WIRTSCHAFTS INFORMATIK

Call for Theses
(Bachelor, Master)

TECHNISCHE UNIVERSITÄT DARMSTADT

Healthcare

Healthcare processes (e.g. patient pathways) and services are often very complex and can involve various parties within an organisation or between organisations such as hospitals and other caregivers, as well as the patients. The design of services is often different from traditional service design – as for many healthcare services patients receive care, but insurance companies pay for it. Implementing processes in this domain should result in providing faster, safer and more effective care, necessitating organising and sharing information among all participants involved in patient care. While the need for well-defined healthcare processes is clear, there are many obstacles and opportunities for research, including technical, behavioural, and organisational topics.

Operational Research approaches including mathematical programming and simulation modelling can help address and solve logistical challenges in designing and managing healthcare processes and services. While mathematical programming can give the optimal locations of ambulances or shift schedules for hospital doctors, simulation approaches are a crucial tool to analyse different scenarios and model complex settings like emergency departments or operating rooms.

Decision support systems play a crucial role in healthcare, not only in the form of clinical decision support systems to assist physicians and other health professionals with medical decision making, but also to support logistical and organisational processes.

A well-performing health care system is a crucial part of a modern society and determines people's lives and livelihood [1]. The importance of a health care system is also reflected in the enormous spending required. More widely, in the European Union, spending in relation to the Gross Domestic Product went up from 8.8% to 9.6% between 2008 and 2017 [2]. While this already demonstrates the importance of a health care system for a society, it is widely recognized that demand for health care will further increase in the future due to demographic changes such as growth in elderly population in nearly all developed countries and increase longevity [3]. For instance, the share of over 65s (over 80s) in Germany increased from 19.8% (4.6 %) to 21.0% (5.7 %) within the recent decade [4]. However, an increase in demand will not automatically lead to more available resources for health care provision. Particularly the present shortage of qualified staff (for example physicians [5,6] and nurses [7]) in the health care sector limits the availability and timeliness of treatments. Consequently, in order to ensure the continued provision of high-quality care and to reduce wasteful spending in the health care sector, the efficient use of scarce resources in the health care sector is inevitable. Currently, the Organisation for Economic Co-Operation and Development (OECD) reports that up to one fifth of the spending in the health care sector might be wasteful and could possibly be avoided without affecting the delivery and provision of care [2].

A health care system consists of various care providers such as general practitioners, minor injury units, pharmacies, emergency medical services, care homes, and hospitals. Among those, hospitals are a key player and account for about 40% of health care spending in OECD countries [2]. In many countries, e.g., in Germany, hospitals have a legally-assigned task of providing care for patients. Their central role in a health care system partly stems from the large amounts of advanced technology and clinical specialization that are necessary to provide best-possible patient care. Since these technologies are scarce and expensive, their function cannot tenably be dispersed across a large number of small facilities [8]. Consequently, hospitals often dominate the health care system organisationally and are viewed by the public as key indication for the performance of a health care system [8]. It is, thus, not surprising that increasing health care expenditures and an ever-rising demand for health care services challenge hospitals to increase the efficiency of their operations [9], which requires efficient resource use and managerial planning approaches. This need for efficient planning is

especially high with respect to clinical staff since a general shortage of nurses [7] and physicians [5,6] means that qualified staff is a particularly scarce resource in hospitals.

I. What We Seek for our Theses:

Our goal is to assess strategic, tactical and operational planning for different forms of e-mobility and e-mobility services. We are looking for theses that draw upon and contribute to the stock of knowledge on the design of these services and the optimisation of relevant planning problems and logistics.

In sum, bachelor theses, student research projects (i.e., “Studienarbeiten”), or master theses on healthcare topics should meet three criteria:

1	**Theses must target healthcare and theorise on the specific elements.** Theses that do not point out the specific elements of a healthcare service or a healthcare logistics problem are not suitable.
2	**Theses must provide novel contributions to knowledge about the design of healthcare services or healthcare logistics.** Any form of theoretical (conceptual or empirical) or practical contribution using any scholarly method is welcome.
3	**Theses can consider the social and/or technical aspect of healthcare**. We encourage studies on healthcare at and across a variety of levels of analysis, including individuals, organisations, environment, ecosystems, and societies.

Potential topics with applications in Germany, New Zealand or other countries include, but are not limited to:

- **Emergency services:** In Germany, the federal states have sovereignty over the emergency medical services (EMS) system. Each state has its own EMS law, including specific rules and definitions for the provided services. Within each state, a number of EMS regions with dedicated coordination centres are responsible for the organisation of the services. In Germany, there are around 230 EMS regions. These regions are mainly urban and rural districts. Emergency rescue is the most important and most time critical service offered by an EMS provider, involving usually an ambulance and sometimes an emergency doctor. In general, there is a maximum allowed travel time for an ambulance to a patient that differs between the states. In addition, EMS coordination centres in Germany are also responsible for scheduling non time-critical transports of patients that need medical assistance or surveillance during the transport. The trips are usually going from, to or between hospitals. Ambulance can only serve one patient at a time and in general two paramedics are needed, transports are quite cost-intensive. Each coordination centre is planning the transports within its own region and transports between regions are still difficult to schedule. Topics could include ambulance location and relocation planning, patient transport scheduling or forecasting EMS demand. Besides, also the integration of first responders or the management of mass casualty incidents are relevant topics.
- **Blood logistics:** The provision of safe and quality-assured blood and blood products is a great challenge for blood establishments – particularly in times of crises. In these situations, it is important that blood establishments can rely on adequate information and emergency plans enabling them to ensure the continuous supply of blood and blood products to both the entire population, as well as the persons severely hit by the crisis. However, blood establishments are rarely included in national or regional emergency management plans, and often lack adequate information technology enabling them to foresee slowly emerging crises, or to react appropriately to catastrophic events that suddenly happen. Topics could include optimising and simulating the blood supply chain (e.g. locations, transports, testing etc.) as well as forecasting donations and demand.
- **Emergency departments:** For many patients, emergency departments (EDs) are an access point to the hospital. EDs also play a crucial role in the emergency services system. In Germany, patients can freely choose to attend the ED. Due to a shortage of general practitioners (GP) and an increasing service demand, EDs have to face high numbers of patients every day, while many of them could have been treated by a GP or a registered specialist. Current research investigates the design of EDs, the

assignment of patients to doctors and rooms, priority queues for patients, a separation of urgent and non-urgent patients or the assignment of patients to EDs.

- **Radiotherapy:** Cancer is a growing burden that challenges individuals and societies physically, emotionally and financially. Aging populations and unhealthy lifestyle increase the number of cancer incidents which is expected to reach 29,5 million in 2040 with 16,4 million deaths. Radiotherapy (RT) is one modality of cancer treatment often combined with chemotherapy and surgery. Approximately 25% of cancer patients are treated with RT. However, studies suggest that 50% of cancer patients worldwide should be treated with high-energy radiation beams. Modern RT is based on integrated systems and services that are supported by information systems. These systems are operated by specialized RT staff interacting intensively with patients and co-workers. Topics could include the design of user assistance systems and optimisation models or simulations for radiotherapy logistics (e.g. appointment planning, imaging, laboratory, patient transports).
- **Hospital logistics:** In hospitals, scheduling problems and internal logistics play a crucial role. Hospital logistics include many different technical and organisational measures taken in a hospital in order to transfer patients, goods and corresponding information. As in many healthcare areas, also hospital processes are often grown historically ("We have always done it like this."). Due to an increasing pressure on hospitals (i.e., cost pressure, demographic change and staff shortage), hospitals are trying to improve their processes, especially their logistics. Operations research and machine learning approaches can help predict the demand or process times, schedule staff or tasks, and use resources efficiently, for example. Potential areas of interest include patient transports, bed management, operating room planning, inventory management etc.
- **Primary care logistics:** A majority of countries worldwide suffer from a shortage of general practitioners (GPs). Providing primary care in rural areas is especially challenging, while the definition for rural is significantly different between the countries. Even though the healthcare systems worldwide differ significantly, primary care practices often need a sufficient number of patients to be profitable and attractive for GPs to work in. At the same time, primary care is crucial for people's welfare. Patients benefit from having easy and timely access to GPs in close proximity, often to their home, but sometimes to their place of work. Especially in rural areas this is difficult to ensure as GPs also need sufficient patients in their panel, i.e. the number of patients per GP, to cover their costs. Often, too few GPs are available to fill open spots, and rural practices can be even less attractive. Due to the shortage of GPs, there is a need for a wise use of resources, for example by reasonably locating GPs and practices in order to minimise traveling distances for patients and assuring a "sufficient" number of patients per GP. In order to support decision makers with location planning, it is necessary to first assess the current GP coverage.
- **E-ambulances:** In Borkum, an e-ambulance is already in use. Other regions and providers are investigating the options and the design of an e-ambulance. Besides legal regulations and organisational aspects, planning problems arise including the location of charging infrastructure. Theses could investigate the use of e-ambulances for patient transports and/or emergency rescues and address one or several planning problems.
- **Drones and VTOLs:** Unmanned Aerial Vehicles (UAV) or drones are making their way into many different areas, especially in crisis response and health care. Their use is particularly promising when conventional road transport is not possible or would take too long. There are already the first pilot projects that are investigating the use of drones, for example for the transport of blood products, vaccines or AEDs. In the future, VTOLs might even be used to transport patients in reduce travel times and needed staff.
- **Optimisation of other healthcare services and processes:** Students can also suggest other topics around the design and optimisation of healthcare services and processes in other areas or for other types of care. Examples could include rehabilitation, health apps, artificial intelligence to improve patient care etc.

II. Possible Methodologies

Theses should cover one or more methodologies, such as:

- *Discrete Optimisation approaches*
- *Machine Learning approaches*

- *Discrete-event or agent-based simulations*
- *Structured literature reviews*
- *Quantitative online surveys*
- *Experiments*
- *Qualitative interviews*
- *…*

III. Application Requirements

Important: If you are interested in writing a thesis in Healthcare, please send an email application that includes:

1. a **brief CV,**
2. a current **performance record** (can be downloaded in TUCaN),
3. a **short description** of your proposed topic including a **research question**, and
4. the **time period** in which you would like to work on the thesis

to: oppermann@is.tu-darmstadt.de.

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