**Summary of the EFOP-3.6.2.-16-2017-00015 miniproject for the period of 1 September 2018 – 31 August 2019**

**Title: Markov-chain methods in monitoring health-care processes**

Our work can be divided into two main sections. The aim of the first research topic was to develop a flexible process cost-optimisation method, which is applicable to various real life medical processes, involving diseases and their treatments. Emphasis was put on checking the robustness of the cost components, most importantly the out-of-control cost and the assumptions about the shift distribution. We tested the properties of the model via simulations and applied it to real-world data.

 During the project two papers were published in this research topic. In the first paper, we developed a flexible framework which uses a Markov chain-based approach. The advantage of this approach was that it allowed generalisations for random shift sizes, random repairs and random sampling times, all of which are common in healthcare applications. Using these control charts, we were able to estimate the optimal parameters of a patient monitoring setup, which consisted of the optimal time between samplings (i.e. control visits) and critical value (i.e. medical criteria). [1] These results were also presented at a webinar and at an international conference.

The second paper aimed to assess the effect of different shift size distributions - distributions which model the degradation in quality - on the optimal parameters, expected cost and cost standard deviation. We demonstrated the flexibility and usefulness of the Markov chain-based framework with the comparison of a continuous and a mixed distribution. The choice of the distributions was motivated by their potential application in healthcare. We compared these distributions for different parameter setups. [2]

A similar approach can also be applied to chronic disease progression. These are processes composed of 3 states, a disease free state, a preclinical state in which the disease has not yet manifested itself through clinical symptoms, and a clinical state in which the disease finally reveals itself. For these disease progression models, we started by studying the classical progression models and checked their performance under different setups. We found that they are highly unstable and only work under specific assumptions. In order to deal with that, we proposed a gamma deterioration process for disease progression using the level of deterioration on detection. We have shown that under this new framework, estimates for the parameters are stable and accurate. Besides, it is more reasonable to link the preclinical time to the deterioration at detection, as it gives some information on the amount of time the patient had the disease, therefore leading to more accurate estimates of the lead time bias. We applied both models to a simulated breast cancer screening program. Our results were summarized in two manuscripts [3,4] and three conference presentations at international conferences.

The implementations and results were created using custom-made functions in the R programming language.

***References***

1. Dobi, B. and Zempléni, A., (2019) Markov chain‐based cost‐optimal control charts for health care data. *Quality and Reliability Engineering International*, 35(5) p. 1379–1395.
2. Dobi, B. and Zempléni, A., (2019) Markov chain-based cost-optimal control charts with different shift size distributions. *Annales Univ. Sci. Budapest., Sect. Comp.,* 49 p. 129–146.
3. Hijazy, A. and Zempléni, A., (2019) Gamma process-based models for disease progression. *Methodology and Computing in Applied probability,* submitted.
4. Hijazy, A. and Zempléni, A., (2019) How well can screening sensitivity and sojourn time be estimated? *Manuscript.*

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