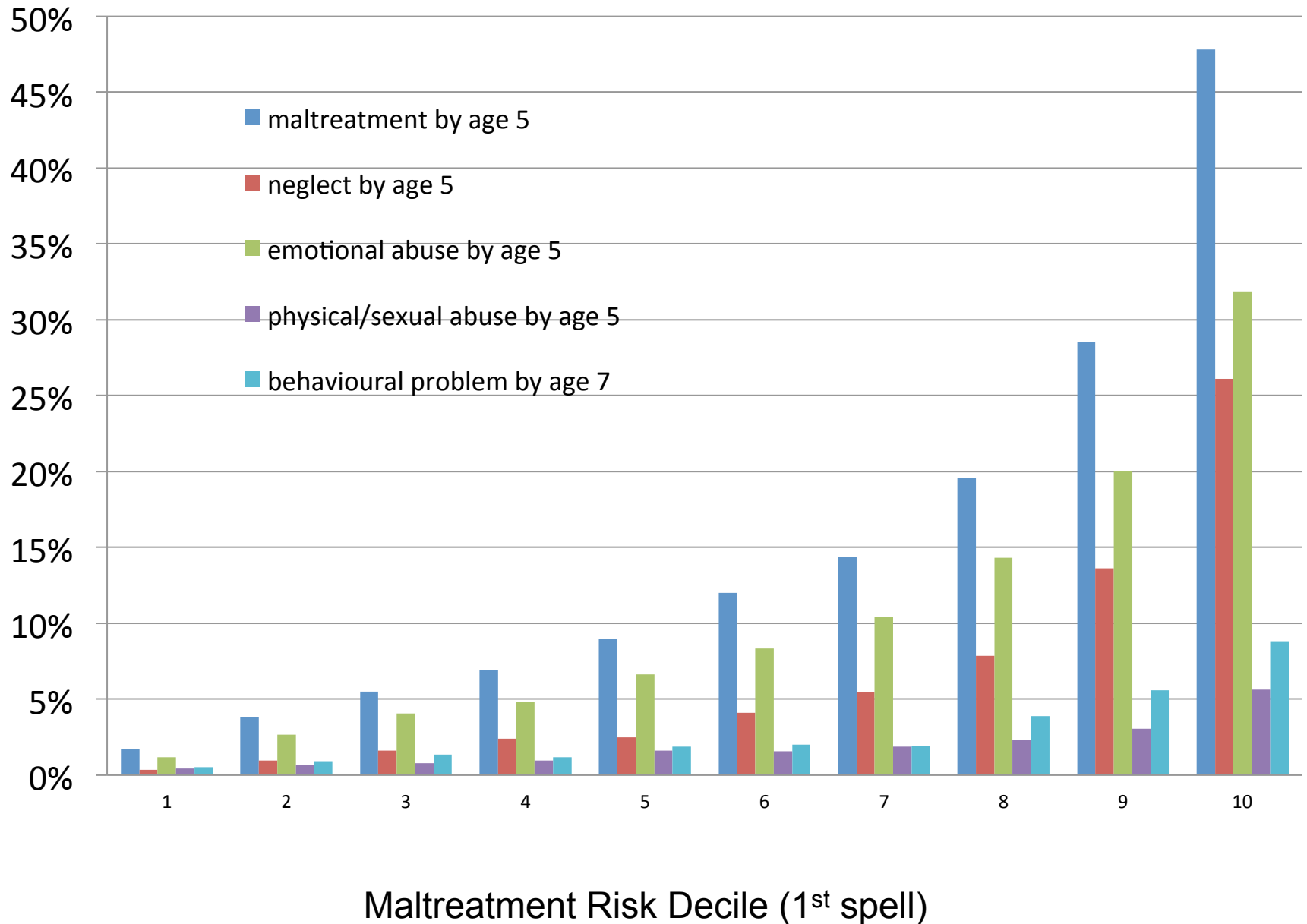
Maltreatment Risk Decile (1<sup>st</sup> spell)



Maltreatment Risk Decile (1<sup>st</sup> spell)



... and is correlated with other outcomes



what proportion of finding  
will be “captured”?

(Based on risk score of the first  
spell)



Targeting the first spells in the top 2 deciles capture about

40 - 50 % of all findings that occur to children on the benefit

# Numbers Needed to Treat (NNT)

20,671 children start a spell aged less than 2 p.a.

Suppose we offered services to those in the top risk deciles

Decile equal to or greater than...	Number of children	True Positives	False Positives
8	5,398	1,624	3,773
9	3,284	1,211	2,073
10	1,425	681	744

## Numbers Needed to Treat (NNT) (to avoid **one** maltreatment finding)

	Efficacy of the Intervention		
Decile equal to or greater than...	10%	25%	50%
8	33	13	7
9	27	11	5
10	21	8	4



NNT for statins as secondary prevention is around 30\*

	Efficacy of the Intervention		
Decile equal to or greater than...	10%	25%	50%
8	33	13	7
9	27	11	5
10	21	8	4

\*Source: J R Soc Med. 2004  
October; 97(10): 461–464  
Thompson and Temple.

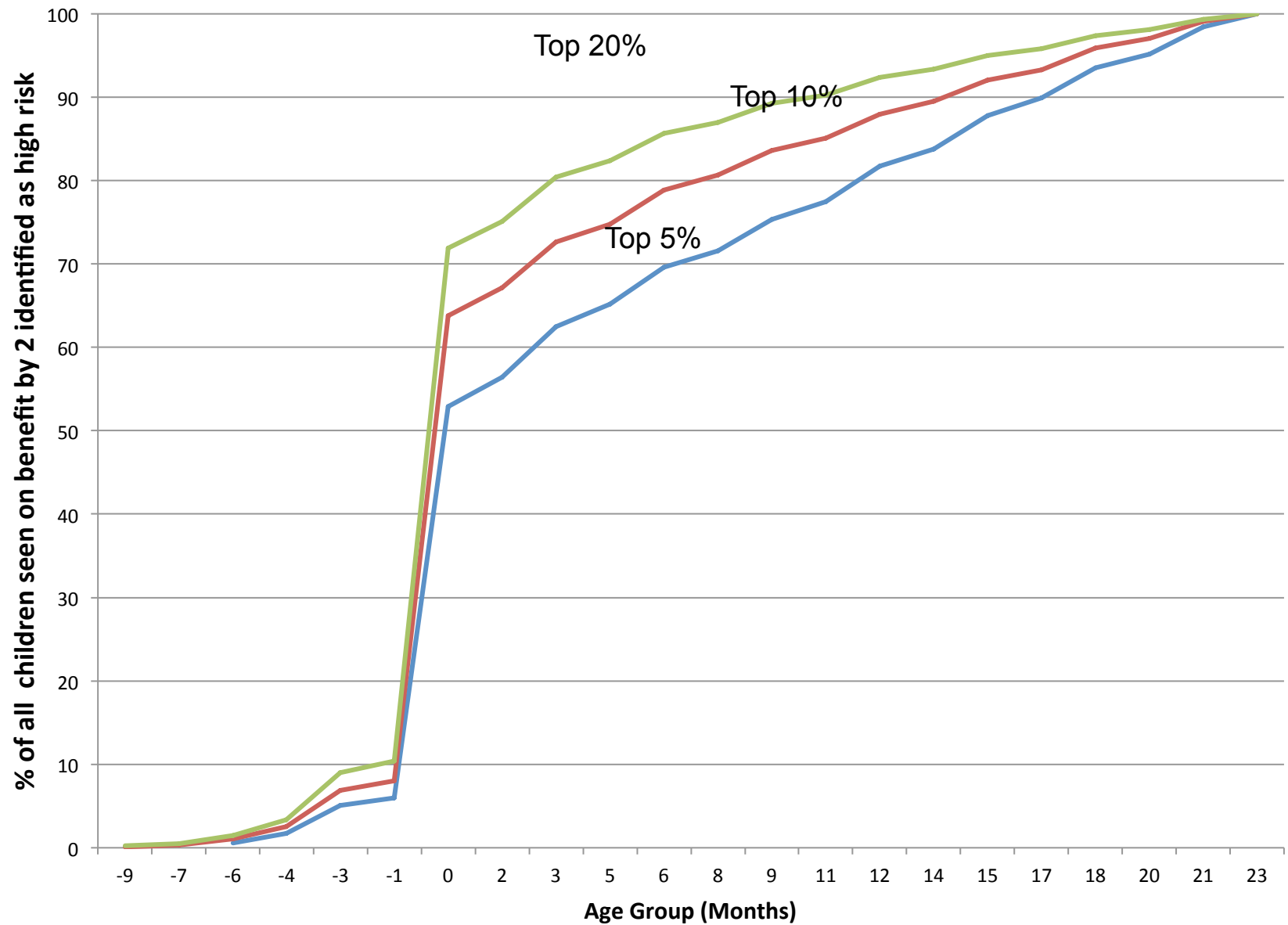


Suppose we were to recruit children when they hit a certain risk score threshold

e.g. top 20%

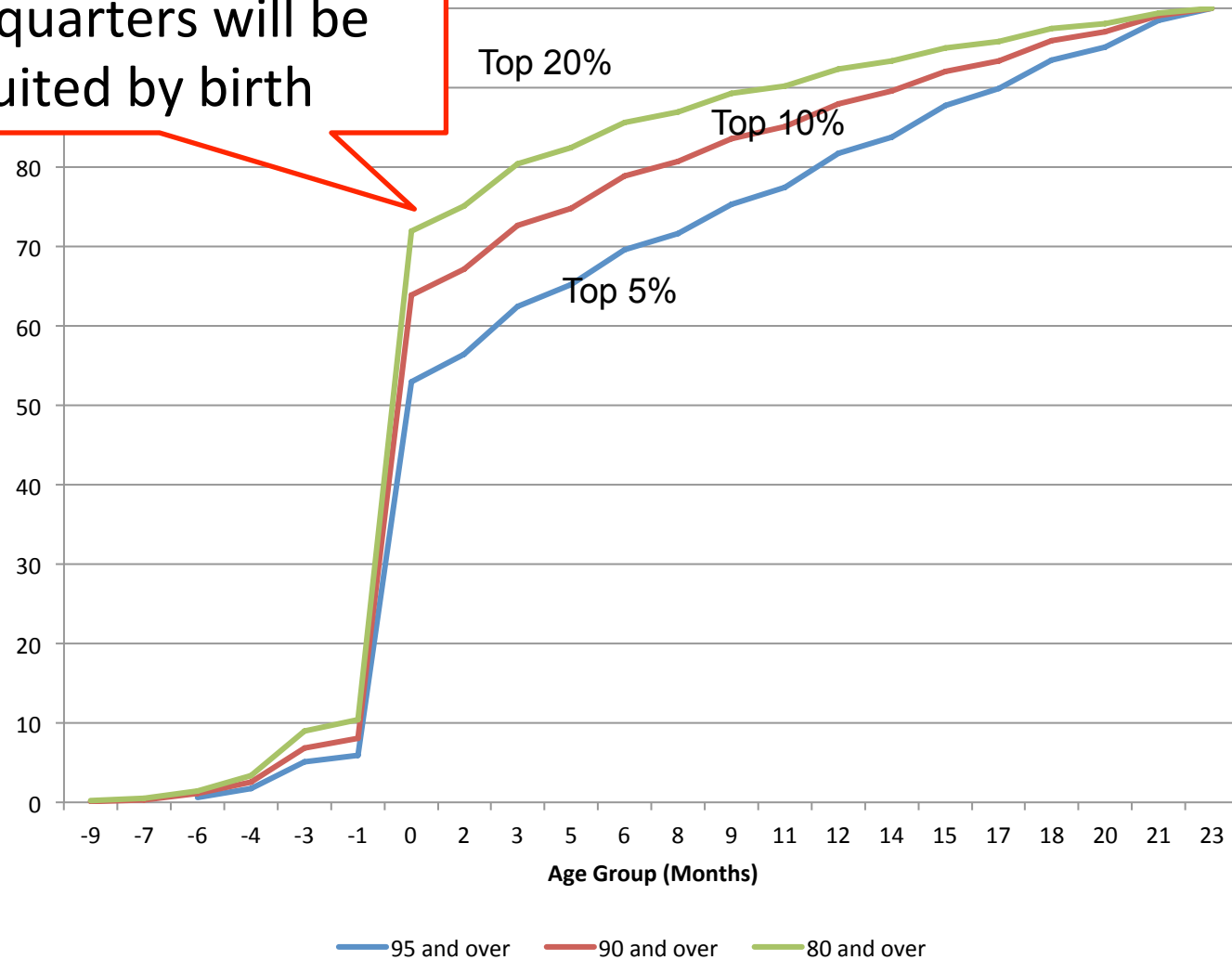
at what age would they “hit”  
the threshold?

# Age at Recruitment into a Service Based on risk score



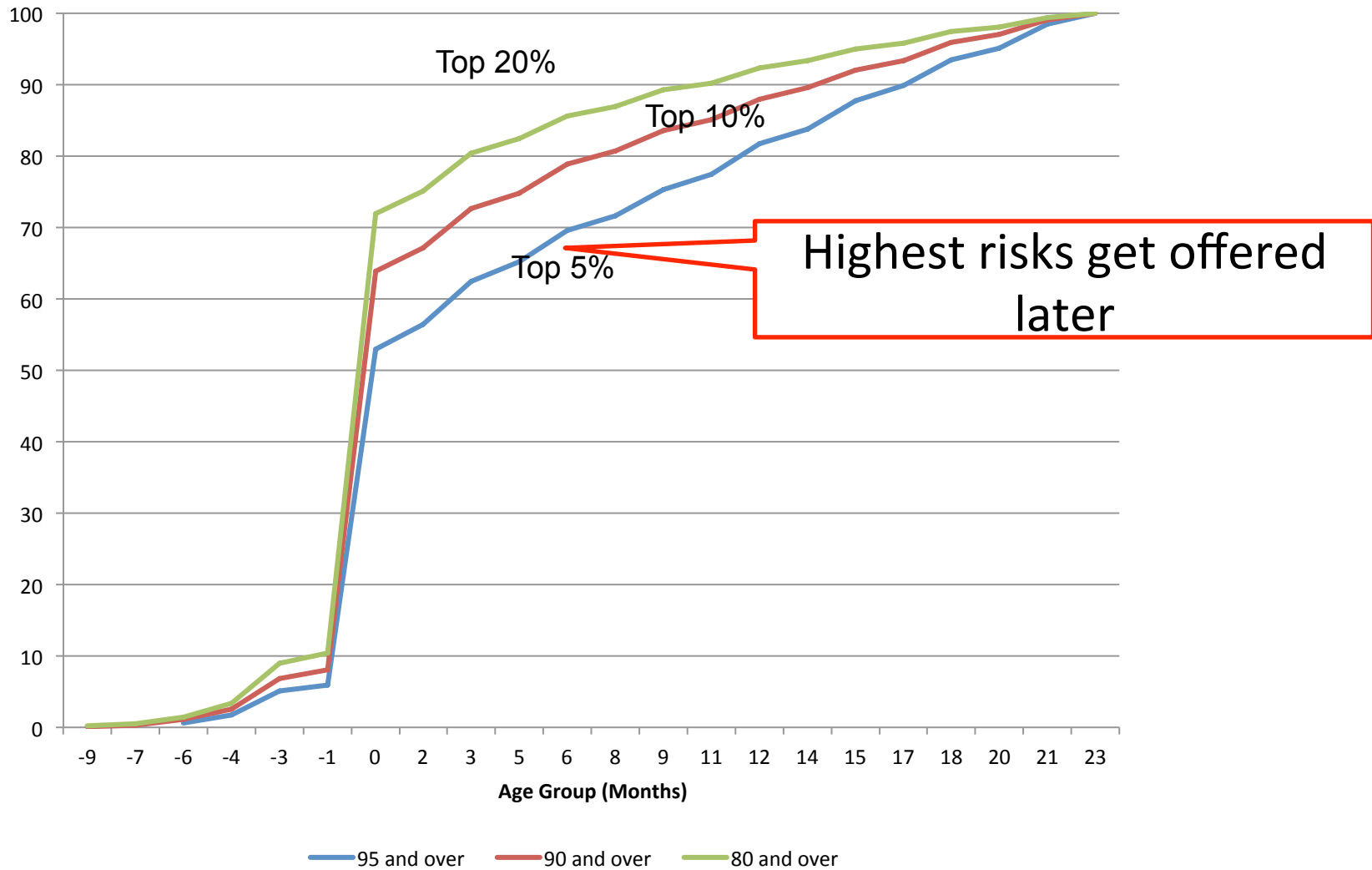
# Age at Recruitment into a Service Based on risk score

Three-quarters will be recruited by birth





# Age at Recruitment into a Service Based on risk score



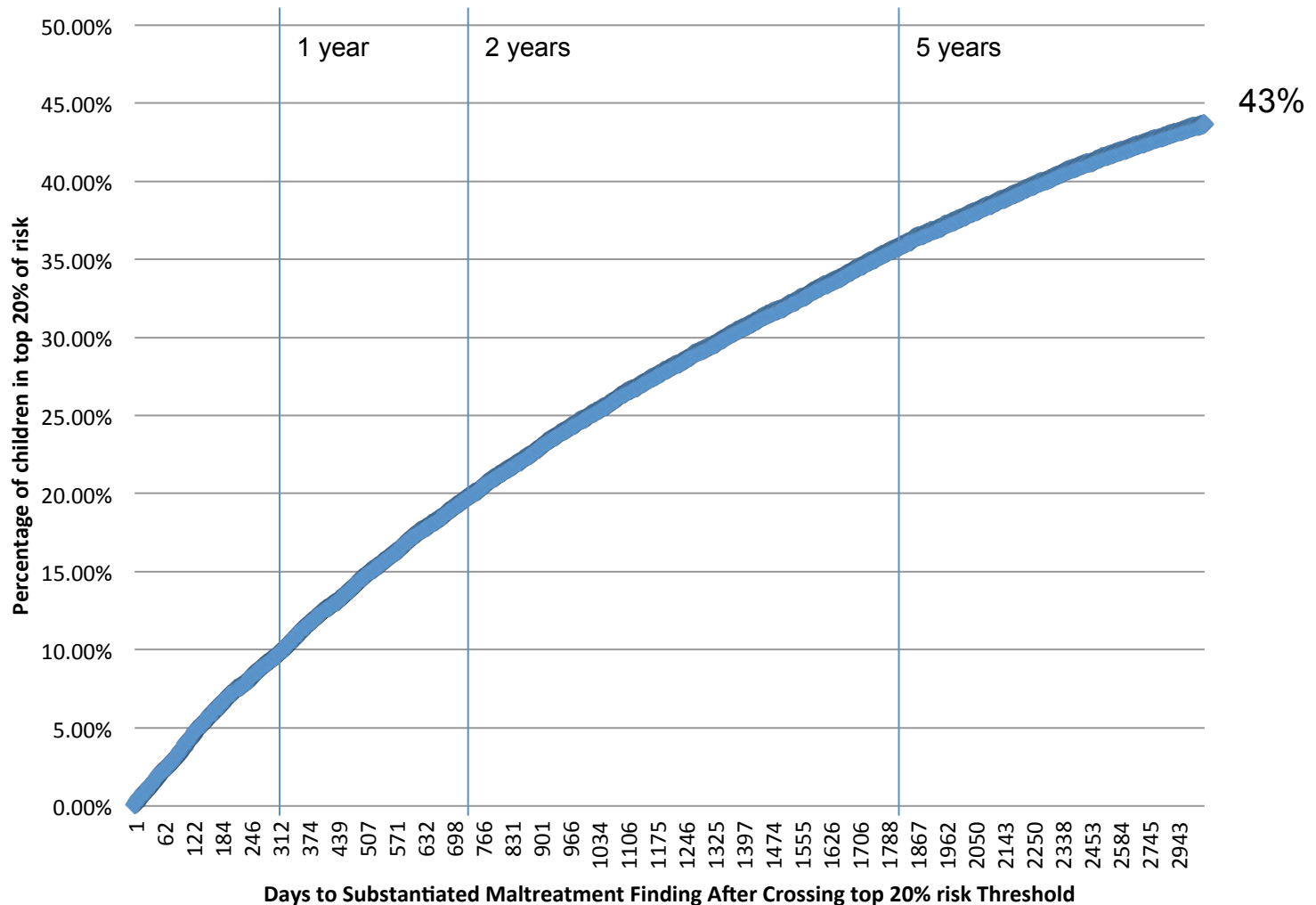
How **long** do we have

**after** they get the service offering

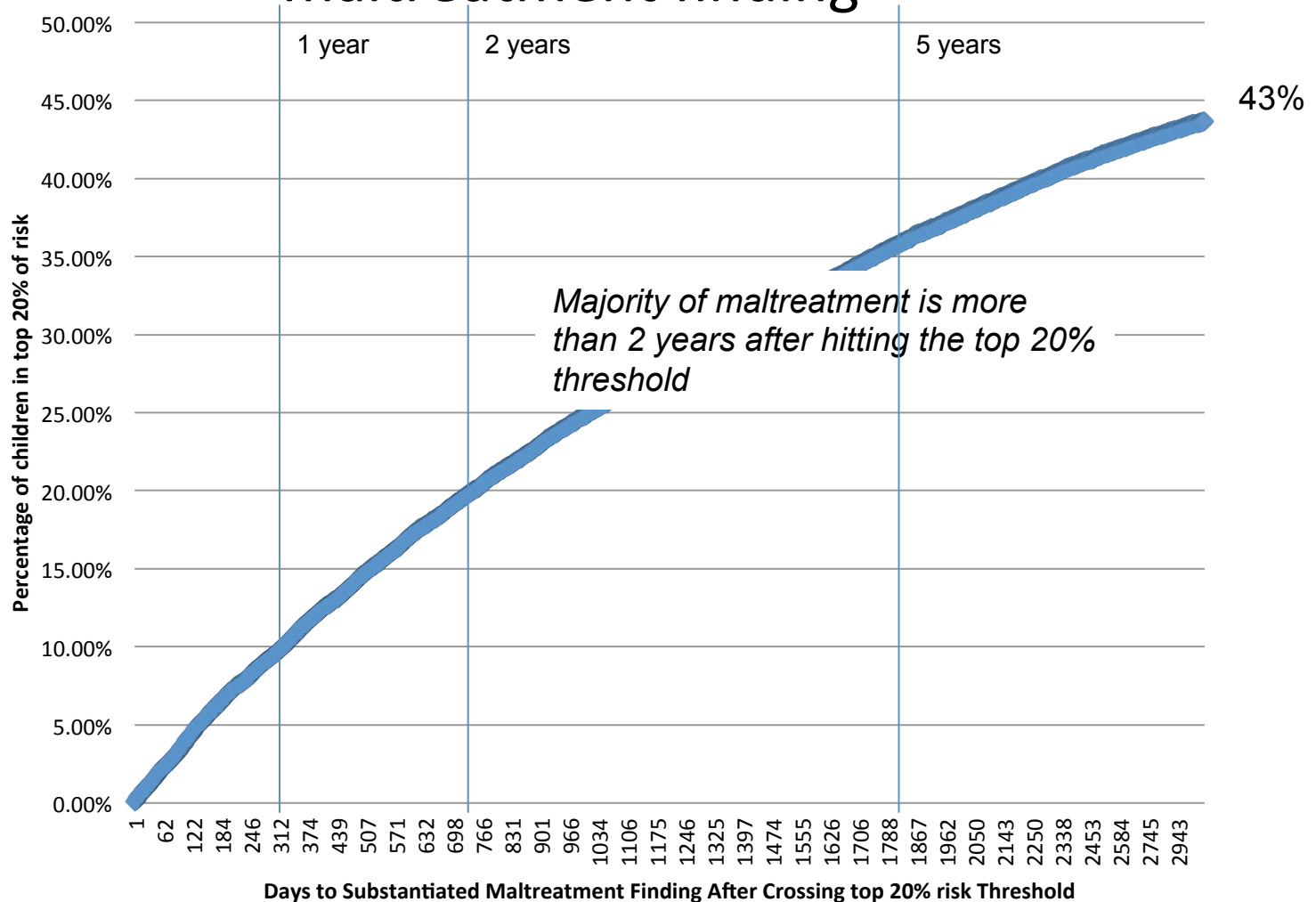
before there is a substantiated  
finding?



# Being scored as in the top 20% and days to subsequent maltreatment finding



# Being scored as in the top 20% and days to subsequent maltreatment finding



# Prototype II

- Data from public benefit, care and protection, Corrections, birth and death registration and Ministry of Health administrative systems
- linkages formed by matching on names and dates of birth
- Apply to all children with a birth registration or included in a main welfare benefit within three months of birth (~ 94 % of all new-born children)

# Results

Suppose we target the top 5% of children in the 2007 birth cohort

.... *by age 5* → 31 % have maltreatment finding and 57% had 1 notification

... *by age 10* (projected) → 40% have a finding and 70% have a notification

# Prototype II -- Variables (base model)

## Child

- **Gender** of child (male / female)
- **Low birth weight** or pre-term (yes / no or unknown)

## Other children of the parents and/or caregivers

- **Parenting demands** (high demands - multiple birth child, other children under 2, or 3 plus other children / no other children / other children but not high demands)
- **Other children with care and protection** history in the last 5 years (yes / no)

# Prototype II -- Variables (base model)

## Parents and/or caregivers

- Single parent (yes / yes and father not listed on birth registration / no or unknown)
- At least one benefit caregiver is not a birth registration parent (yes / no / no birth registration by 3 months)
- Age of mother or primary benefit recipient when child was born (<20 / 20-24 / 25-29 / 30-34 / 35-39 / 40+)
- Parents or caregivers with a care and protection history as a child (yes / no)
- Parents or caregivers with findings of behavioural or relationship difficulties as a child (yes / no)
- Mother or primary benefit recipient's time on benefit in the last 5 years (no time / 0-20% / 20-80% / 80-100%)
- Parents' or caregivers' mental health in the last 5 years (no known substance abuse or other mental health disorder / substance abuse disorder / 3+ years in last 5 with substance abuse disorder / mental health disorder other than substance abuse / 3+ years in last 5 with mental health disorder other than substance abuse)
- Parents' or caregivers' number of benefit address changes in the last year (no address changes / 1-2 address changes / 3 plus address changes/missing - no benefit in last year)
- Parents' or caregivers with a Corrections history in the last 5 years (no history / non-custodial sentence only / custodial sentence for non-violent crimes / custodial sentence for violent crimes)

## Community / office

- CYF service centre (43 categories)



# Of the highest 5% of risk scored children in the 2007 sample...

	% of all children	% of children with findings by age 2	% of the 3,000 children with the highest PRM scores
Male child	51.5	53.0	52.5
Low birth weight child or pre-term birth	8.2	10.7	8.2
Multiple birth child, other children under 2 or 3+ children	20.1	32.9	38.1
No other children (estimated) <sup>(2)</sup>	59.4	51.1	45.7
Other children with a care and protection history in the last 5 years	4.8	34.9	59.9
Other children with a Police family violence notification or contact record in the last year	0.8	8.6	12.4
Single parent	24.6	74.3	87.7
No birth registration at 3 months of age	6.3	26.1	35.5
Mother or caregiver aged under 25	25.3	53.5	54.6
Parents or caregivers with a care and protection history as a child	9.8	43.2	57.2
Parents or caregivers with findings of behavioural or relationship difficulties as a child	3.5	19.1	29.1
Child seen on benefit by 3 months of age	23.2	79.0	92.3
Mother or caregiver's spent 80-100% of time on benefit in the last 5 years	11.7	50.7	65.5
Parents or caregivers received benefit for a substance abuse disorder in the last 5 years	1.5	8.2	14.1
Parents or caregivers received benefit for other mental health disorder in the last 5 years	4.9	17.4	19.0
Primary caregiver's with 1+ address changes recorded in benefit data in the last year	11.6	26.1	30.4
Parents or caregivers with any sentence in the last 5 years	7.2	25.5	33.6
Parents or caregivers with a custodial sentence in the last 5 years	3.1	11.1	16.6
High deprivation neighborhood (deciles 8-10, of non-missing)	36.9	69.0	70.7

# Confluence of Family Start and Risk Score

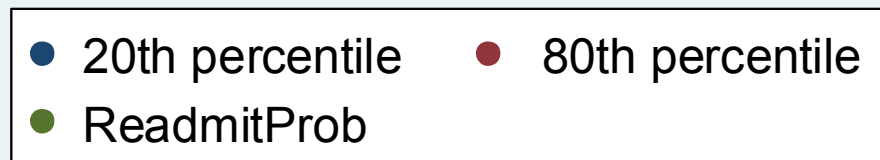
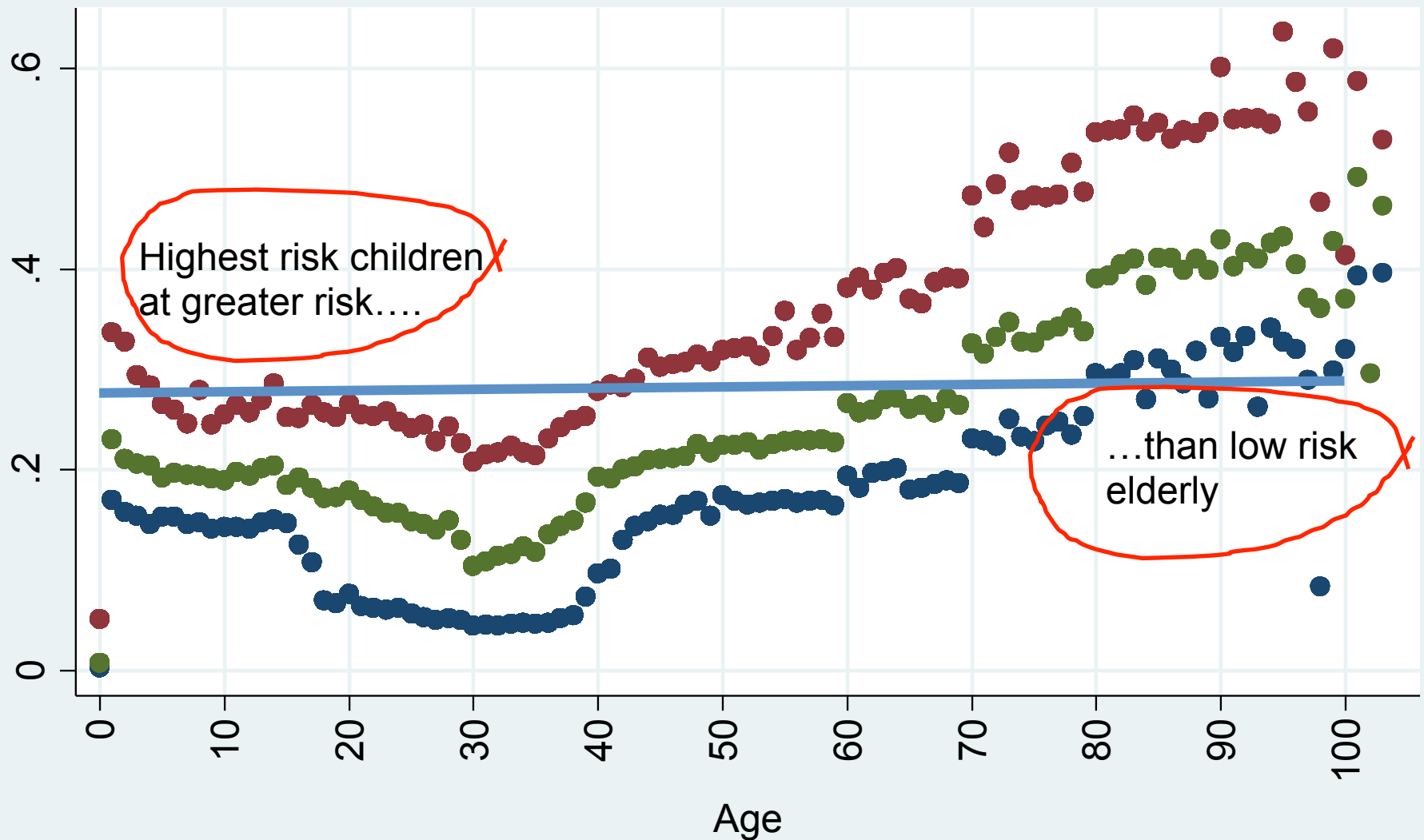
- MOIRA??

# Auckland hospitalisation PRM model (365 days readmission risk)

- When patients are discharged from hospital they are **risk scored**
- The score indicates the risk of re-hospitalisation within 365 days
- Risk score sent to the General Practitioner (Medical home)
- Case review high risk patients
- Currently being evaluated

\* Panattoni, L. E., Vaithianathan, R., Ashton, T., & Lewis, G. H. (2011). Predictive risk modelling in health: options for New Zealand and Australia. *Australian Health Review*, 35(1), 45-51.

Vaithianathan, Rhema, Nan Jiang, and Toni Ashton. *A Model for Predicting Readmission Risk in New Zealand*. No. 2012-02. 2012. Melbourne Institutr



Source: New Zealand Hospital Episode Statistics, NMDS, 2009-10

# Factors Used to Predict Readmission

- Age
- Past utilisation
- Charlson Index
- Distance to hospital
- Diagnosis
- Ethnicity
- Deprivation in neighbourhood

# Prognostic Strength

	Risk score threshold			
	70	80	90	99
No. of patients flagged	2,403	1,268	526	96
Share of those flagged who are re-admitted (PPV (%))	73.37	78.08	83.46	91.67
Share of those flagged who are <i>not</i> re-admitted (1-PPV, %)	26.63	21.92	16.54	8.33
Share of re-admitted patients correctly flagged (Sensitivity (%))	8.75	4.91	2.18	0.44
Specificity (%)	98.64	99.41	99.81	99.98
Average number of re-admissions for correctly flagged patients	4.15	4.94	6.66	11.76

# Conclusion

- Evaluation of PRM for hospitalisation is currently taking place
- Need to pull frontline into the discussion
- Building prediction models is easy ...  
convincing frontline to use them is hard!