Steffen Hamm*, Ann-Christin Schleser, Juliana Hartig, Petra Thomas, Silke Zoesch and Clemens Bulitta

5G as enabler for Digital Healthcare

Abstract: Healthcare in rural areas faces specific challenges, which make homecare of elderly people and cross-sectoral integrated care of chronically ill and multimorbid patients very complex and costly. Mobility and logistics are among other issues that need to be solved in this context. Therefore, it will be crucial to realize the potential of innovative solutions along the complete healthcare value chain, in order to deliver patient focused healthcare according to a value-based-healthcare-approach in the future. Against this background it is the objective of the project 5G4Healthcare, which is funded by the Federal Ministry of Transport and Infrastructure, to establish a platform based on 5G technology, that enables the testing and the evaluation of digital applications in the context of rural healthcare. Consequently, the project 5G4Healthcare aims at assessing the feasibility, opportunities and limitations of 5G regarding efficiency and effectiveness improvements in rural healthcare in order to derive recommendations and scalable solutions.

Keywords: rural healthcare, digital healthcare, 5G, integrated care, homecare

https://doi.org/10.1515/cdbme-2020-3001

1 Status quo healthcare in rural areas

Healthcare industry is both a growth market and an industry under enormous economic pressure. This conflict becomes obvious in demographic change, increasing morbidity, a shortage of skilled workers, medical-technical progress and a growing sense of entitlement to healthcare among the population. Insufficient health and technology competence (digitisation) and encrusted care structures reinforce this and lead to a leverage effect. Particularly in rural areas – which include the Northern Upper Palatinate – the provision of medical care close to the individuals' homes is becoming increasingly difficult. Spatial distances are not only a challenge in acute care, but also make homecare for the elderly and the integrated, cross-sectoral care of multimorbid and chronically ill patients very resource-intensive. Questions of mobility and logistics are becoming central challenges for healthcare. Therefore, it will be crucial to realize the potentials of innovative solutions along the entire healthcare value chain in order to deliver patient-oriented healthcare according to a value-based-healthcare approach. In contrast to sector related care (outpatient-inpatient), in which the added value is understood as the sum of individual services, the value-based-healthcare approach aims at seamless and thus integrated care that is measured against the actual, individual needs of the patient and the personal benefit achieved for his or her individual state of health. However, this paradigm not only enables these individual benefits, but also an improvement of efficiency and effectiveness in medical care from an economic perspective. In the Northern Upper Palatinate it is already clear that healthcare as we know it will change. In the outpatient sector, for example, the current General Practitioner (GP) care can still be considered sufficient, but the age structure of practicing GPs and the fundamental regional population development make comprehensive care increasingly difficult in the future. In some communities, more than 40 percent of GPs are already over 60 years old [1]. It is uncertain whether each of the GPs will find a successor. The inpatient sector also shows that that the care structures are undergoing a process of change. In the hospital group of the Kliniken Nordoberpfalz AG, which includes – besides the hospital in the city of Weiden that provides full medical care and acts as referral centre – also smaller locations, facilities have already been repurposed in recent years – e. g. to specialized clinics – and acute inpatient care has been discontinued. This illustrates that the region is facing typical challenges of rural healthcare, and that innovative concepts and care models are necessary in order to preserve comprehensive healthcare coverage. Digital solutions may be critical for managing this transition and maintaining efficient and effective healthcare delivery despite these major changes.

* **Corresponding author: Steffen Hamm,** Technical University of Applied Science Amberg-Weiden, Hetzenrichter Weg 15, Weiden, Germany, e-mail: s.hamm@oth-aw.de
Ann-Christin Schleser, Juliana Hartig, Petra Thomas, Silke Zoesch and Clemens Bulitta, Technical University of Applied Science Amberg-Weiden, Hetzenrichter Weg 15, Weiden, Germany

2 The project 5G4Healthcare

Against this background it is the objective of the project 5G4Healthcare, which is funded by the Federal Ministry of Transport and Infrastructure until the end of 2022, to establish a platform based on 5G technology, that enables testing and evaluation of digital applications in the context of rural healthcare. Along the entire healthcare value chain, from prevention to diagnostics, therapy, rehabilitation and care, defined use cases and a standardised procedure are to be used to determine which value-added effects can be realised through digital solutions in rural healthcare and, in particular, which impact the 5G technology can provide in this context. In a three-step approach consisting of conception, implementation and evaluation, a 5G-based research and development platform will be implemented as a network with corresponding living labs and test beds. In this context two major use cases comprehensively address the challenges of healthcare in rural areas and enable a multi-dimensional evaluation of the use of 5G. On the one hand, this is intended to create a direct added value and starting point for future supply solutions and structures in the Northern Upper Palatinate and, on the other hand, to make an important contribution to the federal government´s 5G strategy, into which the funding by the Federal Ministry of Transport and Infrastructure is to be classified. The intended testing of 5G applications in a real environment (living labs) will allow detailed requirements, ideas and solutions to be derived that will serve as a blueprint for a comprehensive 5G implementation in healthcare.

3 Focus use cases “integrated care” and “homecare”

Within the framework of the use case integrated care and with the involvement of representatives of the outpatient and inpatient sectors, a comprehensive digital-health-based integrated care approach for rural areas is to be implemented. According to the objective of integrated care, which is intended to overcome the sectoral boundaries in the German healthcare system, the patient is supposed to benefit from high-quality care by the close interconnection of care sectors. For participating service providers, there are opportunities apart from the rigid collective agreement system with innovative care options and thus new and additional remuneration and an overall more efficient allocation of resources. In order to implement this, telemedical procedures are to be used technically at the application level, which enable location-independent availability of patient data of patients participating in integrated care (keyword electronic health record). Additionally, concrete measures of telemedical therapy and diagnostics (keyword tele-consultation) facilitate the cooperation of professions involved, which is also independent of location. In the final stage, the aim is to create a virtual care centre which, in addition to conventional care facilities, will enable permanently available high-quality treatment by experts, even if the actual coverage of care further decreases.

Also, the second use case aims towards implementation of a comprehensive digital health-based approach, explicitly addressing homecare in rural areas. Here challenges in securing seamless care especially arise from the extremely decentralized infrastructure. GPs, nursing services and patients´ relatives travel considerable distances between their location, the patient and other actors such as pharmacies or medical supply stores. It is not uncommon for medication to be out of stock; they are ordered by pharmacy and delivered by medical supply store at a later date. Also, medical aids are often delivered by the medical supply store at a later date. Moreover, especially in rural areas, it is not unlikely that the nursing service is not updated immediately about new medication or changes of medication. This can lead to incorrect drug administration with dramatic consequences. Due to lack of communication between GP – patient – pharmacy – medical supply store – nursing service – health insurance company, current care of homecare patients in rural areas is complex, costly and afflicted with many sources of error.

On application level, therefore, solutions are to be used that primarily contribute to the optimization of the entire logistics around the homecare patient. In addition to information and patient logistics (e.g. organisation of patient transport) the main focus – in terms of content and processes – is on fast and correct coordination of supply of drugs, sterile goods, medical supplies, etc. By connecting the actors in rural homecare around a patient, a relief for all parties involved is to be aimed in order to achieve a higher quality of care and economic optimisations for service providers. The secondary objective is to achieve care in a domestic environment for a longer time. The infrastructure for the actors involved is to be supplemented by the use of assistance solutions and smart devices for a self-determined life in daily situations (ambient assisted living) as well as by automation solutions.

4 5G: The catalyst to digitisation

5G is to be introduced in Germany as a new mobile communication standard by the end of 2020. The new standard is regarded as a pioneer for the Internet of Things (IoT) and thus billions of networked end devices. Particularly in rural areas, such as the Northern Upper Palatinate, expansion of this gigabit network is not an end in itself, but is breaking the ground for economic and social development in the 21st century. In many industries 5G is prerequisite for new business models such as predictive maintenance or IoT platforms which allow machines to exchange data with each other along industrial processes in a fully automated manner. Autonomous and networked driving, logistics processes and management of energy networks are just a few more applications in which 5G can become a key technology. In doing so, 5G will enable continuously increasing requirements of digital applications in terms of capacity, bandwidth, availability and latency, which are prioritised differently depending on application. There are three main application groups in which 5G can be used [2]:

Enhanced Mobile Broadband (eMBB): High bit rate applications, such as ultra-high resolution video streaming, are characterized by high bandwidths per user and high capacities in one cell.
Massive Machine Type Communication (mMTC): When every object is interconnected, the Internet of Things is becoming reality. Communication with control centres that is made possible by this development places are demands on network capacity in terms of managing hundreds of thousands of locked-in devices per cell.
- *Ultra-Reliable and Low-Latency Communication (URLLC):* Safety-critical applications, e.g. in medical care, depend on maximum quality, availability and interference immunity (quality of service) of connections. In addition, they also require tactile networks that transmit mission critical data in real time.

Simplified the application scenarios can be summarized in terms of requirements in the cases of “many users”, “large data volumes” and “low latency”. Individually or in combination, these use cases represent elementary scenarios, especially in the healthcare sector, in order to explicitly guarantee the security of healthcare delivery for the population in rural areas in the future.

A majority of digital health applications can only reach their full potential in a 5G network. These digital health applications and solutions include, for example, robot-assisted operations, remote monitoring and analysis of patients´ vital functions and video-based physician´s consultations. For example, in robot-assisted surgery, there must be no long delays (low-latency) between the control impulse from the physician and the reaction of the surgical robot. Data from cameras and sensors must be transmitted with the highest reliability. In the future this may even make it possible for specialists located hundreds of kilometres away to perform or support operations. When remotely monitoring medical parameters of patients, it is important that sensors not only operate stably, but are also as durable as possible and consume as little energy as possible. After all, these can also be sensors in body implants such as pacemakers, which are only replaced after a period of many years. 5G chips with long battery life offer tailor-made solutions, e.g. for long-term monitoring of chronically ill patients. Finally, mobile digital health applications benefit from ability of 5G to guarantee stable connections even at high relative speeds of movement. For example, paramedics can transmit their patients´ vital signs and video data from a digitalized ambulance via 5G to the hospital without delay and obtain advice from specialists there. A benefit of 5G, that can save lives, especially in rural areas where the transfer to a hospital or specialist clinic is long. In particular, the advantage of rapid transferability of large data volumes at 5G is added in this telemedical context when it comes to transferability of medical image data, e.g. in form of video data, MRI or CT images. High transmission rates, partly in real-time, can be seen synonymous with faster and therefore more effective treatment of the patient in an emergency. This also applies to the location-independent use of applications with artificial intelligence or Augmented Reality (AR) and Virtual Reality (VR) applications, which can represent further value-added scenarios of 5G development in (rural) healthcare.

In order to test and evaluate possibilities and limits of 5G, the project is organized in three phases as sequence of conception, implementation and evaluation. The aim is to design, test and evaluate the use of 5G from different perspectives – medical, technical, (health) economic, social, etc. - in the two use cases integrated care and homecare. In detail this is achieved for the use cases applying different scenarios which are defined, modelled, prioritised and selected with an appropriate set of methods and tools in the first step of the conception phase of the project. The scenarios will first be created in a test bed on the premises of the Technical University of Applied Sciences Amberg-

Weiden and further detailed in a situation analysis, on the basis of which an intended target concept will be modelled. In the second phase, the implementation, the scenarios will be tested in a real environment. For this purpose, so-called living labs are planned at local care facilities, sites of the cooperation partner Kliniken Nordoberpfalz AG. There the scenarios will then be assessed from different perspectives. These i.e. include medical outcome, health economic effects, the already mentioned technical trade-off between 4G and 5G, data protection aspects and regulatory affairs, logistics issues, IT security issues or ethical aspects. In the third phase, the evaluation, these real scenarios are assessed using a maturity model developed in-house. This model views the scenarios from a holistic perspective and structures the optimization cases according to the quality dimensions of structure, process and result. Each dimension is evaluated and subdivided. The result will for example deal with the sub-dimensions costs, quality, patient and staff satisfaction based on the Quadruple Aim concept.

The multi stage approach shows that the project 5G4Healthcare is not about the sole application of 5G technology in the sense of replacement of 4G or WiFi, but rather about the derivation of a scenario-related setting of context factors in order to derive the maximum added value of 5G in healthcare use cases - with regard to the effectiveness and efficiency of the technology.

5 Recommendations for actions and long-term use of the platform

The processing of use cases with the corresponding scenarios is characterized by a high level of application relevance. There is a close connection between the identification of the scenarios to be worked on, the multidimensional processing and evaluation as well as healthcare challenges that actually exist on site and are typical for rural areas. The main objective of the project is to derive recommendations for action regarding use of 5G and fundamental digitisation in the healthcare system as well as to create the necessary framework and conditions. By establishing necessary infrastructure, prerequisites for application-oriented research and a process of translation in the field of digital healthcare management will be sustainably created. It is therefore intended to continue the structures of test beds and living labs beyond the planned project duration and thus to provide a permanent platform for the testing and development of digital applications in the healthcare sector within a 5G infra-structure. On the one hand this will enable the nationwide digitisation of healthcare, testing of innovative solutions and the establishment of new care processes and models. On the other hand, a blueprint for future-oriented healthcare in rural areas will be created.

Author Statement

Research funding: Funding provided by the Federal Ministry of Transport and Infrastructure

Conflict of interest: Authors state no conflict of interest.

References

[1] Spiekermann & Wegener Stadt- und Regionalforschung, Analyse der Versorgung mit Einrichtung und Dienstleistungsangeboten der sozialen Infrastruktur in der Planungsregion Oberpfalz-Nord; 2018

[2] BMVI, 5G-Strategie für Deutschland; 2017