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# Targeting high-cost beneficiaries for care management with predictive modelling

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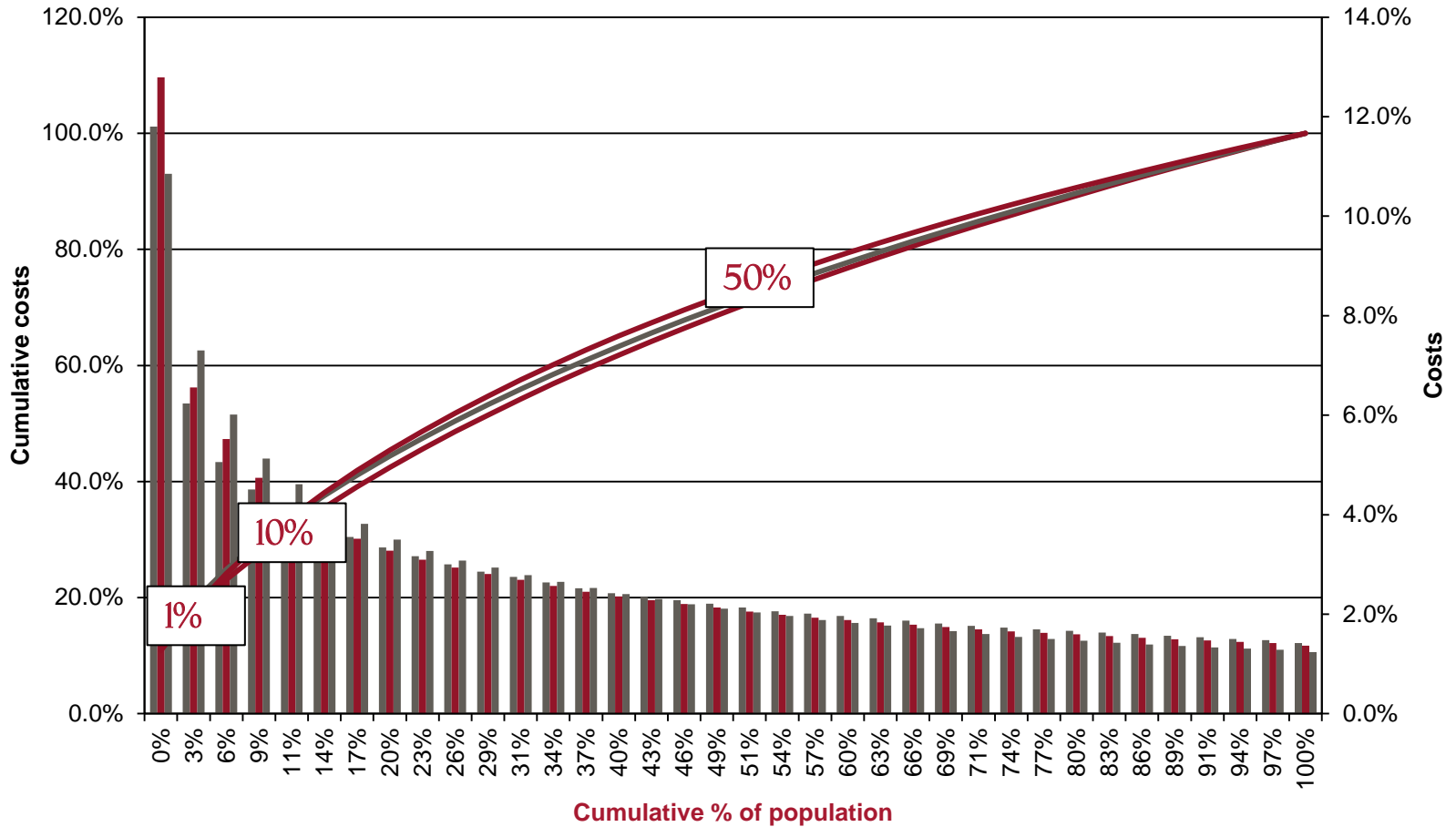
# Agenda

1. Introduction to care management and predictive modelling
2. The South African environment
3. Review of the literature
4. Data and methodology
5. Results
6. Discussions and conclusions

# Care management

- Care management aims to provide the most appropriate care for patients in order to manage costs and improve health outcomes
- Limited and costly resources with which to implement
- Need to identify interventions that represent the greatest opportunity to achieve beneficial outcomes
- High-cost patients constitute small proportion of population but large proportion of all costs

# Concentration of costs



# The South African environment- private sector

- Significant cost escalation pressures
- Medical Schemes governed by the Medical Schemes Act
  - Schemes operate on basis of social solidarity
  - Open enrolment
  - **Inability to exclude or underwrite**
  - Prescribed Minimum Benefits
  - Benefits paid at “Full cost”
  - **Open ended liability**

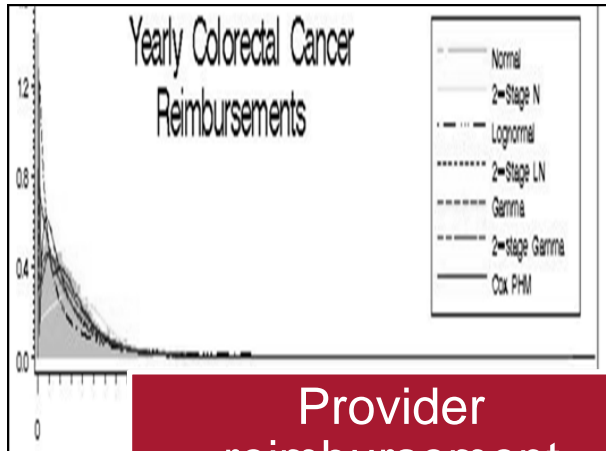
# The South African environment- public sector

- South Africa's quadruple burden of disease
  - High levels of morbidity and costly care
- Constrained financial and human resources
  - Management of utilisation
  - Efficient allocation of scarce resources
- Current efforts to revitalise public sector

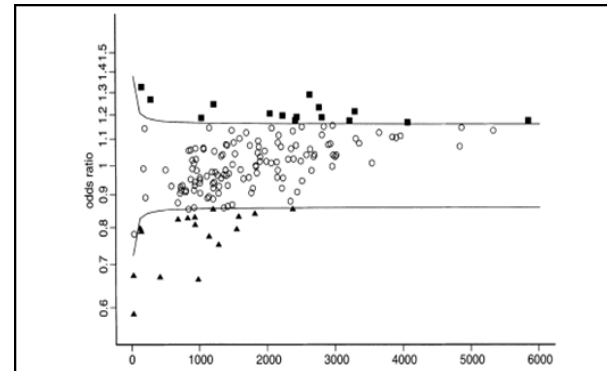
# This paper

- Who are the future high cost beneficiaries?
- What are their common characteristics?
- Implications of common characteristics
- Analysis extended to multiple years
  - High costs may come at the end of a long and gradual build-up
  - Appropriate care may transition over time
  - Long term management of costs for private sector, particularly where membership turnover is low
  - Efficient long-term allocation of scarce resources for public sector

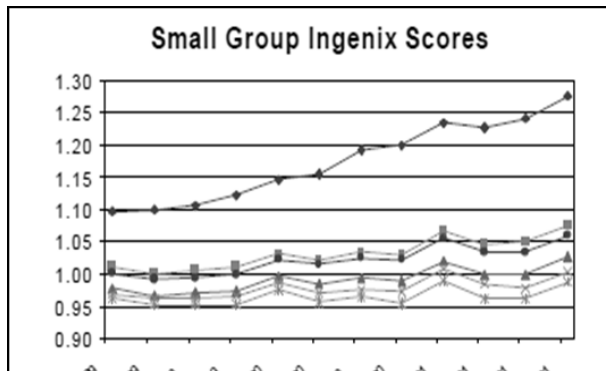
# Predictive modelling in healthcare



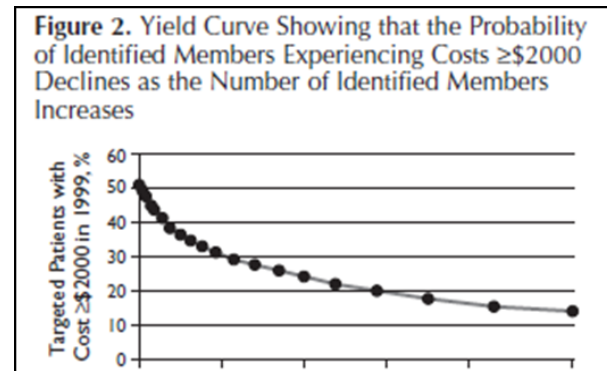
Provider reimbursement



Provider profiling



Underwriting and pricing



Targeting high-cost individuals



# Literature review: predictive modelling for care management

- Identifying high-cost individuals
  - Risk stratification in terms of risk score
  - Sensitivity and specificity of identifying high-costs individuals
  - Mean reversion in costs- individuals shift between cost categories
- Methodologies for predicting costs
  - Statistical models
  - Commercial grouper-based models
- Predicting over different time horizons
  - Studies typically have a one-year time horizon
  - Concurrent analysis give more accurate results than prospective

# Data

- Panel data of beneficiaries enrolled between 2007 and 2012 from South African medical scheme administrator
- Variables

| Variable name         | Description  |
|-----------------------|--|
| <b>PLPY</b>           | The cost per beneficiary per year in Rands   |
| <b>Age</b>            | The age of the beneficiary, categorised in five-year age bands                             |
| <b>Sex</b>            | Sex of the beneficiary   |
| <b>Plan</b>           | The plan to which the beneficiary belongs at the beginning of the first year of prediction |
| <b>Province</b>       | Province in which the beneficiary lives  |
| <b>Chronic Status</b> | Indicator of the presence of one or more chronic diseases                                  |
| <b>CCS1-64</b>        | Indicator of the presence of CCS grouper aggregated conditions                             |

- Trauma and neonatal expenditure excluded
- Range of Variables limited by extent of data recorded by medical scheme administrators

# The CCS grouper

- Beneficiary conditions included as binary variables
- CCS grouper used to collate clinical information into 64 categories
- Clinical identification algorithm that balances sensitivity and specificity

# Defining high-cost

- Binary definition of low- and high-cost
- Annual expenditure above \$2 000 considered high-cost
  - Corresponds to 90<sup>th</sup> percentile of costs
- High-cost threshold set as a percentile so that costs at different time-horizons can be treated consistently
- High-cost threshold sensitivity tested

# The modelling objective

- Mean reversion in beneficiary costs
  - Beneficiaries who are high-cost may not persistently be high-cost
  - Beneficiaries who are low-cost may become the high-cost beneficiaries

| High cost beneficiaries in 2007 |                      |                     |
|---------------------------------|----------------------|---------------------|
|                                 | Proportion high-cost | Proportion of costs |
| 2008                            | 40.1%                | 54.5%               |
| 2010                            | 34.3%                | 31.0%               |
| 2012                            | 31.2%                | 27.5%               |

- Majority of high-cost beneficiaries and costs come from individuals who were classified as low-cost
- Aim is to identify these beneficiaries ahead of time

# Modelling approach

- Statistical approach
- Cost distribution characteristics
  - Right skewed, heavy tailed, particularly in-hospital costs
  - Large proportion of observations of 0, particularly in-hospital costs
- Similar shapes for all time-horizons
- Choice of statistical models



# Model formulation

- All factors (including time) treated as fixed effects with repeatable levels
- 64 CCS categories treated as binary fixed effects
- Two part GLM with Negative Binomial and Gamma response distributions to characterise unexplained variation
- Model validated on out of sample data using validation sample
- Risk scores assigned to individuals based on predicted cost
- Results extracted

# Results

- Analyses performed on five periods
  - 1 year (“short-term”)
  - 3 years (“medium term”)
  - 5 years (“long term”)
  - 1-3 years (“medium term aggregated”)
  - 1-5 years (“long-term aggregated”)



# Model fit

- R-squared sensitive to prediction error for very high costs
- MAPE measures the average absolute deviation relative to observed value

|                               | R-squared | MAPE  |
|-------------------------------|-----------|-------|
| <b>Short-term</b>             | 11.7%     | 0.850 |
| <b>Medium-term</b>            | 9.6%      | 0.869 |
| <b>Long-term</b>              | 9.1%      | 0.909 |
| <b>Medium-term aggregated</b> | 18.2%     | 0.701 |
| <b>Long-term aggregated</b>   | 22.9%     | 0.653 |

- Better model fit in short term
- Better fit for aggregated costs
- Improvement of fit most substantial from short- to medium- term

# Predicting high-cost beneficiaries

- Accuracy of correctly identifying high-cost beneficiaries evaluated using the proportion of true positives

|                               | 2007 Low-cost beneficiaries | 2007 High-cost beneficiaries | All beneficiaries |
|-------------------------------|-----------------------------|------------------------------|-------------------|
| <b>Short-term</b>             | 28.1%                       | 53.4%                        | 40.1%             |
| <b>Medium-term</b>            | 27.2%                       | 48.6%                        | 37.3%             |
| <b>Long-term</b>              | 28.3%                       | 43.3%                        | 35.1%             |
| <b>Medium-term aggregated</b> | 33.1%                       | 60.0%                        | 46.0%             |
| <b>Long-term aggregated</b>   | 36.3%                       | 60.1%                        | 47.8%             |

- Overall accuracy highest for short-term
- Accuracy does not decline by time for previously low cost
- Aggregated cost models predict more accurately, especially for short- to medium

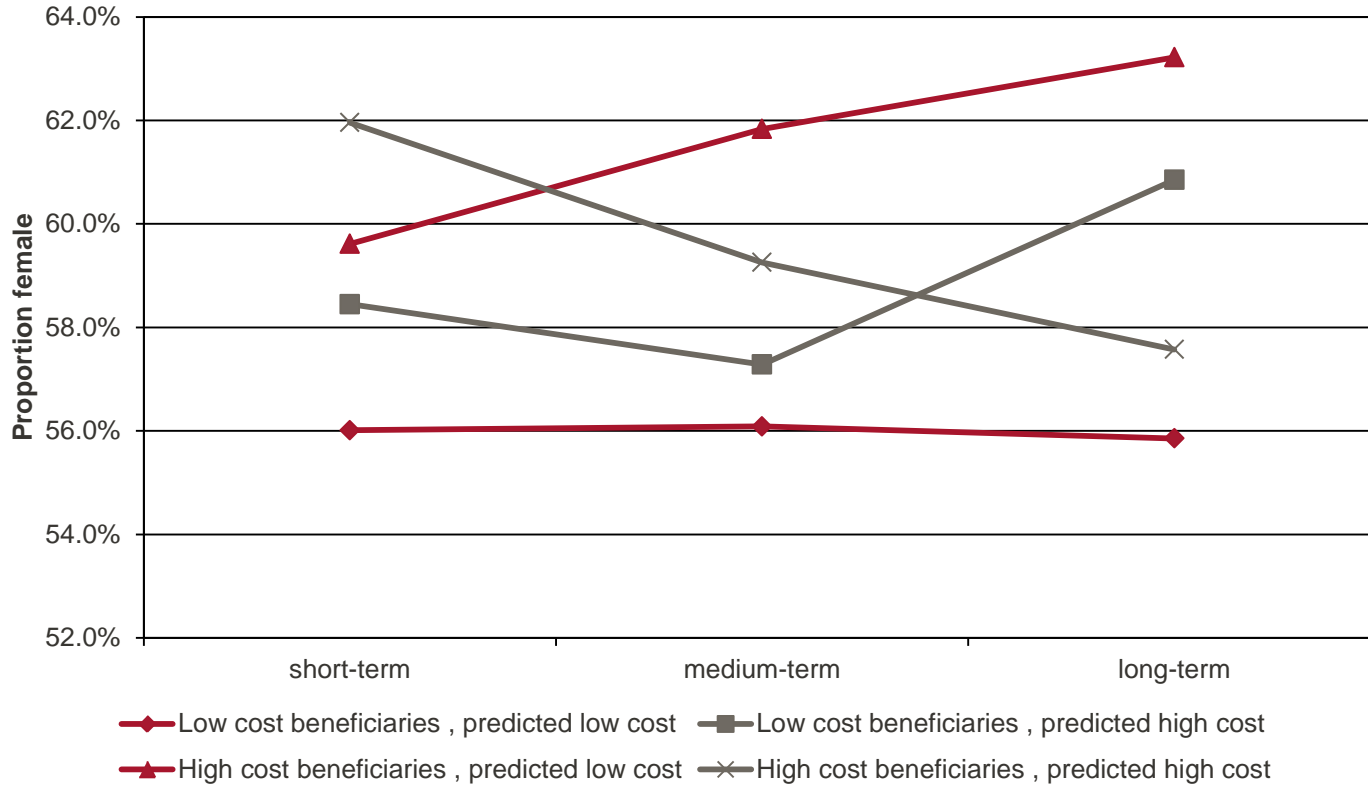
# Sensitivity tests

- Threshold level for high costs
  - Large effect on accuracy
  - Little effect on patterns among time horizons
- The clinical identification algorithm
  - Little effect on results

# Characteristics of high-cost beneficiaries

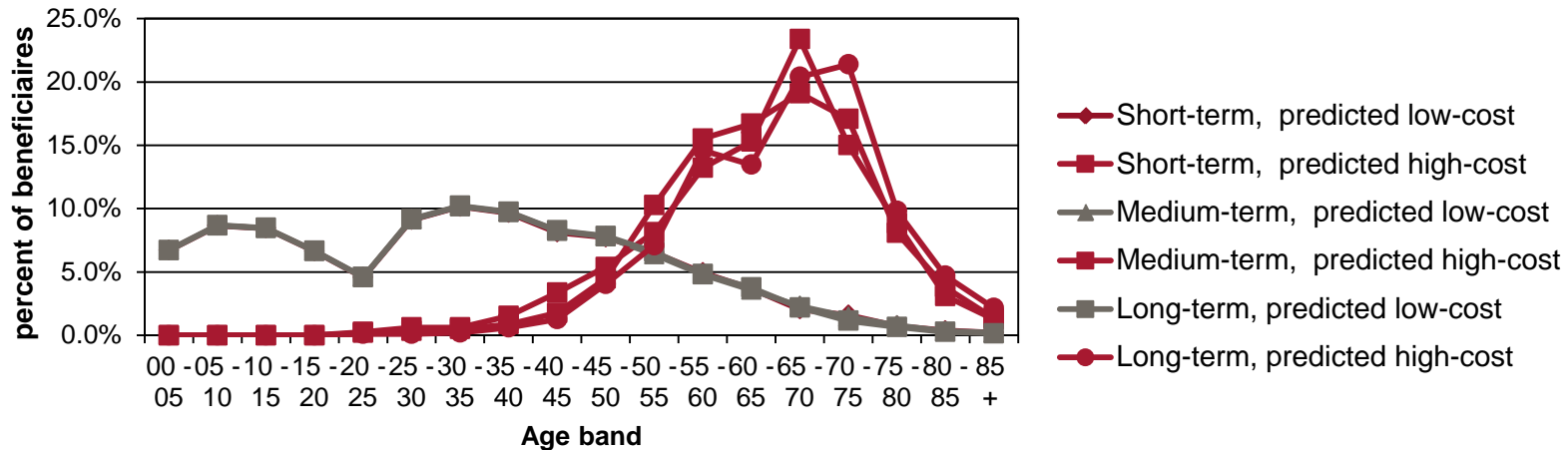
- Characteristics of high-cost beneficiaries according to:
  - time-horizon
  - Whether beneficiary was initially low- or high-cost
- Predictions of characteristics for high aggregated costs differed little from single years

# Characteristics of high-cost beneficiaries: Gender

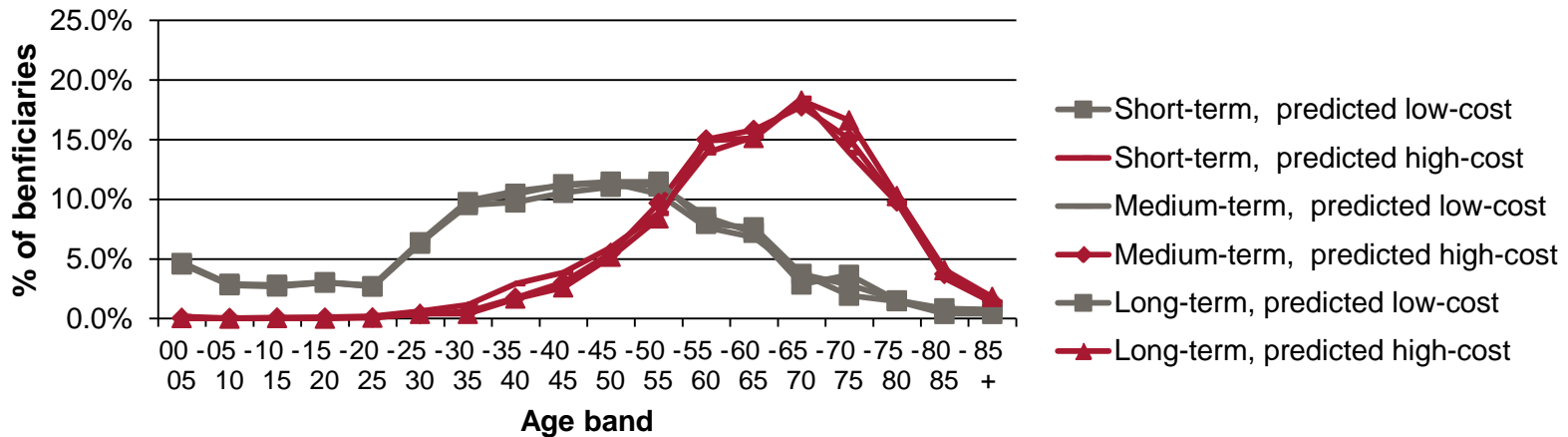


# Characteristics of high-cost beneficiaries: Age

## Low-cost beneficiaries

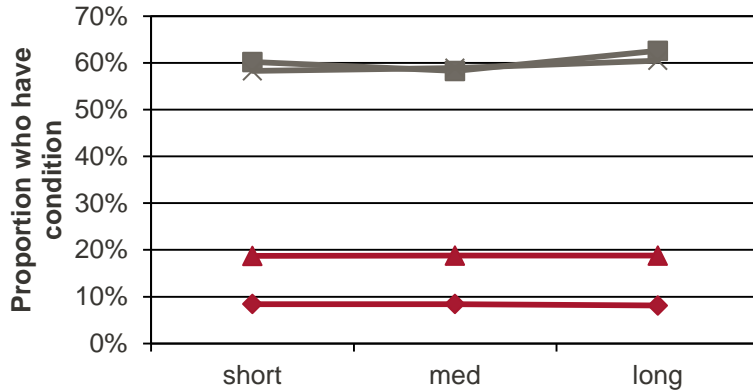


## High-cost beneficiaries

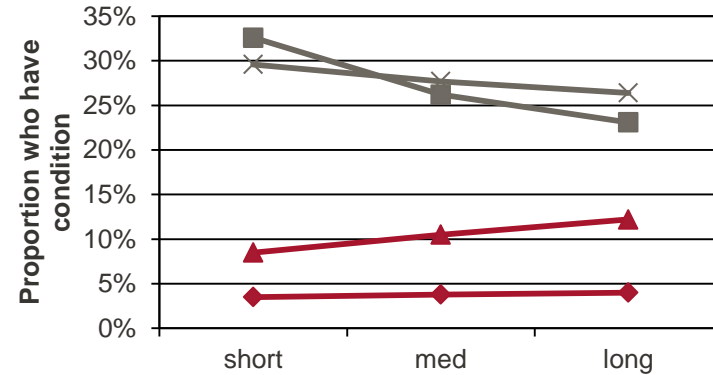


# Characteristics of high-cost beneficiaries: Chronic disease prevalence

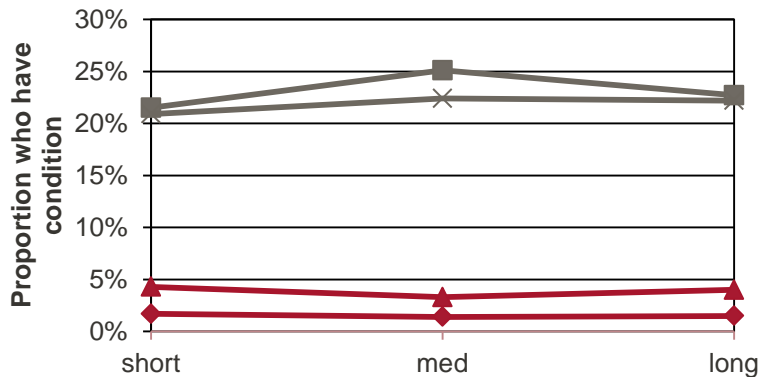
## Hypertension



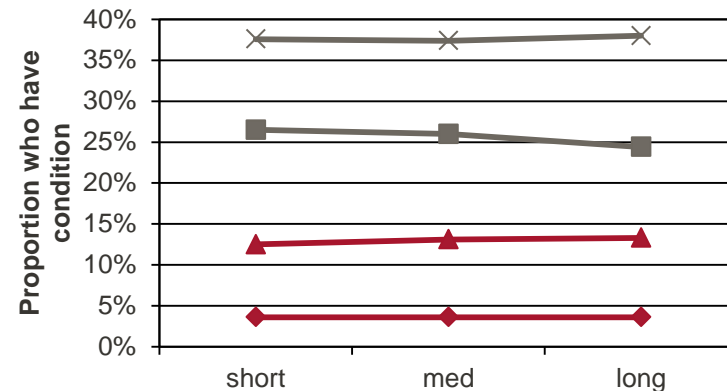
## Hyperlipidaemia



## Diabetes Melitis



## Heart condition



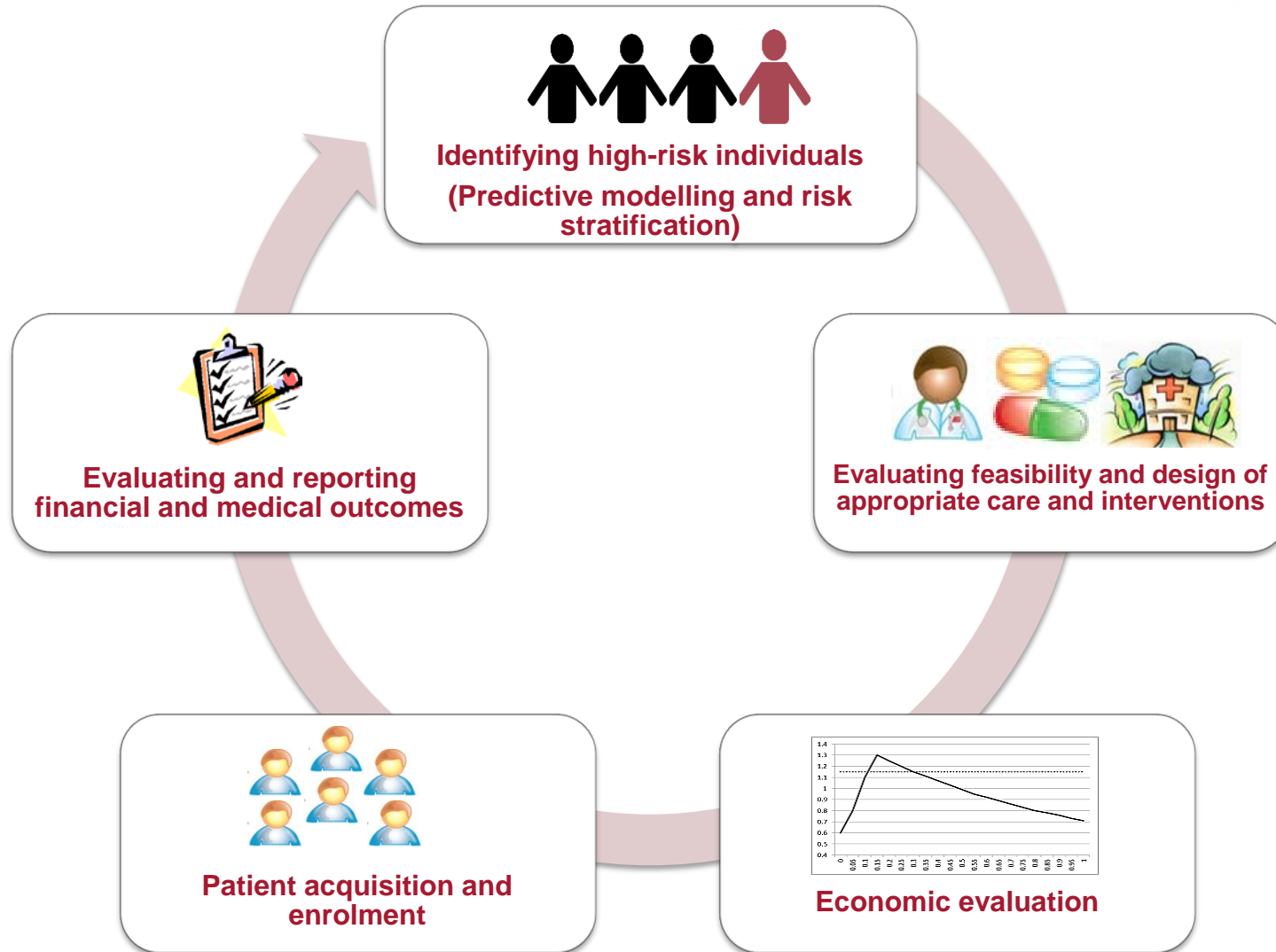
◆ Low cost beneficiaries, predicted low-cost   
 ■ Low cost beneficiaries, predicted high-cost  
▲ High cost beneficiaries, predicted low-cost   
 × High cost beneficiaries, predicted high-cost

# Furthering the work

- Use of Adjusted Clinical Groups (ACGs) in models
- Full care management programme implementation
- Application of modelling to other settings



# The full care management process



# Discussion

- High-cost beneficiaries should not necessarily be the focus
- It was possible to find patterns in the data to identify high-risk patients in the future with reasonable accuracy
- The degree of accuracy decreased with time
- Extension of cost from single to multiple years increased accuracy- a few additional years makes a big difference
- Suggests longer-term approach to care management is affective where this is the aim

# Discussion

- High-cost beneficiaries mainly elderly and more likely to be female
- Distinctive diseases burdens for low- and high-cost
- Changes in disease profile of high-cost beneficiaries varies for different diseases
- For some diseases focus on short-term disease treatment likely to be effective for long term as well
- Hypertension very prevalent for high-cost individuals, especially long-term high-cost individuals

# Conclusions

- Predictive modelling of medium-term costs can be of value for care management
  - Identifying high-cost beneficiaries
  - Characterising patients, their diseases and transitions
- Developing care management programmes involve planning, economic evaluation and implementation
- This is the next step in this research....

**THANK YOU!**