# MONITORING and COST OPTIMISATION in HEALTHCARE by MARKOV CHAIN METHODS

## CHALLENGES

**Monitoring and cost optimisation**

**The Industrial Problem**

Consulting companies in healthcare and health-economics are often faced with finding cost-efficient therapies and therapeutic regimens and comparing them. These challenges also emerged and need to be solved at Healthware Consulting Ltd., Budapest.

**INDUSTRIAL SECTOR:** HEALTHCARE AND HEALTH-ECONOMICS CONSULTING

*Research group*

**Markov-chain methods**

¡ Research Group for developing
! Markov-chain methods in monitoring healthcare processes

UNIVERSITY of DEBRECEN

Simulation, cost estimation and optimisation using Markov chains with the help of custom-developed programs written in R and C++.

*Company*

**Healthware Consulting Ltd.**

HEALTHWARE

The Healthware Consulting Ltd. was founded in 2004. Over the years it became a market-leading health-economic consulting company in Hungary.

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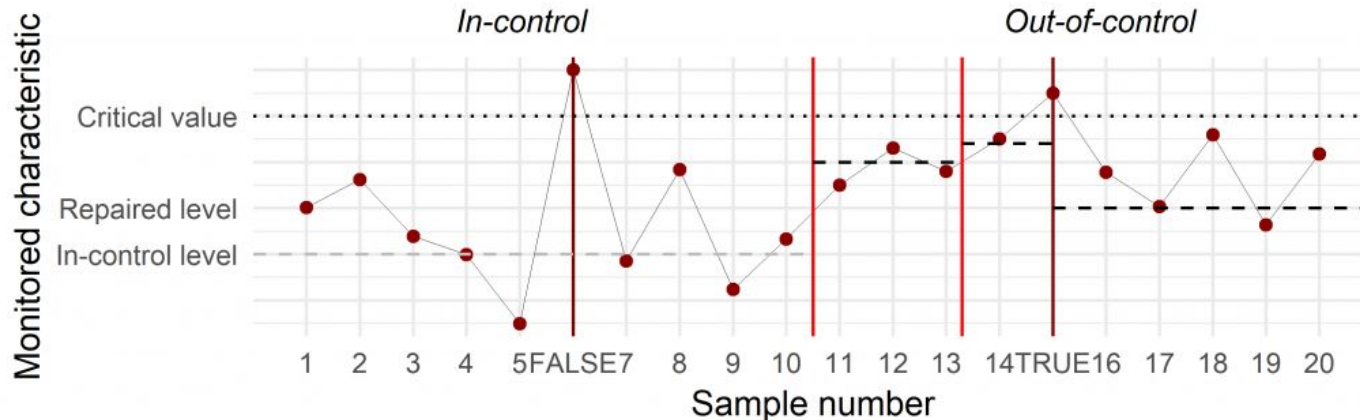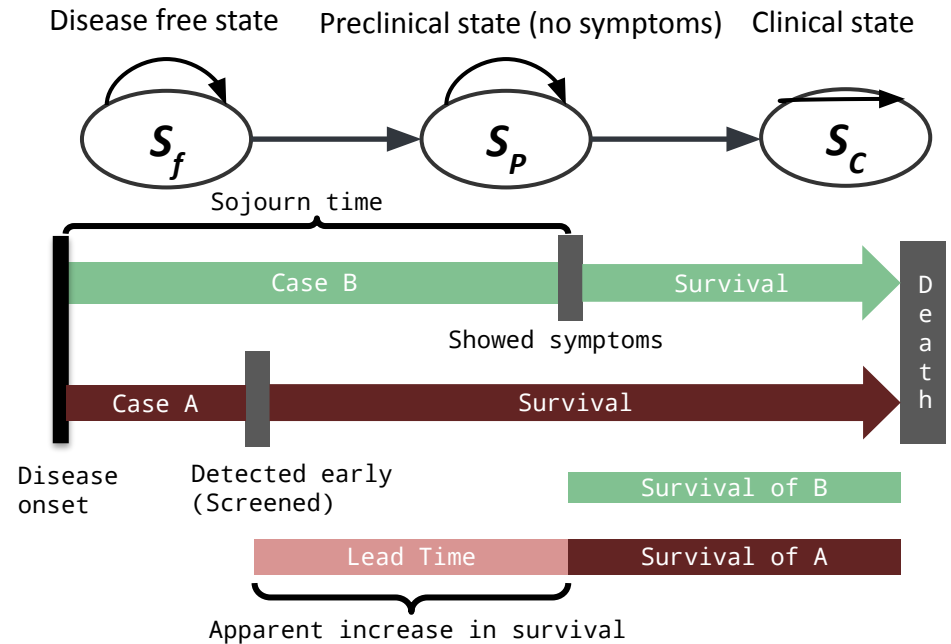Európai Strukturális
és Beruházási Alapok
MAGYARORSZÁG KORMÁNYA
BEFEKTETÉS A JÖVŐBE

# MONITORING and COST OPTIMISATION in HEALTHCARE by MARKOV CHAIN METHODS

**HU-MATHS-IN**
Hungarian Service Network for
Mathematics in Industry and Innovations

## Challenges & Goals

- To develop cost-optimization methods, which apply to medical processes

- To incorporate random degradation, random treatment effectiveness, and patient incompliance

- To model and simulate chronic disease progression and deal with left-censored survival data

- To estimate the sojourn time and correct the lead-time bias

**Chronic disease progression:**

Disease free state    Preclinical state (no symptoms)    Clinical state

$S_f$    $S_p$    $S_c$

Sojourn time

Case B    Survival    Death

Showed symptoms

Case A    Survival

Disease onset    Detected early (Screened)

Survival of B

Lead Time    Survival of A

Apparent increase in survival

*Disease states in chronic diseases (right) and disease progression-treatment cycles (bottom)*

## Mathematical and computational methods and techniques applied

- Incorporation of transition probabilities into a Markov chain's transition matrix, which represents the state of the patient at the sampling times (i.e., control visits)

- Calculation and optimization of costs using the stationary distribution of the Markov chain

- Simulation and modeling disease progression as a gamma deterioration process

- Determine optimal screening strategies based on cost and survival
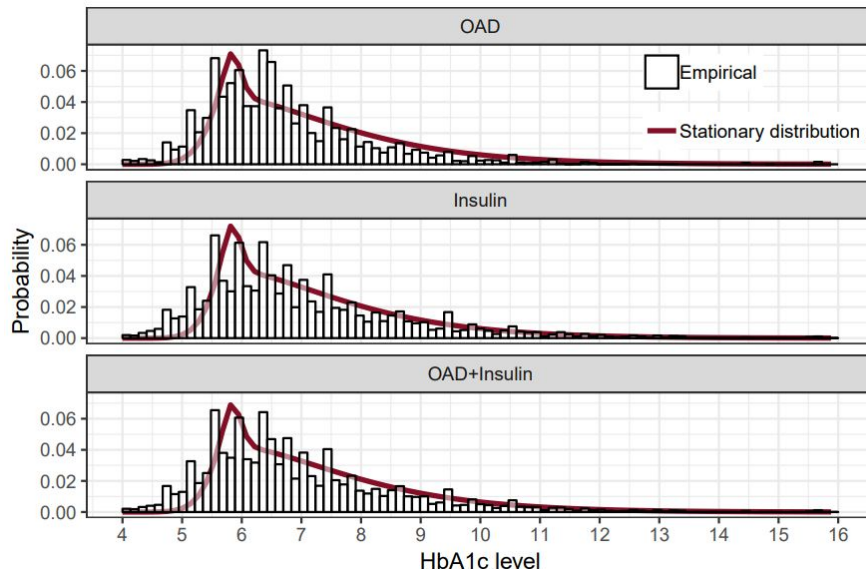


Empirical and control chart-calculated theoretical stationary distribution for diabetes data
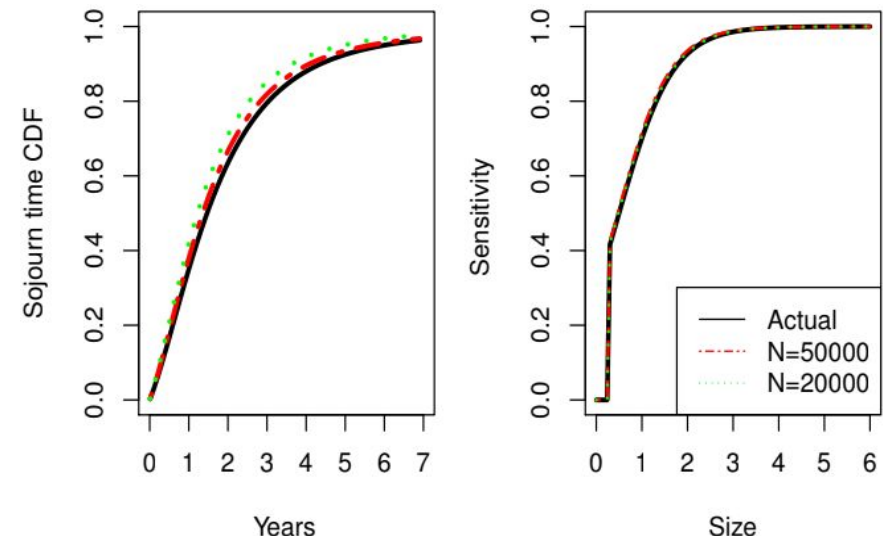


Estimated and actual sojourn time CDF for different sample sizes

## Results & Benefits to the company

- Cost estimation in different treatment regimens
- More accurate estimation of the lead-time bias
- The results were presented at several conferences (some together with Healthware Consulting Ltd.) and a webinar
- Two published papers while another two have also been submitted
- Successful application of control charts to real-world medical data
- A preliminary analysis using control charts was sent to a client, and it may be followed by further research applying the model.
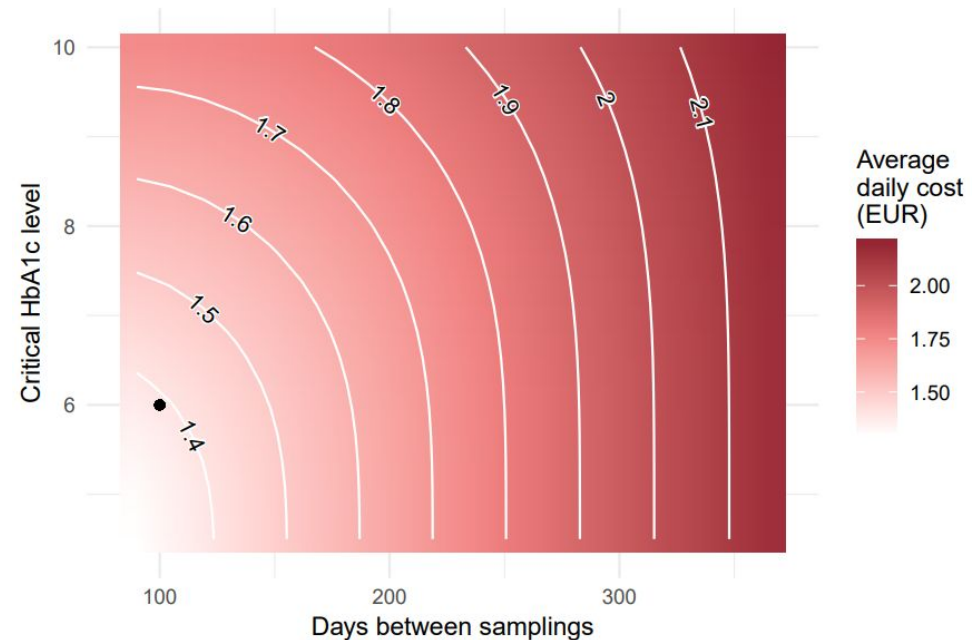


Relationship of the intervention-inducing critical disease level, the days between control samplings and the average daily costs.
*(The dot corresponds to the parameters fitted to the empirical data.)*

The company has R programs to estimate and optimise costs related to illness progression and treatment