STRATEGY FOR SCIENCE AND RESEARCH TO 2025 WITH A VIEW TO 2030+

Faculty of Health Studies
Technical University of Liberec

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INTRODUCTION

The Faculty of Health Studies of the Technical University of Liberec (hereinafter referred to as FZS TUL) was established on 1 August 2016 by transformation from the Institute of Health Studies, which was established at the Technical University of Liberec (hereinafter referred to as TUL) on 1 December 2004.

FZS TUL operates in the field of health care and non-medical health programmes. The development of scientific, research, development, innovation and other creative activities of FZS TUL is primarily oriented towards the field of accredited study programmes for the training of non-medical health professionals.

Within the framework of Bachelor's study programmes, FZS TUL implements the study programmes **General Nursing**, **Radiological Assisting, Paramedics**, and **Biomedical Technology.** As part of the Master's degree programme, FZS TUL implements the study programme **Biomedical Engineering**. In the field of lifelong learning of non-medical health care professionals, FZS TUL implements a certified course entitled Mentor of Clinical Practice in Nursing and Midwifery, Lifelong Learning of Non-Medical Health Care Professionals - Specifics of the Work of a Nurse Manager and a course entitled Electrocardiography in Clinical Practice, and others based on the needs of health care providers.

The key workplaces of FZS TUL are two institutes, namely **the Institute of Nursing and Urgent Care** and the **Institute of Clinical Disciplines and Biomedicine**. FZS TUL cooperates closely with the Regional Hospital Liberec (KNL), a.s., as well as other health service providers, e.g., IKEM Prague, FN Motol, ÚVN VFN, General Hospital Prague, etc.

Two departments are also managed by the Dean's Office of the **Faculty of Science and Research** and the **Department of IT and Simulation Technology**. FZS TUL has a number of specialised laboratories, new technologies, including various specific simulators for simulation of clinical pathologies, and 3D virtual reality. Educational, scientific, research, development, innovation, and other creative activities at FZS TUL are performed by experts who are recognised in medical and non-medical fields in the Czech Republic and abroad, which ensures a connection with practice, according to the latest scientific findings. Academic staff are also members of several scientific committees of professional journals, conferences, professional organisations or other committees.

Basic and applied research is based on very close cooperation with KNL, a.s. and other health service providers throughout the Czech Republic. FZS TUL also provides further education for medical and non-medical health care professionals. This includes training based on simulation of model tasks in the ambulance and emergency medicine laboratory. Creative activities are also systematically developed FZS TUL in cooperation with other faculties of the University (especially the Faculty of Mechatronics, Informatics and Interdisciplinary Studies and the Faculty of Textiles) and with health service providers.

Academic staff are members of the research teams. Creative activity is also recorded in the records of projects implemented at TUL, in the Annual Reports on the Activities of TUL and in the Annual Reports on the Activities of the Faculty of Science and Technology of TUL. The creative activity of the Faculty of Science and Technology of TUL consists mainly in the publishing activities of faculty members and also in the involvement of academic and research staff and students in various projects (e.g., within the framework of the Technology Agency of the Czech Republic (TACR), Student Grant Competition, etc.). Academic staff and students are motivated to participate in various programmes to support creative and scientific research activities, which result in peer-reviewed texts, conference papers, as well as other scientific results. FZS TUL systematically performs and develops creative activities corresponding to the field of education and the profile of non-medical study programmes. The creative activity is directed towards the field of health care using the potential of the University. TUL and its units, including the FZS TUL, implement scientific grants and projects that are professionally related to certain areas to which the study programme belongs. The most recent are new technologies in healthcare and the related application area. Examples include addressing the issue of healthcare-associated infections, including biofilms, as well as new possibilities for teaching effectiveness, including the use of simulation technology, and innovations in healthcare, such as the use of robotic systems in rehabilitation and assistive robotics, etc.

In accordance with the Strategic Plan for the period 2021-2025 with a view to 2030 and the annual Strategic Plan Implementation Plans, FZS TUL currently focuses on the following main research areas:

In the field of prevention of healthcare-associated infections, FZS TUL deals with nanofibrous materials for biomedical applications, prevention and reduction of the occurrence and spread of healthcare-associated infections, tissue culture research in the prevention of healthcare- associated infections, and visualisation of transmission of healthcare-associated infections using UV fluorescence.

In the area of new possibilities and effectiveness of teaching, FZS TUL deals with simulation methods of teaching in various clinical situations, new possibilities and effectiveness of teaching simulation methods, personal learning environment, education in non-medical health programmes, and effectiveness of the adaptation process in practice.

In the field of new innovations in health care, including public health, FZS TUL deals with the issue of waste, its use in the removal of pathogenic bacteria and their resistance. In addition, this sector is involved in new robotic systems and rehabilitation devices, the improvement of magnetic resonance imaging and the development of new options for magnetic resonance imaging, basic cytotoxicity testing of newly developed nanoparticles, microbial water quality, and other activities.

In the field of assistive systems and technologies in nursing, physiotherapy and other non- medical fields, the Faculty of Physical Therapy of the TUL assumes the use of automated control systems in complex human care, including robotic systems, virtual reality systems, etc.

FZS TUL mainly implements projects supported by the Ministry of Education, Youth and Sports (MOE), the Agency for Medical Research of the Czech Republic, TACR, and the Operational Programme Research, Development and Education (OP RDE), etc. Through these projects, study aids were upgraded and new teaching and research laboratories were built. An example of new equipment is the acquisition of an ambulance simulator with complete and appropriate equipment, including

technology for the implementation of simulation teaching. Another example is the introduction of simulation laboratories for practical teaching of patient care skills (using computer technology and electronic recording and evaluation software, including electronic nursing documentation). It is the intention of FZS TUL to further deepen the use of special laboratories for testing materials under strictly aseptic conditions. FZS TUL also has newly established and modernly equipped laboratories for teaching courses within the study programme Radiological Assisting within the ERDF I project, Educational Infrastructure of TUL for Increasing Relevance, Quality and Access to Education in the Conditions of Industry 4 .0, and the study programme General Nursing within the ERDF II project, Infrastructural Support for New Study Programmes at TUL.

MISSION

The main mission of FZS TUL is to provide higher education in non-medical medical programmes and to be a very modern space for scientific research activities in areas linking health care and technology. FZS TUL aims to inspire students to develop knowledge, critical thinking, social responsibility, and ethical principles. FZS TUL wants to continue to contribute its creative activities to the expansion of knowledge and to strive for the practical application of new knowledge and its use in the development of society, especially in the areas of simulation education, robotics, development of functional materials in biomedicine, and infection prevention.

VISION

FZS TUL aims to become a renowned provider of education in the field of non-medical medical programmes, building on quality teaching using modern technologies and cutting-edge equipment. In the field of science and research, it will deliver research and development tailored to health service providers, applicable in the health sector, especially in patient care. An integral part is to develop close cooperation (due to its strategic location) with foreign partners of the Euroregion Nisa in order to share experience and practice and to participate in joint projects.

OPPORTUNITIES AND CHALLENGES TO STRENGTHEN RESEARCH, DEVELOPMENT AND INNOVATION (SWOT)

Strengths

- Currently, the staff of FZS TUL is made up of very high quality experts with enough professors and associate professors.
- Some of the experts also work for health service providers, which brings several advantages (e.g., excellent linking of theory and practice for students, high expertise, transfer of the most up-to-date information to students, etc.).
- Involvement of students in scientific research activities within the framework of their final theses.
- Close cooperation with health service providers.

Weaknesses

- As the youngest faculty of TUL, FZS TUL has not yet built a long-term system of research teams. The teams now consist of a small number of people or are involved in research in collaboration with other faculties or health service providers.
- Some of the experts also work for health service providers, which has some disadvantages (time constraints, less space for research and administration).
- The above-mentioned fact is related to the low number of quality publications and projects implemented by FZS TUL as the principal investigator.
- Few staff with 100% of their time dedicated to research in addition to teaching.
- Weak administrative facilities for the implementation of the research agenda.
- Insufficient staffing in project management for science and research.

Challenges/Opportunities

- Excellent equipment of various laboratories with modern instruments and technology.
- Possibility of cooperation with other TUL faculties, especially in the field of biocompatibility testing of materials.
- Ability to address current themes:
    - Robotic systems and implantable devices;
    - Tissue and materials engineering;
    - Infection prevention.
- Possibility to be involved in large interdisciplinary projects linking medicine with technology.
- A project manager for science and research was recruited in 2023. In addition, the scientific team was expanded to include a molecular biologist and a biophysicist.

Risks/Threats

- Possible resource constraints from funders.
- The departure of specialists to the private sphere for financial reasons.
- Reduced chances of getting large projects due to the difficult economic situation.

CURRENT STATUS AND PROPOSAL FOR STRATEGIC MEASURES

At present, the staff at FZS TUL is made up of very high quality experts. Some of these experts also work for health service providers, which brings several advantages, but also disadvantages. The management of FZS TUL is now focusing on strengthening the research teams, as the instrumentation and laboratory equipment is above standard. FZS TUL will continue to focus on this and support the existing teams in their activities. The close relationship with health service providers may also be used by FZS TUL to rapidly respond to the turbulent changing research needs in the healthcare sector in recent years.

KEY AREAS OF SCIENCE AND RESEARCH

1) Assistive Systems and Technologies in Human Care

Electromagnetic compatibility of active implantable devices	**Currently:** Research focuses on the electromagnetic compatibility of pacemakers and cardioverter-defibrillators. Specifically, the response of these devices to the presence of external interfering fields of different characteristics is analysed, as well as the identification of sources of potentially dangerous fields, the effect of the implant response on the health of the patient and possible ways of eliminating interference. **In the long term:** Expansion of the research objectives to other types of active implants and wearables electronics is planned.
Molecular imaging	**Currently:** Testing contrast agents for MRI and for optical imaging and visualisation of transplanted organs, tissues and cells. Also, development of software for spectroscopic data processing and design of radiofrequency coils for MRI. **In the long term:** in vivo labelling of cells with theranostic agents.
Medical devices and equipment; Biomedical technology	**Currently**: TACR GAMMA - Validation of a UV robotic system for applications in medical facilities. The theme of the project arose in the context of the COVID-19 pandemic, and the need to disinfect surfaces more effectively.

	Currently, only chemical liquid disinfectants are used, where surface disinfection is performed by staff. The aim is to improve the disinfection of both medical and commercial premises, whereby reducing the incidence of healthcare-associated infections, which threaten the loves of patients and significantly prolong their hospital stay, with the associated increase in treatment costs from the perspective of the healthcare payer. The project will develop a working prototype of a disinfection device on a robotic platform using UV radiation. The development of this device has been discussed with KNL, a.s.. to ensure that it meets all requirements and may be successfully put into practice. Another objective in this area is to analyse the market of available disposable sensors for the invasive blood pressure (IBP) measurement and compare their compatibility with vital signs monitors currently in use. **In the long term:** Research within biomedical technology, magnetic resonance imaging of breast implants. Research of the application of IoT (Internet of Things: networks of physical, electronic devices that are able to send and receive data to each other) in pre-hospital care. Design of solutions for optimal data transmission from ambulances to hospital facilities.

2) Materials Engineering, Microbiology, Biochemistry, and Biophysics

Physics of Materials; Electrophysiology; Electrochemistry	**Currently:** Interaction of an electric field with a solution and phenomena affecting cells, interaction of an electric field with cell mechanisms, including the construction of mathematical models and their validation by experiments. Focus on piezoelectricity. Use of smart materials. **In the long term:** Ferroelectric materials for electroactive implants. Interaction of a ferroelectric implant with a solution and cells. Self-stimulation by piezoelectricity.
Tissue engineering; Cell biology; Study of bacterial biofilm	**Currently:** 1) Cultivation of human cells on newly prepared materials (titanium with modified surface, sol-gel polymers, electroactive 3D supports, polymer fibres and polymer 3D structures, nanocellulose, etc.) and monitoring of cell adhesion, proliferation and differentiation:

	a) optimisation of the existing methodology, b) Introduction of new protocols for the cultivation of selected cell lines and their analysis. 2) Testing interactions of microorganisms with biocompatible micro- and nanomaterials for biomedical applications: a) Optimisation of the existing methodology, b) Introduction of new protocols for the cultivation of selected cell lines and their analysis. 3) Testing and characterisation of the co-cultivation of microorganisms with human cells on nano/micro-materials: a) Optimisation of the existing methodology, b) Introduction of new protocols for the cultivation of selected cell lines and their analysis. **In the long term:** Within the cell biology laboratories, efforts will be made to establish collaboration with scientific groups of TUL departments as well as non-university institutions for the purpose of economic activities and publishing activities. The nano/micro-materials prepared by collaborating groups will be tested under in vitro conditions, students from other departments will be trained to work with cell cultures and nanomaterials, and seminars on the interaction of different cell types with prepared nano/micro-materials will be organised. Efforts will be made to involve FZS TUL in multidisciplinary university and non-university projects, possibly internationally. Planned collaboration with KNL, a.s., especially with the ICU Neurocentre in the field of detection and control of healthcare associated infections (HAI), and with other clinical departments in Liberec and Prague.
Materials engineering; Chemistry of materials	**Currently:** Preparation of electron and optically conductive nanofibrous materials with helical chirality capable of chemisorption and physisorption of bioactive molecules with possible enantioselective enrichment. Their testing for rheological and mechanical properties, biocompatibility, toxicity and functional properties. Preparation of ultraporous nanomaterials for sensing applications and gradual release of bioactive compounds, their structural and morphological characterisation, research of application potential. **In the long term:** Gradual acquisition of autonomy in the fulfilment of research plans, co-principle investigator grants, development of inter-faculty and inter-university cooperation, inclusion of students in research.

3) Innovation in Healthcare, Emergency Medicine, and Public Health

Assistive technologies in radiology	**Currently:** Development of a fixation device for patients with large breasts and clinically confirmed diagnosis of C50, who are curatively treated with external radiotherapy with a photon beam on a linear accelerator at KNL, a.s. Development: 1. Production and design of components for the production of complete fixation devices in cooperation with KNL, a.s. and FT TUL. 2. Dosimetric measurement of the formation of secondary particles of ionising radiation. 3. Clinical verification of functionality. 4. Evaluation of the benefit for the patient, acute radiation skin changes in the irradiated area. 5. Evaluation of the effectiveness of the use of the fixation aid. **In the long term:** The vision is to create a fixation device that will fix soft tissues, whereby preventing acute radiation changes in the irradiated area during the whole irradiation series and to refine the target volume targeting by reproducing the irradiation position. Thanks to its simplicity and manufacturing originality, the fixation device may become part of the equipment of any comprehensive cancer centre or radiation therapy unit in the Czech Republic.
Nursing	**Currently:** Preparation of questionnaires and conducting a survey in selected facilities focusing on waste separation in operation. Based on the questionnaire and other research activities, an up-to-date methodology is being prepared for healthcare waste management with regard to the new legislation and the assigned sub-tasks. A further objective is to integrate themes relating to the biographical care of the elderly into education in all its forms. **In the long term:** Development of software tools for the concept of biographical care; linking nursing with assistive technologies, the importance of an ethical framework.
Prevention; Epidemiology	**Currently:** In 2022, a team of collaborators from FZS TUL and KNL, a.s. submitted a proposal for the project entitled *Repeated Point Prevalence Study of Healthcare Associated Infections in Acute Care at the Regional Hospital Level*. The essence of the project is to repeatedly assess the prevalence of healthcare-associated infections (HAIs), resistance of microorganisms to antibiotics and antibiotic consumption, thereby contributing to knowledge of their dynamics and the safety

	of patients in the healthcare facility. Information on the incidence, pattern of infections, affected patients, and the antibiotic resistance of the causative agents of these infections and antibiotic consumption will be obtained. The study has international links to studies coordinated by the European Centre for Disease Prevention and Control in Stockholm. **In the long term:** Focus research on HAI and infection control issues in healthcare facilities. The research will use digital surveillance and monitoring of risk factors for the emergence of HAIs and antibiotic resistance
Education	**Currently:** Optimisation of the education of non-medical professions with a focus on the effectiveness of the theory-practice ratio in teaching. **In the long term:** The effectiveness of educational processes in nursing practice.
Biomedical Informatics	**Currently:** Active participation in the EU4Health programme 2021-2027 (Vision for a healthier EU). **In the long term:** Building on the theme of digital skills by educating future and current medical and non-medical staff in digital literacy, skills regarding cyber security, etc.
The importance of supervision and its contribution to the development of soft skills	**Currently:** Efforts to create a project entitled *Training and development of social skills in nurses, prevention of burnout syndrome*. The project targets nurses at the bedside in health care facilities. Proposed method (alternative): Balint group and individual supervision (once a month). A social skills questionnaire will be distributed before the project begins and after its completion. **In the long term:** Expansion of the application.
Health Sciences Research - Paramedicine	**Currently:** Research of the effective application of the tourniquets recommended by the Tactical Combat Casualty Care committee in students in the Paramedic programme. Comparison between students of FZS TUL with students from the Polish Uniwersytet Medyczny Im, Piastów Śląskich in Wroclaw. Furthermore, research in the field of first aid training for children, adolescents, and adults. The research will focus on the effectiveness of first aid teaching for children, adolescents, and adults. **In the long term:** Research in the field of management of polytraumatised patients in the emergency medical service. Research on pain management in pre-hospital emergency care. Cost-effectiveness associated with the provision of pre-hospital emergency care in polytraumatised

	patients. Research of the effectiveness of teaching mass casualty management through the use of virtual reality. Research of the use of non-invasive ventilation by paramedics in emergency medical service settings in V4 countries.
Anatomy; Osteology	**Currently:** Preparation of a paper analysing bone density obtained from abdominal CT scans with a focus on pre- and postmenopausal women. **In the long term:** Comparison of bone density in the whole bone volume obtained from CT scans with that obtained from DEXA scans, which are now commonly used in clinics. This comparison should provide more information on whether the DEXA scan is the most appropriate method for diagnosing osteoporosis.

HIGH-END EQUIPMENT

The laboratories of FZS TUL are well equipped with medical technology and equipment for the most effective teaching as well as for the related scientific activities and research.

The Laboratory of Microbial Techniques is designed for research activities in the field of microbiology and epidemiology. The laboratory has, among others, microscopes and macroscopes.

The Tissue Culture Laboratory is used for tissue engineering research using tissue culture. It includes a CO_2 incubator, a cooled benchtop centrifuge, and a spectrophotometer measuring absorbance, fluorescence, and bioluminescence.

The Microbiology Laboratory allows testing of bacterial strains and fungi of the second degree of danger. Testing of antibacterial and antifungal activity on prepared materials (nanofibres, nanoparticles, nanolayers) is performed primarily for the development of materials for dermal and environmental applications, or for the study and analysis of biofilm growth on materials used in healthcare. It includes a spectrophotometer, a CO_2 incubator for cultivation of biological agents, a centrifuge, and a germicidal lamp.

The Advanced Materials Laboratory is used for the preparation of wetting solutions for the production of inorganic, organic, and hybrid types of nanofibres, as well as for the analysis of the created nanofibres and their subsequent processing for various applications. The laboratory is equipped, for example, with a fluorescence inverted microscope with a digital camera as well as 4SPIN jet electrostatic wetting apparatus.

The Cell and Tissue Culture Laboratory is used for cell culture work, culturing, staining, and imaging. Cytotoxicity testing, as well as testing the effect of radiation on cells, tissues and materials (nanomaterials, nanowires, nanoparticles) is performed here. It also tests engineered materials used in radiological examinations as well as testing the effect on tissues and use in clinical practice. Among the equipment, there is a device for the determination of the toxicity of materials, and a CO_2 incubator for the cultivation of biological agents in an anaerobic environment.

The Biomedical Technology Laboratory is dedicated to research in the field of bionanotechnology. Among the equipment, there is a fluorescence microscope, spectrophotometers, Real-time PCR, and a multi-image system.

The Emergency Medicine Laboratory enables the most modern way of simulation teaching and research using simulators and aids providing and monitoring basic life functions such as SimMan, 3G adult, SimMan 3G Bleedings mods, SimJunior, SimBaby, a resuscitation trolley, a simulator for training techniques to secure the airway, an AMT, and a stretcher.

Nursing Technology Laboratories simulate the hospital room environment and allow nursing skills training (e.g., the Little Anne resuscitation model). A system for 3D virtual simulations of extraordinary events with mass disability is also available for teaching purposes.

The Preclinical Laboratory has a variety of specific and illustrative models for learning about anatomy, pathology, and other subjects.

The Functional Diagnostics Laboratory is used for teaching students examination methods. It is equipped with devices for non-invasive patient examination such as an ECG and EEG, ultrasound simulator, fibroscope, treadmill ergometer, patient monitors, ADinstruments allowing to demonstrate electrophysiological examination methods.

The Emergency Laboratory is used to teach students how to provide specific care to patients with various urgent and life-threatening conditions. It contains equipment for diagnosis and examination methods such as a resuscitation kit and automated external defibrillator, an airway simulator for intubation, a first aid bag, a plethysmograph, and manikins.

The Intensive Care Laboratory simulates an intensive care unit. It is equipped with a pulmonary ventilator, nebuliser, twelve-lead ECG, transport biphasic defibrillator, and AED.

The Interactive Laboratory provides a highly sophisticated 3D virtual learning portal for imaging methods. The anatomical virtual table offers a complete model of the human body, the ability to view the 3D model on different planes, import CT/MR images, etc.

The Anatomy Laboratory contains two plastic anatomical bodies and plastic organs of authentic human bodies for teaching purposes.

Ambulance Simulator enables complex training of patient care in pre-hospital emergency care. The vehicle is fully equipped according to the current legislation. Simulation training is recorded by a camera system.

Between 2024 and 2025, a multimodular simulation centre is planned to be built at TUL, where FZS TUL will have its own simulation centre. In it, it will be possible to practice various situations according to the current teaching needs. An ambulance simulator and an outdoor zone will be part of the teaching centre, which will allow a visual change of the environment thanks to projections. Virtual reality technology will be used in the context of emergency preparedness for mass casualty incidents. The use of state-of-the-art technologies such as 5G networks, deep learning, virtual reality supported by 3D imaging, and artificial intelligence is envisaged. With the construction of the centre, it will be necessary to spend considerable funds to equip it with the latest IT and simulation technology and to train qualified staff.

INTERNATIONAL COOPERATION

FZS TUL supports international cooperation through strategic partnerships and membership in international networks/organisations. This is closely related to applying for international grants and joint international projects of various types. One of the main activities will be cross-border cooperation in the Euroregion Nisa with the aim of addressing informatics issues with a focus on crisis management. FZS TUL wants to further develop cooperation in the field of biomedical technology with Slovakia (TU Žilina, TU Košice, TU Bratislava), the Federal Republic of Germany (University of Cooperative Education Bautzen (Saxony) and Bavaria), Austria (Vienna), Spain (Mondragon University), Poland (UM Wroclaw), and France (UPS, INP Toulouse). Emphasis is placed on establishing close contacts with foreign partners, followed by exchange internships of academic and scientific staff at partner universities in order to map the possibilities of effective mutual cooperation with the aim of creating joint projects. One of the platforms is the Blended Intensive Programme within the Erasmus+ programme, which allows for a combination of virtual and physical parts for student education. The results of such collaboration allow themes and areas for further research activities to be identified.

LIST OF ABBREVIATIONS

FZS TUL	Faculty of Health Studies, Technical University of
Liberec ERDF	European Regional Development Fund
FT	Faculty of Textiles
IKEM	Institute of Clinical and Experimental
Medicine INP	National Polytechnic Institute
HAI	Healthcare Associated Infections
KNL	Regional Hospital Liberec
DEXA	Dual-Energy X-Ray
MOE	Ministry of Education, Youth and
Sports TU	Technical University
TUL	Technical University of Liberec
UPS	Universite Paul Sabatier
TACR	Technological Agency of the Czech Republic
OP RDE	Operational Programme Research, Development and Education
ÚVN VFN	Military University Hospital Prague

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