

Project ID: TKP2021-NKTA-36

Project title: „Development and assessment of innovative digital technologies in the health industry”

RESEARCH REPORT

Summary of the progress of
‘Development and assessment of innovative digital technologies in the health industry’
research project between January 1, 2022 and October 31, 2023

This project has been supported by the National Research, Development, and Innovation Fund of Hungary, financed under the TKP2021-NKTA-36 funding scheme.

Óbuda University

Prof László Gulácsi DSc, head of the research project

Prof. Levente Kovács, PhD, habil, head of subproject I

Prof. Márta Péntek DSc, head of subproject II

Dániel András Drexler PHD, principal investigator of subproject I.

November 6, 2023



ÓBUDAI EGYETEM
ÓBUDA UNIVERSITY



NATIONAL RESEARCH, DEVELOPMENT
AND INNOVATION OFFICE
HUNGARY

PROJECT
FINANCED FROM
THE NRDI FUND

1 PERSONALIZED DIGITAL PHYSIOLOGICAL MODELING AND CONTROL SYSTEMS FOR CANCER THERAPY OPTIMIZATION AND ARTIFICIAL PANCREAS

Dániel András Drexler PhD, principal investigator of subproject I
Prof. Levente Kovács PhD, habil, head of subproject I.

1.1 ABSTRACT

The research focuses on two fundamental public health problems: cancer treatment and diabetes.

Personalizing cancer therapy (work packages No. 1 and 2) has several potential

- a. increasing the overall survival of the patients;
- b. increasing the quality of life of the patients;
- c. decreasing the treatment doses;
- d. decreasing the chance of resistance;
- e. decreasing the side effects.

Our research group has been working on these problems for more than a decade, our work was supported by an ERC grant and also a competence center grant. In these projects we proved the concept in mouse experiments.

Personalizing treatment requires the knowledge of the mathematical model which describes the effect of the drug on the tumor of the patient. We develop algorithms which determine this model (work package No. 1). The mathematical structure is already given from previous research, the aim of our newly developed algorithms is to determine (identify) the parameters of the model for specific patients.

Therapy optimization requires the knowledge of the identified mathematical model. Based on this model, we can calculate the optimal treatment (work package No. 2) tailored for the specific patient (the model is tailored using the results from work package No. 1). We develop several algorithms at the same time for therapy optimization based on different perspectives. In practice, different algorithms may be required for different scenario, thus we evaluate them using in silico experiments.

Development of physiological control algorithms (work package No. 3) are different from the therapy optimization problem in the sense that they can give injections more frequently (continuously in some cases), while in the therapy optimization problem discussed in work package No. 2 is used for the cases when we have injections with low frequency, e.g., two times a week. We develop control algorithms for **artificial pancreas** applications, focus on the handling of external disturbances like meal intake and physical activity. The developed algorithms help people living with diabetes have better quality of life.

1.2 PUBLICATIONS

Table 1 Published and submitted publications of subproject I.

1. Tumor model personalization and therapy optimization (work packages No. 1 and 2)	
Original articles	
1	L. Kovács, T. Ferenci, B. Gombos, A. Füredi, I. Rudas, G. Szakács, and D. A. Drexler. Positive Impulsive Control of Tumor Therapy—A Cyber-Medical Approach. IEEE TRANSACTIONS ON SYSTEMS MAN AND CYBERNETICS: SYSTEMS, vol. in press, p. in press, 2023. IF: 11.471, D1, https://ieeexplore.ieee.org/document/10255720
2	B. Czakó, D. A. Drexler, and L. Kovács. Proof of Concept Control of a T1DM Model Using Robust Fixed-Point Transformations via Sliding Mode Differentiators, MATHEMATICS, vol. 11, no. 5, 2023. IF: 2.4, Q1 (JCR) https://doi.org/10.3390/math11051210
3	D. A. Drexler, I. Nagy, V. Romanovski. Stability analysis of the singular points and Hopf bifurcations of a tumor growth control model, MATHEMATICAL METHODS IN THE APPLIED SCIENCES, IF: 3.007, Q1, UNDER MINOR REVISION
4	E. Virágh, B. Kiss, D. A. Drexler. Motion planning methods for consecutive and one-step chemical reactions. JOURNAL OF MATHEMATICAL CHEMISTRY. 2023 IF: 2.413, Q1 SUBMITTED
5	L. Kovács, B. Czakó, M. Siket, T. Ferenci, A. Füredi, B. Gombos, G. Szakács, and D. A. Drexler. Experimental Closed-Loop Control of Breast Cancer in Mice, COMPLEXITY, vol. 2022, 2022. IF: 2.121, Q2 https://doi.org/10.1155/2022/9348166
Proceedings	
1	B. Gergics, F. Vajda, A. Ládi, A. Füredi, and D. A. Drexler. Pharmacodynamics modeling based on in vitro 3D cell culture experiments, in IEEE 17th International Symposium on Applied Computational Intelligence and Informatics SACI 2023 : Proceedings, 2023, pp. 499–504. https://ieeexplore.ieee.org/document/10158623
2	B. Gergics, F. Vajda, M. Puskás, A. Füredi, and D. A. Drexler. Mathematical modeling of phototoxicity during fluorescent imaging of tumor spheroids, in IEEE 27th International Conference on Intelligent Engineering Systems 2023 (INES 2023), 2023, pp. 291–296
3	M. F. Dömény, M. Puskás, L. Kovács, and D. A. Drexler. Population-based chemotherapy optimization using genetic algorithm, in SISY 2023 IEEE 21st International Symposium on Intelligent Systems and Informatics, 2023, pp. 23–28
4	E. Virágh, D. A. Drexler, and B. Kiss. Motion planning and modeling for isothermal parallel chemical reactions, in IEEE 17th International Symposium on Applied Computational Intelligence and Informatics SACI 2023 : Proceedings, 2023, pp. 91–96. https://ieeexplore.ieee.org/document/10158663
5	L. Kisbenedek, M. Puskás, L. Kovács, and D. A. Drexler. Clustering-based parameter estimation of a tumor model, in SISY 2023 IEEE 21st International Symposium on Intelligent Systems and Informatics, 2023, pp. 43–48.
6	L. Kisbenedek, M. Puskás, L. Kovács, and D. A. Drexler. Indirect supervised fine-tuning of a tumor model parameter estimator neural network, in IEEE 17th International Symposium on Applied Computational Intelligence and Informatics SACI 2023 : Proceedings, 2023, pp. 109–116. https://ieeexplore.ieee.org/document/10158651
7	M. F. Dömény, M. Puskás, L. Kovács, and D. A. Drexler. In silico chemotherapy optimization with genetic algorithm, in IEEE 17th International Symposium on Applied Computational Intelligence and Informatics SACI 2023 : Proceedings, 2023, pp. 97–102. https://ieeexplore.ieee.org/document/10158619
8	M. Puskás, B. Gergics, B. Gombos, A. Füredi, G. Szakács, L. Kovács, and D. A. Drexler. Noise modeling of tumor size measurements from animal experiments for virtual patient generation, in IEEE 27th International Conference on Intelligent Engineering Systems 2023 (INES 2023), 2023, pp. 53–60.

9	T. D. Szűcs, M. Puskás, D. A. Drexler, and L. Kovács. Model predictive fuzzy control in chemotherapy optimization, in IEEE 17th International Symposium on Applied Computational Intelligence and Informatics SACI 2023 : Proceedings, 2023, pp. 103–108. https://ieeexplore.ieee.org/document/10158569
10	E. Virágh, B. Kiss, and D. A. Drexler. Closed-loop control and motion planning for parallel structural chemical reactions, in SISY 2023 IEEE 21st International Symposium on Intelligent Systems and Informatics, 2023, pp. 283–288.
11	B. Gergics, B. Gombos, F. Vajda, A. Füredi, G. Szakács, and D. A. Drexler, “Pharmacodynamics modeling based on in vitro 2D cell culture experiments,” in 2022 IEEE International Conference on Systems, Man, and Cybernetics (SMC), 2022, pp. 2409–2414. https://ieeexplore.ieee.org/document/9945355
12	B. Czakó, D. A. Drexler, and L. Kovács. Time-Varying Parameter Identification of a Tumor Growth Model Using Moving Horizon Estimation, in 2022 IEEE 26th International Conference on Intelligent Engineering Systems (INES 2022), 2022, pp. 73–78. https://ieeexplore.ieee.org/document/9922626
13	B. Czako, D. A. Drexler, and L. Kovacs. Control of a T1DM Model Using Robust Fixed-Point Transformations Based Control With Disturbance Rejection, in 2022 IEEE International Conference on Automation, Quality and Testing, Robotics (AQTR), 2022, pp. 1–6. https://ieeexplore.ieee.org/document/9801992
14	B. G. Czakó, D. A. Drexler, and L. Kovács, “Discrete time derivation of the Robust Fixed-Point Transformation method,” IFAC PAPERSONLINE, vol. 55, no. 1, pp. 535–540, 2022 https://www.sciencedirect.com/science/article/pii/S240589632200088X
15	D. A. Drexler, M. Ghita, and L. Kovacs. On the relative degree of perturbed nonlinear systems, in 2022 13th Asian Control Conference (ASCC), 2022, pp. 1759–1764. https://ieeexplore.ieee.org/document/9828296
16	E. Nagy, M. Puskás, and D. A. Drexler. Comparison of artificial neural network and ANFIS for parameter estimation of a tumor model, in IEEE 20th Jubilee World Symposium on Applied Machine Intelligence and Informatics SAMI (2022), 2022, pp. 133–139. https://ieeexplore.ieee.org/document/9780819
17	M. Puskás, B. Gergics, A. Ládi, and D. A. Drexler. Parameter estimation from realistic experiment scenario using artificial neural networks, in IEEE 16th International Symposium on Applied Computational Intelligence and Informatics SACI 2022, 2022, pp. 161–168. https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9919464&casa_token=C4AzC_jEV6MAAAAA:Pz_gbp8gI_GdL_zagry6HOuKlwfTx4-QGkNjdeLM4xxXYRyBXhizvB4NZvOZhYgoW9nsLYnqZQ7dw
18	E. Nagy and A. D. Drexler. The Effect of the Choice of initial estimation for a tumor model parameter estimation problem, in IEEE Joint 22nd International Symposium on COMPUTATIONAL INTELLIGENCE and INFORMATICS and 8th International Conference on Recent Achievements in Mechatronics, Automation, Computer Science and Robotics (CINTI-MACRo 2022), 2022, pp. 227–231. https://ieeexplore.ieee.org/document/10029496
19	E. Nagy, B. Czakó, M. Siket, B. Gombos, A. Füredi, G. Szakács, L. Kovács, and D. A. Drexler. Tracking parameter changes of an Impulsive Tumor Growth Model, in IEEE 10th Jubilee International Conference on Computational Cybernetics and Cyber-Medical Systems ICC 2022, 2022, pp. 179–184. https://ieeexplore.ieee.org/document/9922736
Scientific dissemination	
1	D. A. Drexler, L. Kovács, and G. Moza, “Towards personalized medicine by mathematical modeling of tumors,” OPEN RESEARCH EUROPE, vol. 2, p. 59, 2022. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10446033/
Book chapters	
1	D. A. Drexler and L. Kovács. Modeling the physiological phenomena and the effects of therapy on the dynamics of tumor growth, in Modeling of Mass Transport Processes in Biological Media, 2022, pp. 391–403. https://www.sciencedirect.com/science/article/abs/pii/B9780323857406000169#!
2	G. Eigner, M. Siket, B. Czakó, D. A. Drexler, I. Rudas, Á. Zarándy, and L. Kovács., Model Predictive Tumour Volume Control using Nonlinear Optimization, STUDIES IN SYSTEMS DECISION AND CONTROL, vol. 415, pp. 235–250, 2022. https://link.springer.com/chapter/10.1007/978-3-031-00978-5_10
Conference presentations	
1	D. A. Drexler, B. Czakó, T. Ferenci, A. Füredi, B. Gombos, E. Nagy, M. Puskás, G. Szakács and L. Kovács. Personalizing chemotherapy based on mathematical modeling, 12th European Conference on Mathematical and Theoretical Biology, Sept. 19-23, 2022, Heidelberg, Germany https://ecmtb2022.org/program/bookofabstracts/

2	T. Ferenci and M. Szigeti. Anomaly detection and extreme value analysis of blood glucose measurements, 12th European Conference on Mathematical and Theoretical Biology, Sept. 19-23, 2022, Heidelberg, Germany https://ecmtb2022.org/program/bookofabstracts/
3	D. A. Drexler. MATEMATIKAI ALAPÚ TUMORMODELLEZÉS ÉS TERÁPIAGENERÁLÁS, 51. Membrán-Transzport Konferencia, May 18-20, 2022, Sümeg, Hungary https://www.remedicon.hu/315/51-membran-transzport-konferencia/program
2. Development of physiological control algorithms for artificial pancreas (work package No. 3)	
Original articles	
1	G. Kocsis, N. Garam, T. Javorfi, M. Svebis, B. Toth, T. Ferenci, G. Eigner, L. Barkai, and L. A. Kovacs, "THE IMPACT OF MINIMED (TM) 780G INSULIN PUMP SYSTEM - A SINGLE CENTRE PROSPECTIVE STUDY," DIABETES TECHNOLOGY AND THERAPEUTICS, vol. 25, pp. A70–A70, 2023, IF: 5.4, Q1
2	M. Siket, K. Novak, G. Eigner, and L. A. Kovacs. MEAL ESTIMATION ACCURACY IN MODEL PREDICTIVE CONTROL-MOVING HORIZON ESTIMATION CONTROL STRATEGY, DIABETES TECHNOLOGY AND THERAPEUTICS, vol. 25, pp. A112–A112, 2023., IF: 5.4, Q1
3	T.-A. Tran, M. Péntek, H. Motahari-Nezhad, J. Abonyi, L. Kovács, L. Gulácsi, G. Eigner, Z. Zrubka, and T. Ruppert. Heart Rate Variability Measurement to Assess Acute Work-Content-Related Stress of Workers in Industrial Manufacturing Environment—A Systematic Scoping Review, IEEE TRANSACTIONS ON SYSTEMS MAN AND CYBERNETICS: SYSTEMS, 2023. IF: 11.471, D1 https://ieeexplore.ieee.org/document/10177984
4	L. Dénes-Fazakas, M. Siket, L. Szilágyi, L. Kovács, and Gy. Eigner. Detection of Physical Activity Using Machine Learning Methods Based on Continuous Blood Glucose Monitoring and Heart Rate Signals, SENSORS, vol. 2022, 2022., IF: 3.847, Q1 https://www.mdpi.com/1424-8220/22/21/8568
Proceedings	
1	K. Novák, L. Kovács, A. D. Drexler, and G. Eigner. Glycemic control metrics for in silico testing of artificial pancreas systems, in IEEE Joint 22nd International Symposium on COMPUTATIONAL INTELLIGENCE and INFORMATICS and 8th International Conference on Recent Achievements in Mechatronics, Automation, Computer Science and Robotics (CINTI-MACRo 2022), 2022, pp. 287–292. https://ieeexplore.ieee.org/document/10029513
2	L. Dénes-Fazakas, M. Siket, L. Szilágyi, Gy. Eigner, and L. Kovács. Investigation of reward functions for controlling blood glucose level using reinforcement learning, in IEEE 17th International Symposium on Applied Computational Intelligence and Informatics SACI 2023 : Proceedings, 2023, pp. 387–392. https://ieeexplore.ieee.org/document/10158621
3	M. Siket, R. Tóth, L. Szász, K. Novák, G. Eigner, and L. Kovács. An application programming interface for the widely used academic version of the UVA/Padova Type 1 Diabetes Mellitus Metabolic Simulator, in IEEE 21st World Symposium on Applied Machine Intelligence and Informatics SAMI (2023) : Proceedings, 2023, pp. 287–292. https://ieeexplore.ieee.org/document/10044485
4	L. Dénes-Fazakas, M. Siket, G. Kertész, L. Szilágyi, L. Kovács, and Gy. Eigner. Control of Type 1 Diabetes Mellitus using direct reinforcement learning based controller, in 2022 IEEE International Conference on Systems, Man, and Cybernetics (SMC), 2022, pp. 1512–1517. https://ieeexplore.ieee.org/document/9945084
5	M. Siket, L. Dénes-Fazakas, L. Kovács, and Gy. Eigner. Numba-accelerated parameter estimation for artificial pancreas applications, in IEEE 20th Jubilee International Symposium on Intelligent Systems and Informatics (SISY 2022), 2022, pp. 279–284. https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=10036259
6	M. Siket, K. Novák, L. Kovács, and G. Eigner. Automatically estimated meals in Model Predictive Control-Moving Horizon Estimation control strategy, in 2022 13th Asian Control Conference (ASCC), 2022, pp. 1367–1372. https://ieeexplore.ieee.org/document/9828202
7	M. Siket, R. Tóth, I. Rudas, G. Eigner, and L. Kovács. Parameter estimation of T1DM models with a particular focus on endogenous glucose production, in 2022 IEEE International Conference on Systems, Man, and Cybernetics (SMC), 2022, pp. 1891–1896. https://ieeexplore.ieee.org/abstract/document/9945097
8	M. Szántó, G. Strasser, L. Szász, L. Dénes-Fazakas, G. Eigner, G. Kertész, and L. Kovács. Utilization of IMU-Based Gesture Recognition in the Treatment of Diabetes, in 2022 IEEE International Conference on Automation, Quality and Testing, Robotics (AQTR), 2022, pp. 1–5.

	https://ieeexplore.ieee.org/document/9801950
	Scientific dissemination
1	L. Kovács, G. Eigner, R. Tóth, M. Siket, K. Novák, G. Kocsis, and L. Barkai, “Mesterséges hasnyálmirigy közösségi fejlesztése – kitekintés a „csináld magad” mozgalomra,” DIABETOLOGIA HUNGARICA, vol. 31, no. 1, pp. 27–37, 2023. https://m2.mtmt.hu/api/publication/34079754
	Conference presentations
1	Á. Varga, J. Tar, and G. Eigner. Fixpont transzformáció alapú adaptív szabályozások implementációjának gyakorlati kérdései és kísérleti vizsgálata, in KVK PhD Workshop Minikonferencia : Absztrakt kötet, 2023, pp. 22–23. https://phdworkshop2023.kvk.uni-obuda.hu/static/2023/03/08/KVK_PhD_workshop_absztrakt_kotet_2023_V02.pdf

2 EVALUATION OF DIGITAL MEDICAL DEVICES: EFFICACY, SAFETY AND SOCIAL UTILITY

Prof. Márta Péntek, head of subproject II.

2.1 ABSTRACT

The aim of this research subproject is to develop methods for measuring health gains and socio-economic benefits from the use of digital medical devices (DMDs) in order to support scientifically and economically successful development of innovative DMDs. In the first two years of our subproject (2022, 2023), our focus is on the first three (out of the five) research objectives outlined in our research proposal:

- **Are DMDs clinically effective and safe?** How much more effective and safer than existing DMDs? Are the DMDs more effective and safe than DMDs?
- **What is the outcome of DMDs from the perspective of patients and users?** Outcome measurement, patient user skills, knowledge, attitudes and preferences
- **How can digital data from DMDs be used in medical decision-making?**

In addition, we are preparing research for work packages No. 4 (**cost-effectiveness analysis, health technology assessment**) and No. 5 (**measuring innovation performance and competitiveness of DMDs**).

Why our research results are useful...

-... for developers of digital medical devices?

Our research project helps to conduct a systematic literature review of existing DMD developments, evaluate the effectiveness and safety of DMDs that are comparators in the field, designing clinical trials of DMDs and measuring and disseminating results in a way that can be directly used in the evaluation of new technologies (health technology assessment) and financial decision-making.

- ...for physicians?

Our research project provides scientifically sound evidence about DMDs using and adapting methods of evidence-based medicine, helps to understand the value of DMD outcomes from the patients' perspective, and how to use digital DMD data in clinical decision-making.

- ...for patients?

Methods developed as a result of our research provide an opportunity to consider the patients' perspective (preferences, acceptability, usability) in DMD development and to accelerate the process of development, approval and reimbursement decisions of new devices, thereby improving awareness of and access to DMDs.

- ...for funders, health policy makers?

Our methodological developments will allow better measurement of the individual and societal benefits of DMDs, thereby supporting clinically and economically sound decision-making.

2.2 PUBLICATIONS

Table 1 Published and submitted publications of subproject II.

1. Evidence synthesis on digital medical devices (DMDs), development of methods for systematic literature reviews using artificial intelligence methods	
Original articles	
1	Zsombor Zrubka, Levente Kovács, Hossein Motahari Nezhad, János Czere, László Gulácsi, Márta Péntek. Artificial Intelligence in Medicine: A Systematic Review of Guidelines on Reporting and Interpreting Studies. Target journal: BMC Medical Research Methodology. IF: 4.614 Scimago D1. SUBMITTED
2	Zsombor Zrubka, Gábor Kertész, László Gulácsi, János Czere, Áron Hölgyesi, Hossein Motahari Nezhad, Amir Mosavi, Levente Kovács, Atul J Butte, Márta Péntek. Reporting Quality of Machine Learning Studies in Paediatric Diabetes Mellitus: a Systematic Review. Journal of Medical Internet Research. SUBMITTED
3	Tóth B, Berek L, Gulácsi L, Péntek M, Kertész G, Gulyás Oldal L, Zrubka Z. Automation of systematic reviews of biomedical literature: a systematic review of studies indexed in PubMed. Target journal: Scientific Reports. Impact factor (2022) 4.6; Scimago (2022) Q1; SUBMISSION IN PROGRESS
4	Hossein Motahari-Nezhad; Hana Al-Abdulkarim; Meriem Fgaier; Mohamed Mahdi Abid; Márta Péntek; László Gulácsi; Zsombor Zrubka. Digital Biomarker–Based Interventions: Systematic Review of Systematic Reviews. 2022 Dec 21;24(12):e41042. doi: 10.2196/41042. IF (2021): 7,08; Scimago (2021): Q1 (D1) https://www.imir.org/2022/12/e41042/
Proceedings	
1	Zsombor Zrubka ; László, Gulácsi ; Márta, Péntek. Time to start using checklists for reporting artificial intelligence in health care and biomedical research: a rapid review of available tools. In: Szakál, Anikó (szerk.) 2022 IEEE 26th International Conference on Intelligent Engineering Systems (INES 2022) Budapest, Magyarország : IEEE Hungary Section (2022) 273 p. pp. 15-20. , 6 p. https://ieeexplore.ieee.org/document/9922639
2	Barbara, Tóth ; Laura, Gulyás Oldal. Automation of systematic literature reviews: Development of a gold standard of articles in PubMed 2020-2021, a research protocol. In: Szakál, Anikó (szerk.) IEEE 20th Jubilee International Symposium on Intelligent Systems and Informatics (SISY 2022) Szabadka, Szerbia : IEEE (2022) 457 p. pp. 59-64. , 6 p. https://ieeexplore.ieee.org/document/10036252
4	János, Tibor Czere ; László, Gulácsi ; Zsombor, Zrubka ; Márta, Péntek. Quality assessment of clinical trials with artificial intelligence based chatbots in healthcare: points to consider in the protocol development for a systematic literature review. In: Szakál, Anikó (szerk.) IEEE 16th International Symposium on Applied Computational Intelligence and Informatics SACI 2022, Temesvár, Románia : IEEE (2022) pp. 335-340. , 6 p. https://ieeexplore.ieee.org/document/9919543
5	János, Tibor Czere ; Márta, Péntek. Exploring the Feasibility of the Meta-analysis of Randomized Controlled Trials on Artificial Intelligence Chatbots for Use in Healthcare Based on a Published Systematic Review. In: Szakál, Anikó (szerk.) IEEE 20th Jubilee International Symposium on Intelligent

	Systems and Informatics (SISY 2022) Szabadka, Szerbia : IEEE (2022) 457 p. pp. 53-58. , 6 p. https://ieeexplore.ieee.org/document/10036294
6	Johanna, Tripo ; József, Fogarasi ; Márta, Péntek. Statistical reporting quality of randomized controlled trials on artificial intelligence chatbots for promoting healthy lifestyle: exploring the SAMPL guideline. In: Szakál, Anikó (szerk.) IEEE 20th Jubilee International Symposium on Intelligent Systems and Informatics (SISY 2022) Szabadka, Szerbia : IEEE (2022) 457 p. pp. 31-36. , 6 p. https://ieeexplore.ieee.org/document/10036314
7	Alabdulkarim H, Zrubka Z. How Effective is Continuous Glucose Monitoring? A Comparison of different Random-Effect Meta-analysis Techniques. Közlésre elfogadva a SISY 2023 konferenciára
8	Hossein, Motahari-Nezhad ; Meriem, Fgaier ; Hana, Alabdulkarim. Methodological and bibliometric examination of systematic reviews of digital biomarker based studies. In: Szakál, Anikó (szerk.) IEEE 20th Jubilee International Symposium on Intelligent Systems and Informatics (SISY 2022) Szabadka, Szerbia : IEEE (2022) 457 p. pp. 47-52. , 6 p. https://ieeexplore.ieee.org/document/10036267
Abstracts	
1	Zrubka, Zsombor, Annette Champion, Anke-Peggy Holtorf, Rossella Di Bidino, Jagadeswara Rao Earla, Artem Boltyenkov, Masami Tabata-Kelly, Carl Asche, Anita Burrell. Qualitative content analysis of secondary digital health terms – Are they sufficient for health outcomes research purposes? Value in Health, 2022, 12: pp S382-S382., 1 p.. (ISPOR Europe 2022) (poszter) https://www.valueinhealthjournal.com/article/S1098-3015(22)04101-8/fulltext
2	Motahari-Nezhad, H ; Fgaier, M ; Péntek, M ; Gulácsi, L ; Zrubka, Z. Populations, Interventions, and Outcomes in Digital Biomarker-Based Interventions' Systematic Reviews: A Scoping Review. VALUE IN HEALTH 25 : 7 pp. S534-S534., 1 p. (2022) (ISPOR 2022. USA: „The Future of HEOR in Patient-Driven Digital Healthcare Systems”) (poszter) https://www.valueinhealthjournal.com/article/S1098-3015(22)01494-2/fulltext
Book	
1	Berek L. A kutatás mérhetősége, tudományometriai adatbázisok és mérőszámok, különös tekintettel a digitális orvostechikai eszközök terén való alkalmazásra. Kiadó: Óbudai Egyetem, 2023. ISBN 978-963-449-325-9
Conference presentations	
1	Gulácsi L, Balázs Gy, Péntek M.: EU MDR: új szabályozók az orvostechikai eszköznek minősülő fényforrások piacán. Világítástechnikai Társaság XIII. LED Konferencia Óbudai Egyetem, Bécsi út 96/B Auditórium Maximum 2022. február 2. 11:50 – 12:15
2	Gulácsi L, Péntek M, Zrubka Z. Az orvostechikai eszközök piacra lépésének kérdései az EU-MDR klinikai bizonyítékokra vonatkozó előírásai alapján. Lehetőségek és kihívások 2022, Óbudai Egyetem, Bécsi út 96/B, 2022. február 2. 14:35-14:50
2. Methods of measuring health gains from DMDs, the role of patient reported outcome measures (PROMs)	
Original articles	
1	Hölgyesi Á, Tóth B, Kozlovsky M, Kuti J, Weszl M, Balázs G, Baji P, Kovács L, Gulácsi L, Zrubka Z, Péntek M. Epidemiology and patients' self-reported knowledge of implantable medical devices: Results of a cross-sectional survey in Hungary. PLoS One. 2023 Apr 18;18(4):e0284577. doi: 10.1371/journal.pone.0284577. eCollection 2023. Impact factor (2022): 3,7. Scimago (2022): Q1 https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0284577
2	Hölgyesi Á, Luczay A, Tóth-Heyn P, Muzslay E, Világos E, Szabó A, Baji P, Kovács L, Gulácsi L, Zrubka Z, Péntek M. Focus on parental electronic health literacy: associations with disease management and outcomes in pediatric type 1 diabetes mellitus. Target journal: Pediatric Diabetes Impact factor (2021): 3,409; Scimago (2022) Q1. SUBMITTED
3	Hölgyesi Á, Zrubka Z, Gulácsi L, Baji P, Haidegger T, Kozlovsky M, Weszl M, Kovács L, Péntek M. Robot assisted surgery and tumour diagnostics; public preferences with representative cross sectional survey. Target journal: BMC Medical Informatics and Decision Making Impact factor (2022): 3,5, Scimago: Q1. SUBMISSION IN PROGRESS.
4	Tóth B, Gulácsi L, Kovács L, Zrubka Z. Beyond Bits and Bytes: The role of internet skills in shaping life and career satisfaction and subjective future expectations. Target journal: Journal of Happiness Studies. IF (2022): 4.6, Scimago (2022): Q1. SUBMISSION IN PREPARATION
Proceedings	
1	Brito Fernandes, Oscar ; Hölgyesi, Áron ; Péntek, Márta. Patient-centred care in Hungary: Contributions to foster a policy agenda. ZEITSCHRIFT FÜR EVIDENZ, FORTBILDUNG UND QUALITÄT IM GESUNDHEITSWESEN 171 pp. 58-61. , 4 p. (2022) IF: - Scimago: - https://www.sciencedirect.com/science/article/pii/S1865921722000654

2	Tóth B, Gulácsi L, Zrubka Z. The relationship between young adults' internet skills and their satisfaction with life and career. In: Szakál, Anikó (szerk.) SISY 2023 IEEE 21st International Symposium on Intelligent Systems and Informatics Budapest, Magyarország : IEEE Hungary Section (2023) 663 p. pp. 309-314. , 6 p.
3	Péntek M, Czere JT, Zrubka Z, Haidegger T, Kovács L, Gulácsi L: EQ-5D studies in robotic surgery: a mini-review. In: Szakál, Anikó (szerk.) IEEE 17th International Symposium on Applied Computational Intelligence and Informatics SACI 2023: Proceedings Konferencia helye, ideje: Temesvár, Románia 2023.05.23. - 2023.05.26.; Budapest, Magyarország : Óbudai Egyetem, IEEE Hungary Section (2023) 818 p. pp. 519-524. , 6 p. https://ieeexplore.ieee.org/document/10158630
4	Zrubka Z, Hölgyesi A, Neshat M, Motahari Nehzad H, Mirjalili S, Kovács L, Péntek M, Gulácsi L. Towards a single goodness metric of clinically relevant, accurate, fair and unbiased machine learning predictions of health-related quality of life. In: Szakál, Anikó IEEE 27th International Conference on Intelligent Engineering Systems 2023 (INES 2023) Budapest, Magyarország : IEEE Hungary Section (2023) pp. 285-290. , 6 p.
Abstracts	
1	Péntek, M ; Hölgyesi, Á ; Tóth, B ; Kozlovsky, M ; Kuti, J ; Weszl, M ; Czere, J ; Baji, P ; Kovács, L ; Gulácsi, L, Zrubka, Z. Citizens' Thoughts about Implantable Medical Devices: Results of a Cross-Sectional Survey Among the General Population in Hungary. VALUE IN HEALTH 25 : 7 p. S537 , 1 p. (2022) (ISPOR 2022. USA: „The Future of HEOR in Patient-Driven Digital Healthcare Systems”) (poszter) https://www.valueinhealthjournal.com/article/S1098-3015(22)01506-6/fulltext
2	Hölgyesi, Á ; Tóth, B ; Kozlovsky, M ; Kuti, J ; Weszl, M ; Baji, P ; Kovács, L ; Gulácsi, L ; Zrubka, Z ; Péntek, M. Epidemiology and Patients' Knowledge of Implantable Medical Device Management and Safe Use: Results of a CROSS-Sectional Survey Among the General Population in Hungary VALUE IN HEALTH 25 : 7 p. S538 (2022) (ISPOR 2022. USA: „The Future of HEOR in Patient-Driven Digital Healthcare Systems”) (poszter) https://www.valueinhealthjournal.com/article/S1098-3015(22)01511-X/fulltext
3	Áron Hölgyesi, Barbara Tóth, Miklós Kozlovsky, József Kuti, Miklós Weszl, György Balázs, Petra Baji, Levente Kovács, László Gulácsi, Zsombor Zrubka, Márta Péntek LIVING WITH ORTHOPEDIC IMPLANTS: RESULTS OF AN ONLINE CROSS-SECTIONAL STUDY IN HUNGARY. Value in Health, 2022, 12: pp S381-S382., 1 p.. (ISPOR Europe 2022) (poszter) https://www.valueinhealthjournal.com/article/S1098-3015(22)04100-6/fulltext
4	Hölgyesi, Áron ; Zrubka, Zsombor ; Gulácsi, László ; Kovács, Levente ; Tóth, Barbara ; Weszl, Miklós ; Balázs, György ; Kozlovsky, Miklós ; Kuti, József ; Baji, Petra ; Péntek, Márta. Ortopédiai és csonttörés miatti implantátumok epidemiológiája és a betegek tájékozottsága: magyarországi keresztmetszeti lakossági felmérés eredményei. MAGYAR REUMATOLÓGIA 63 : 3 p. 167 , 1 p. (2022) (poszterelőadás).
5	Péntek, M ; Kozlovsky, M ; Weszl, M ; Kuti, J ; Hölgyesi, Á ; Tóth, B ; Czere, J ; Baji, P ; Kovács, L ; Gulácsi, L ; Zrubka, Z. Patients' Experiences with Shared Decision Making about Implantable Medical Device Surgery: Results of a Cross-Sectional Survey in Hungary. VALUE IN HEALTH 25 : 7 p. S533 , 1 p. (2022) (ISPOR 2022. USA: „The Future of HEOR in Patient-Driven Digital Healthcare Systems”) (poszter) https://www.valueinhealthjournal.com/article/S1098-3015(22)01487-5/fulltext
6	Hölgyesi Á, Zrubka Z; Luczay A; Tóth-Heyn P; Muzslay E; Szabó A; Világos E; Gulácsi L; Kovács L, Péntek M. Digital Health Literacy of Parents and Health-Related Quality of Life of Their Children with Type 1 Diabetes Mellitus. VALUE IN HEALTH 26 : 6 p. S349 Paper: PCR201 , 1 p. (2023) https://www.valueinhealthjournal.com/article/S1098-3015(23)02480-4/fulltext
7	Hölgyesi Á; Zrubka Z; Luczay A; Tóth-Heyn P; Muzslay E; Szabó A; Világos E; Gulácsi L; Kovács L; Péntek M. Association of Children's Type 1 Diabetes with Parents' Capability Well-Being Assessed By the ICECAP-A Measure. VALUE IN HEALTH 26 : 6 p. S313 Paper: PCR7 , 1 p. (2023) https://www.valueinhealthjournal.com/article/S1098-3015(23)01887-9/fulltext
8	Áron Hölgyesi, Barbara Tóth, Miklós Kozlovsky, József Kuti, Miklós Weszl, György Balázs, Petra Baji, Levente Kovács, László Gulácsi, Zsombor Zrubka, Márta Péntek. CITIZENS' PREFERENCES FOR ROBOT-ASSISTED HIP REPLACEMENT: RESULTS OF AN ONLINE CROSS-SECTIONAL STUDY IN HUNGARY. Value in Health, 2022, 12: pp S440-S440., 1 p.. (ISPOR Europe 2022) (poszter) https://www.valueinhealthjournal.com/article/S1098-3015(22)04396-0/fulltext
9	Hölgyesi, Áron ; Zrubka, Zsombor ; Gulácsi, László ; Kovács, Levente ; Tóth, Barbara ; Weszl, Miklós ; Balázs, György ; Kozlovsky, Miklós ; Kuti, József ; Baji, Petra ; Péntek, Márta. Robotsebészet alkalmazással kapcsolatos preferenciák csípőprotézis-beültetés esetén: keresztmetszeti kérdőíves felmérés a magyarországi lakosság körében. MAGYAR REUMATOLÓGIA 63 : 3 p. 168 , 1 p. (2022); (poszterelőadás).

10	Péntek M, Hölgyesi Á, Czere JT, Kovács L, Zrubka Z, Gulácsi L. EQ-5D studies in pediatric diabetes: a systematic literature review. Közlésre elfogadva az ISPOR Europe 2023 konferenciára, idézhető absztrakt a Value in Health folyóirat különszámában fog megjelenni.
3. Usability of digital patient data for the evaluation of health gains and social utility of DMDs	
Original articles	
1	Tran, Tuan-anh; Péntek, Márta; Hossein, Motahari Nezhad; Abonyi, Janos; Kovács, Levente; Gulácsi, László; Eigner, György; Zrubka, Zsombor; Ruppert, Tamás. Heart rate variability measurement to assess acute work content related stress of workers in industrial manufacturing environment - A systematic scoping review. IEEE Transactions on Systems, Man and Cybernetics: Systems. IF (2022): 8,7; Scimago (2022): Q1 (D1) https://ieeexplore.ieee.org/document/10177984
2	Móga K; Hölgyesi Á; Zrubka Z; Péntek M*; Haidegger T. Augmented or Mixed Reality Enhanced Head-Mounted Display Navigation for In Vivo Spine Surgery: A Systematic Review of Clinical Outcomes. JOURNAL OF CLINICAL MEDICINE 12 : 11 Paper: 3788 , 14 p. (2023) Impact faktor (2022): 3,9; Scimago (2022): Q1. https://www.mdpi.com/2077-0383/12/11/3788
3	Voniatis C, Bánsági S; Veres DS; Szerémy P, Jedlovsky-Hajdu A, Szijártó A; Haidegger T. Evidence-based hand hygiene: Liquid or gel handrub, does it matter? ANTIMICROBIAL RESISTANCE AND INFECTION CONTROL 12 : 1 Paper: 12 , 12 p. (2023) Impact faktor (2022) 6,456; Scimago (2022) Q1 https://aricjournal.biomedcentral.com/articles/10.1186/s13756-023-01212-4
Proceedings	
-	
Abstracts	
<i>ongoing</i>	
4. (Health technology assessment of DMDs, incorporation health economic aspects in the development process) and 5. (Innovation performance and competitiveness of the DMD sector)	
Original articles	
1	Fgaier M, Hana Al-Abdulkarim, MSc; Hossein Motahari-Nezhad; Nhlanhlayakhe Nkwanyana; Márta Péntek; László Gulácsi, Zsombor Zrubka. A systematic review on the methodology and reporting quality of health economic analysis studies using transferred costs from the Middle East and North Africa region. Target journal: Health Policy and Technology. SUBMITTED
Proceedings	
1	Fgaier, Meriem ; Zrubka, Zsombor. Cost-effectiveness of using chatbots in healthcare: a systematic review. In: Anikó, Szakál (szerk.) IEEE Joint 22nd International Symposium on COMPUTATIONAL INTELLIGENCE and INFORMATICS and 8th International Conference on Recent Achievements in Mechatronics, Automation, Computer Science and Robotics (CINTI-MACRo 2022) : Proceedings Budapest, Magyarország : IEEE Hungary Section (2022) 418 p. pp. 305-310. , 6 p. https://ieeexplore.ieee.org/document/10029478
2	Meriem, Fgaier ; Zsombor, Zrubka. Cost-effectiveness analysis and sustainable innovation in healthcare: A review of cost transferability from the MENA region. In: Ágnes, Csiszárk-Kocsir; Anett, Popovics; Pál, Fehér-Polgár (szerk.) XVII. FIKUSZ 2022 International Conference : Proceedings. Budapest, Magyarország : Óbuda University Keleti Károly Faculty of Business and Management (2022) 653 p. pp. 309-322. , 14 p.
3	Meriem, Fgaier. Health economic studies using transferred costs from the Middle East and North Africa region: a protocol for a systematic review of the methodology and reporting quality. Review. In: Szakál, Anikó (szerk.) IEEE 20th Jubilee International Symposium on Intelligent Systems and Informatics (SISY 2022) Szabadka, Szerbia : IEEE (2022) 457 p. pp. 41-46. , 6 p. https://ieeexplore.ieee.org/document/10036324
4	Fgaier M, Zrubka Z. Less is more: imputing for missing direct medical costs within the Middle East and North Africa region using macroeconomic indicators. Közlésre elfogadva a SISY 2023 konferenciára
Abstracts	
-	