The Telemedical Rescue Assistance System "TemRas" – Development, First Results and Impact

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Abstract German emergency medical services (EMS) face the challenge to ensure high-quality emergency care against a background of continuously increasing numbers of emergency missions, resource shortages concomitant with greatly increased arrival times, particularly in rural areas. Because German EMS physicians are at maximum capacity, an immediate response is not always possible and thus delays in commencing advanced life support measures sometimes occur. In such scenarios, paramedics start the initial treatment until the EMS physician arrives. The delayed availability of a physician can defer the decision process of the paramedics and thus postpone the start of the patient's essential treatment, which is particularly dangerous during the care of cardiovascular emergencies. Therefore, the project TemRas (Telemedical Rescue Assistance System) has developed an innovative concept to improve quality of emergency care. The objective is to introduce so-called tele-EMS physicians providing remote medical support for the emergency team on site by transmitting audio and video data, as well as vital signs and 12-lead-ECG from the emergency site to a teleconsultation center. In this paper the development process as well as first results of the evaluation phase and the impact for further use of telemedicine in emergency medical services are presented.

Keywords Emergency Medical Services · Healthcare · Teleconsultation · Telemedicine · Quality Assurance

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1 Introduction

With more than 30 % of today's emergencies having a cardiovascular background, response and arrival times of emergency medical services (EMS) are of crucial importance [1]. To ensure a sustainable medical treatment and increase survival rates, diagnosis and treatment have to be done as soon as possible. However, the increasing numbers of emergencies combined with a shortage of so-called EMS physicians result in an opposite effect; the untreated time interval in an ongoing emergency gets longer [2]. The German EMS rendezvous system consists of paramedics and separately disposed EMS physicians to perform the medical treatment. Within this premise, telemedicine and the use of telemedical emergency systems is gaining importance [3–6].

This challenge is the focus of the research project Telemedical Rescue Assistance System (TemRas), which aims to support the EMS team on site with a so-called tele-EMS physician. A complex IT system is developed and implemented that allows real-time data streaming from the case of incident to a teleconsultation center; these data included vital parameters, pictures, video streaming, and voice data. Specially trained physicians are connected to the system from this remote center and can therefore analyze and interpret the streamed data and communicate with the EMS team on scene.

The predecessor of this project called "Med-on-@ix" [funded by the German Federal Ministry of Economics and Technology (BMWi) from 2007 to 2010] prove the actual plausibility of such a system by equipping a regional ambulance with an early prototype of this system. The "TemRas" project focuses on real-life conditions and on improving the prototype toward a marketable product that comprises adaption of the hardware and software as well as the organizational concept [7]. In total, six ambulances have been equipped with the new hardware and communication devices to run a significant case study. The complete bundle of the IT system, combined with modern training concepts and a user-centered system design, is an essential step for the future rollout of the concept.

This article offers an insight into the design and implementation strategy pursued in the project TemRas as well as its first results and impact for further use of telemedicine in EMS. The project description is followed by pointing out the implementation process and the resulting technical system. In addition, the overall medical-organizational concept and first technical and medical results of the evaluation of TemRas are presented. The article concludes with a discussion of the sustainability and the benefit of the project results reached so far according to usage of telemedicine in EMS and its resulting quality improvement of emergency care.

1.1 The Project "TemRas"

The TemRas project constitutes the consequent continuation within the research field Telemedical Rescue Assistance System (TRAS), which evolved with the predecessor project "Med-on-@ix" and has been developed by partners of industry and the RWTH Aachen university as well as the University Hospital Aachen. The research activities within the consortium follow the common goals of increasing quality of EMS and greatly enhancing the involved processes by optimizing information flow with state-of-theart communication technologies. Although "Med-on-@ix" pursued the objective to give proof of the general concept of a TRAS by equipping a single ambulance with a system prototype [8, 9], TemRas represents the consequent continuation of the development to provide a market ready product. To position Aachen as the model region of a successfully implemented TRAS, the research strategy focused on two main goals [7]:

- The original system prototype is enhanced by integrating new heterogeneous components to enable optimized detection and therapy in case of cardiovascular emergencies.
- A detailed concept for launching the system into the market is developed.

The central development task of the consortium is the miniaturization and consolidation of the necessary subsystems, which have been originally developed and tested during the predecessor project and needed to be updated, and optimized to fulfill the needs for a real-life system launch. The main objectives are, e. g., the ergonomic design of the system components to increase acceptance and ease of use as well as the integration of new components (e. g., different producers) for enhanced flexibility and extensibility referring to the results of user surveys conducted to evaluate the first prototype [10].

Aside from a possible increase in the quality of service itself, economic feasibility studies have shown that a cost-effective implementation can be achieved by a broader system implementation and its corresponding economic scale effects [11]. Therefore, the system is implemented in six ambulances in the region of Aachen (Germany) and neighboring communities that are connected to the teleconsultation center, generating important data within a 1-year evaluation period to assure the usefulness under free market conditions in urban and rural areas.

Since 2012, this evaluation phase is running. It has to be stressed that these ambulances are fully integrated into the regional emergency workflow and therefore generate valuable data representing a case study under real-life conditions. Paramedics on scene can now officially consult the connected tele-EMS physicians and use the offered services to get remotely accessible medical expertise to ensure fast treatment of high quality. Evaluating the early gathered data and accessible information generated within the first months of usage (174 successful teleconsultations have been performed up to the end of 2012), the increase in efficiency and general impact appears to be a very promising approach in enhancing the quality of service within EMS.

Analyzing international EMS and therein existent telemedical projects with similar basic approaches, other research projects have focused mainly on the technical feasibility of prehospital, mobile telemedicine [4, 5, 12, 13]. Current research literature, to our knowledge, does not present projects that accompany the integration of such telemedicine systems into EMS with scientific evaluation of medical impact, organizational consequences, and technical challenges. Comparable integrated systems are the DREAMS Telemedicine System from the USA [14] and the Viewcare Telemedicine System from Denmark [15], but neither of these are covered by published research literature. After several expert interviews and own experiences gathered in the past few years, the TemRas system was initiated to have huge impact on the service quality and the cost effectiveness of future EMS worldwide.

2 Materials and Methods

2.1 Development Process

In August 2010, researchers and developers began to develop the concept of the optimized TRAS. The technical improvement took place mainly within the first 2 years of the project. During this phase, the involved physicians, engineers, and sociologists worked closely together in a highly interdisciplinary team to identify and take into consideration all the relevant aspects of the new system [16]. The system's design was created in a mainly linear process with strong user participation and close feedback loops between engineers and users. The original intent of a true iterative, agile development process could not be realized for the whole system but was instead used to develop the individual user facing software components [17].

Furthermore, in 2010, five emergency districts were chosen for the evaluation of the newly developed system and the criterion for choosing the districts was mainly the structural condition (number of emergencies, density of supply and network coverage).

In 2011, the focus of the project work was primarily the restructuring of the teleconsultation center, the redevelopment of the miniaturized communication unit (peeqBOX), equipping the corresponding ambulances with the necessary technical devices, and the development of an integrated system. During the transition in 2012, the TRAS was subjected to intensive testing and the involved paramedics were trained. Physicians were prepared during special training events for their future role as tele-EMS physician within the TemRas system to prepare for the study. Since August 2012, the running system is scientifically evaluated in its planned configuration of six ambulances and two tele-EMS physician workplaces under real-market conditions, fully integrated into emergency workflow of the involved cities and districts. The overall development process is shown in Fig. 1.

Major software updates, working place restructuring, enhancement of the ergonomic design, and process optimization combined with a detailed workflow analysis were implemented to fulfill the new system requirements. Another focus

Fig. 1 Development process of TemRas

was the telemedical integration of clinical establishments into the TemRas system to enable an instant information flow and register the incoming patient for continuous treatment, e. g., cardiac catheterization, intensive care, trauma room.

Aside from adjustments in the conceptual alignment, close cooperation with the health insurance companies were strived to bring forward the economically efficient launch of the system; reducing the number of unnecessary hospital admissions and unnecessary march-outs of EMS physicians hereby prove well to have a strong basis for further negotiations. The hybrid combination of services – all around the technical implementation, the system maintenance, and the daily operation of the TRAS – and highly innovative medical useful products form the essential step toward market maturity of the telemedical system.

2.2 The Technical System

The technical system integrates heterogeneous components and consists primarily of four subsystems: teleconsultation center, ambulance, on-scene equipment, and IT infrastructure (Fig. 2). A redundant and wire-tapping proof network guarantees the safe and reliable mobile transfer of patient data between the IT components and certified medical products on scene and between the ambulances and the teleconsultation center, enabling the telemedical support of EMS teams in emergency situations. The utilized medical products such as the ECG/AED (electrocardiogram/automated external defibrillator) unit and vital data display as well as a Bluetooth stethoscope are certified with the necessary medical certificates for emergency rescue environment.

The integration of the medical products is realized using the corresponding software and advanced programming interfaces, which are provided by the producers. A very important focus of the technical system lies within the concept of modularity [16]. The network that is part of the system consists of the communication units used within the project and the necessary software applications. This enables the system to

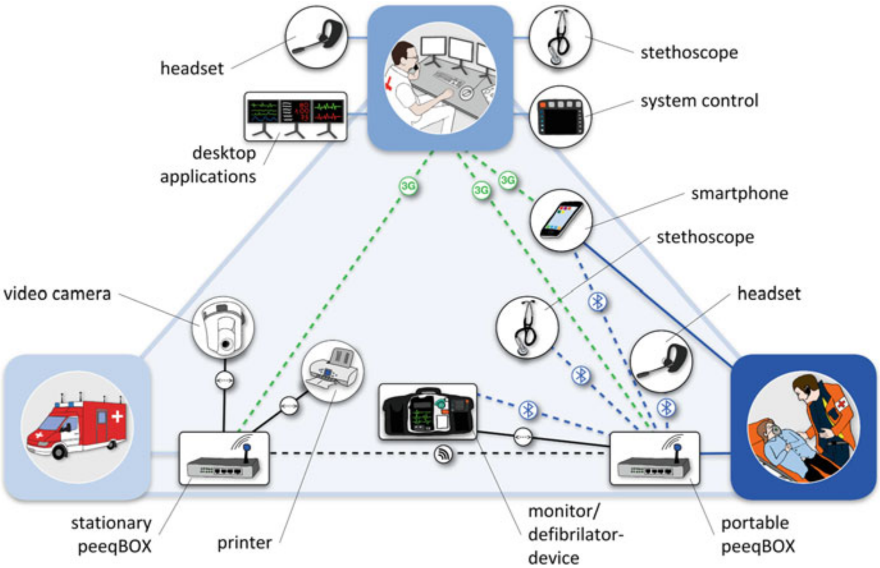

Fig. 2 View on the technical components of TemRas [16]

be used in the mobile context of an emergency rescue environment. The independencies among all offered functionalities, which enhance the consultation, guarantee the exchangeability of individual components and units and therefore underline the sustainability of the concept. The working places within the teleconsultation center are connected to the server environment with a standard network cable connection. The telemedical connection of the emergency scene is realized using redundant mobile connections, either directly through the portable communication unit (peeqBOX) or via the mounted communication unit inside the ambulance. All occurring mobile data traffic is encrypted. The communication between portable peeqBOX and the peeqBOX that is mounted inside the ambulance car is implemented using a secure wireless LAN (WLAN).

2.2.1 Teleconsultation Center

The physicians working in the teleconsultation center (Fig. 3) are experienced, specially trained EMS physicians. *Via* mobile real-time connection, one of these tele-EMS physicians is continuously connected to the scene of incident. Data are transferred in real time to the tele-EMS physician to provide him or her with newest information on the ongoing case. This data flow enables the tele-EMS physicians to use their expertise and decide on possible treatment and order measures to be done by the paramedics on scene. Standard operation procedures (SOPs) and a specially developed documentation software support the tele-EMS physicians in implementing a guideline-fulfilling medical care toward the patients [18]. The availability of

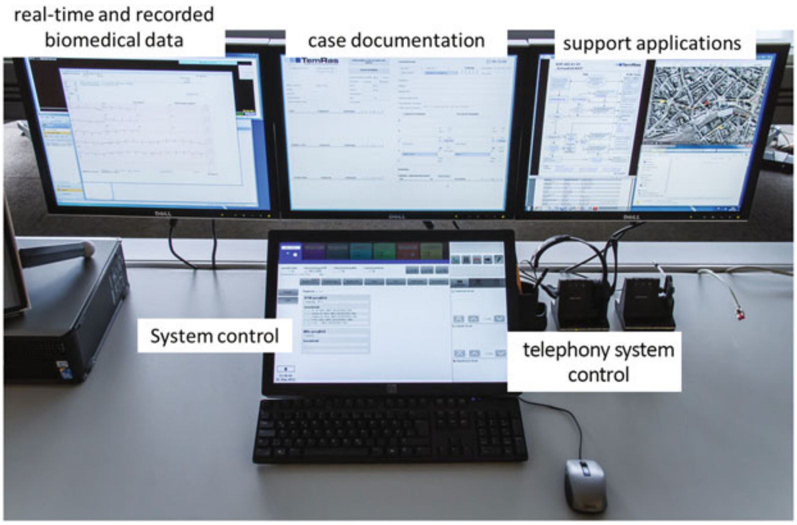

Fig. 3 Tele-EMS-physician workplace

and therefore active orientation on up-to-date and qualified guidelines regarding the workflow within an ongoing medical emergency ensure a high-quality medical consultation for both the patient and the EMS team. Another new feature is the possibility to consult external information sources, e. g., during a rare disease. Aside from the option to directly contact the poisoning hotline, all tele-EMS physicians have access to external databases to support them in their diagnoses. Furthermore, other connections are available within the system, like for instance, experts in specific medical domains and reference persons within hospitals and other medical institutions.

2.2.2 On-Scene Equipment

The EMS teams on scene are using the portable peeqBOX, which has an increased functionality and has its original weight reduced from 10 to 1.8 kg (Fig. 4). This communication unit is responsible for establishing the connection to the teleconsultation center and is physically located in the side pocket of the ECG/AED unit. Using multiple bundled mobile network channels, a reliable data connectivity is provided to assure a potent data streaming from the case of incident to the tele-EMS physician. The paramedics on scene can easily connect to the teleconsultation center; the connection will be established using the best available network at the moment. The center can also be reached by calling special telephone numbers from a smartphone or a fixed phone, e. g., from inside a patient's apartment and are still integrated into the system.

The ECG/AED unit continuously collects vital data such as heart rhythm, blood pressure, and pulsoxymetry of the patient and transfers these data plus a possible

Fig. 4 Miniaturization of the portable peeqBOX

12-channel ECG in real time to the tele-EMS physician for diagnose purposes. For auscultation, an electronic stethoscope is used. The integration of this stethoscope enables the transfer of hearth tones real time from the scene to the corresponding stethoscope of the tele-EMS physician. To provide as many information as soon as possible, the paramedics have the option to take photos and send them instantly to the teleconsultation center; lists of drugs and medical diagnoses and letters already available from the patient are two examples where a picture is very useful. The pictures are being sent automatically without any special action required by the person making them.

2.2.3 Ambulance

In addition, the tele-EMS physician can also accompany the patient on the way to the hospital or any other medical institution. Aside from the portable communication unit, every ambulance is equipped with a similar communication unit as fixed mounted version. With special antennas located on the roof of the car and additional data cards available, the stationary peeqBOX has an increased performance. For exchanging data with the portable peeqBOX, a secured WLAN is available, whereas all other components inside the ambulance are connected with a standard cable network. On the inside roof of each equipped ambulance, a high-resolution video camera is attached, which can be controlled remotely by the tele-EMS physician; the usage is bound to the agreement of an individual patient and is only considered if medically relevant. Generated video data is not stored in any way but instead consists only of the streamed data that is sent from the ambulance to the teleconsultation center. In addition, the printer inside the ambulance can be used to print the documentation protocol and be handed to a physician on scene or to any physician involved in further treatment – e. g., as first written documentation for patients who get assigned to an emergency hospital. This simple but effective feature can greatly enhance the information flow from EMS to the medical institutions.

The actual innovation of the described TRAS is determined by its mobility and modularity [16]. Compared with similar projects, TemRas also facilitates the option for telemedical consultations outside of the ambulance car, e. g., a patient's apartment or any kind of scenario inside a building. This is achieved by integrating the described variety of functionalities into one modular system architecture. The operation of the TemRas system is, with regard to up-to-date Medical Devices Act, without legal restrictions and is legally allowed to be implemented as a real-market system to enhance EMS in Germany [19].

2.3 The Medical-Organizational Concept

The actual communication between the paramedics and the tele-EMS physicians is paramount in the concept of TemRas. This communication is started by the paramedic on scene on demand and initiated with a simple button press on his or her headset. All involved user groups have been schooled and trained regarding the use of the system. The system supports the usage with and without an additional EMS physician on scene. When the physician is not (yet) on scene, measures can be ordered by the tele-EMS physician, which are then delegated to the corresponding paramedic. In the concrete case of an ordered measure, it is still in the paramedics' obligation to verify the measure for plausibility, but the final responsibility for this measure will be on the tele-EMS physician. The classical case in emergencies where the final responsibility is unsure is not the case within a TemRas system scenario. Therefore, paramedics gain legal security, which is another motivating argument for the actual use of the system [19]. Operation possibilities for the paramedics are therefore enhanced, which can result in a decrease in the untreated time interval for patients. Furthermore, medical measures can now be analyzed and the effects be monitored in real time, which can greatly enhance the handling possible complications. Even after an additional physician arrived on scene, he or she can be supported by the connected tele-EMS physician (second opinion, ECG interpretation, assignment to medical institutions). The intended procedures have all been verified by legal opinions [19] and been approved by the Ethics Committee of the University Hospital of Aachen (EK 191/11).

To structure and optimize all processes in combination with the usage of the system – especially for the medical treatment of patients – so-called SOPs have been developed (Fig. 5). The medical SOPs provide an algorithm- based and guideline-corresponding medical care of the patient, which is already an established feature of clinics [18]. For the work of the tele-EMS physician and the EMS team on scene, SOPs for the most common emergency situations have been developed based on national and international guidelines. The tele-EMS physician can access these SOPs any time interactively. For the discussed emergency situations, these SOPs prove to be a valid base of up-to-date and guideline-fulfilling processes for diagnoses and treatment with additional information. SOPs therefore effectively support the tele-EMS physician and the paramedics on scene in the process of decision making, which can increase the general quality of service.

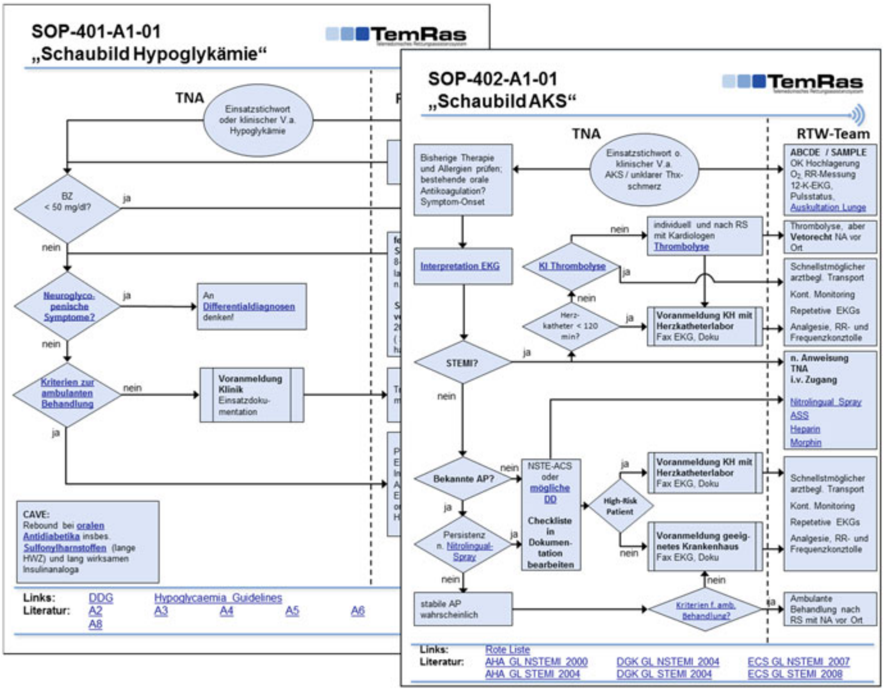

Fig. 5 Examples of SOPs

3 Results

Since August 2012, the system is being evaluated in a real-life environment in the planned configuration of six ambulances and two tele-EMS physician working places. Seventy consultations have been successfully processed using the TemRas system in the first 10 weeks. The following section will show the results gathered within this period of the system in a real-life environment and will also discuss shortly the tests that were made in advance [20, 21]. A detailed presentation and discussion of all evaluation results will be performed after the evaluation phase.

Although the described technical system is currently at its development stage, it is suitable for use in a real-life telemedical consultation environment and is therefore already integrated into the EMS workflow in the discussed areas. During the testing period and before the actual evaluation phase, several unit, system, and performance tests were executed. An *ex ante* evaluation of a precise test is presented in the following. These tests were performed with a minimum of two and a maximum of four UMTS mobile connections accessible at a time (for comparison, in the productive system, a minimum of three and a maximum of five UMTS mobile connections are used). The real-time vital data transfer, which consists of curves and numerical values, had mostly good transfer results if at least one UMTS network was available.

As possible backup for non-optimal network connectivity (GSM, GPRS), the system offers the possibility to transfer data in periodic time intervals rather than continuously. During this periodic vital data transfer, all numeric values, events, ECG, and 12-channel ECG data are transferred every 60 s.

Connectivity from the EMS team to the tele-EMS physician is generally initiated on demand with the paramedic pressing the button on his or her headset. In average, it took < 8 s until the conference call had been established and up to 18 s until the tele-EMS physician was able to accept the incoming call [21]; the general target for the tele-EMS physician was to accept the call as soon as possible ($n = 5$). Photos on scene can be taken with a provided smartphone, whereas new photos are immediately forwarded to the peeqBOX via Bluetooth and then sent to the teleconsultation center using the available mobile network connectivity. The measured time intervals for transferring new photos ($n = 10$; 1 MP) from the smartphone to the peeqBOX (Bluetooth only) were about 30 s and 1 min for the complete transfer [21]. Video streaming was realized with a highresolution video camera attached to the roof inside the ambulance. With at least one UMTS network available, the streaming went without noticeable interruptions. As part of the ongoing case management, it is possible to switch between any available ambulances with the touchscreen application at the tele-EMS physician workplace. After switching from one ambulance to another, it took < 8 s until the real-time streaming of vital data resumed for the new ambulance [21].

The results show that with at least one reliable mobile connection available, an efficient teleconsultation can be conducted. The bad network coverage in some rural areas is at this point of development the most limiting factor, whereas teleconsultations in these areas are still possible due to the availability of the described backup solutions. Future development will focus on enhancing system performance in regions with bad or insufficient network coverage.

Seventy medical consultations – spread over different participating regions – have taken place within the evaluation period in the first 10 weeks. All these consultations were initiated by the paramedic on scene. Those 70 consultations are divided into 63 primary consultations and 7 secondary transfers. A primary consultation is the standard case, where paramedics on the scene of an emergency call the tele-EMS physician, whereas a secondary transfer is a well-planned relocation of a patient into another medical facility [22]. The daily system checks, which also test connectivity and therefore connect the EMS team to the teleconsultation center, are not counted as consultations. Taking a closer look at the operating times of the primary consultations, the average consultation length was in average 25.4 min (mean 25.4 min), with a standard deviation of $\pm$ 9.6 min. The shortest overall consultation length was 3 min, whereas the longest overall consultation length was 58 min (range 3–58 min). Within these consultations, several medications and medical instructions were delegated for the patient's therapy.

A more detailed medical analysis of the first month of evaluation can be found in [22]; further results will be published – as described before – after finishing the whole evaluation phase.

4 Discussion

4.1 Sustainability

Within the scope of TemRas, the EMS of various districts have been equipped with telemedical components and connected to the TemRas system to generate an added value for patients in an emergency situation. This approach enables faster response times, remotely accessible medical expertise, and high-quality support for the paramedics and the relief of EMS physicians. Using this kind of a system will greatly increase the efficiency in which the resource "EMS physician" can be utilized in the upcoming years by offering the necessary medical competence wherever it is required, without physically sending the physicians into the field when only discretionary competence is in demand.

The consortium will use the acquired knowledge and resources in close cooperation to further enhance the competences in the context of technology, innovation, and medical care. Using the regional transfer possibilities within the different districts of the already involved EMS, it is possible to further efficiently increase the total number of system users until the end of the research project in August 2013. This will result in the creation of working places and further increase the scientific reputation – national and international. Although all partners agree on a continuation of the TemRas system even after the end of the actual research project, it will be crucial to use and intensify the existing contacts and interest of the health insurance companies and work on a plausible collaboration concept to enable a long-term commitment.

Within the project TemRas, the EMS in Germany are comprehensively interdisciplinary cross-linked and uniquely optimized. The collaboration of various institutes and organizations along the medical chain of supply does not only support the sustainable optimization of emergency medical care and an improved service quality but also boosts the economy and science in this field. TemRas can therefore positively change the profile of medical care within Germany and influence the way medical care is implemented. By fostering the competence level of telemedicine, it is both the surrounding rural regions and structural weaker regions within whole Germany that profit. With the first-time rollout of a TRAS on multiple EMS districts, current and future development paths and usability scenarios are demonstrated. The Aachen region, with the first and only implementation of a teleconsultation center, hereby takes the position of a role model for the development and establishment of new working places and infrastructures in the whole of Germany as part of the possible adaptation of the TemRas concept.

Various interest groups have shown clear interest in supporting a long-term operation and integration of the TemRas system; the city of Aachen has expressed the interest of connecting all regional EMS to the TemRas system and therefore wants to equip all ambulances with the needed telemedical components in 2014. At the moment, the consortium is working out different operation and maintenance models and discussing with the different stakeholders to find a consistent solution for a long-term operation scenario, with the focus on not only supporting the city of Aachen itself but also integrating additional districts and regions in neighboring areas.

4.2 Impact

The continuation of the research activities to sustainably establish telemedicine within emergency care provides substantial potential for testing innovative medical technologies in this area. During TemRas, for example, new sensor technologies are being developed and evaluated. In addition, synergies regarding different software solution for patient monitoring can be realized; connecting the monitoring system to the teleconsultation center will increase the immediacy of emergency medical care, e. g., during a cardiac insufficiency. There are increased requirements for products in the operation scenario of emergency medicine regarding their robustness, operability, and especially reliability, which result in extended evaluation periods for potential new products in this area.

In general, integrating new IT and medical products into an existing telemedical system requires a lot of expertise and extendable system architecture. The transfer requirements to process the whole variety of vital data plus image and sound data inclusive a digital documentation from the emergency scene to the teleconsultation center are unique, regarding its complexity and reliability. An important criteria for extending the acceptance of users and therefore increase the operation area of the system is its ergonomics and ease of use. The consequent user integration within the development process and sufficient support for the EMS during the implementation period of the product bundle guarantees a future practicability.

The basic result of the project "Med-on-@ix" constitutes that due to scale effects, a cost-efficient operation of such a system will require comprehensive usage. With TemRas, the economical usage of the actual system is evaluated. The necessary scale effects are realized using six ambulances in different regions, and only by using these scale effects does an economically efficient operation of the system become possible. With the possible involvement of the health insurance companies, a successful long-term operation and a future distribution of the necessary product-service bundles can be initiated. The project and all involved partners have continuously been supported by the professional fire service of Aachen. As bearer of the EMS, they are highly interested in optimized and patient-adjusted medical care and are willing to take a leading role in the development of telemedical services within Germany.

The collaboration of the different consortium partners, which has proven to deliver outstanding results in the past, is a good starting point for future projects. In this context, the close connection of TemRas and other telemedicine projects at the RWTH Aachen and the proximity to the Euregio are of great importance. The consequent exchange of knowledge with all involved partners supports the transfer of medical expertise and experience into the development of new clinical products. On the European level, the use of tele-EMS physicians to support nonspecialists in this field will most likely result in a distinct quality augmentation because in many foreign countries, considerably more emergencies are operated by paramedics only. As an explicit example for the model region of Aachen, a transnational teleconsultation center could be implemented to support emergency cases in Germany, the Netherlands, and Belgium alike.

The German emergency care model involving a paramedic and an additional EMS physicians takes a leading role in the quality of emergency services in an international comparison. Nevertheless, an enormous potential for added value still stays unused with the common approach, which is compensated by the utilization of a tele-EMS physician. By further developing the telemedical system TemRas into a market-mature integrated product and service concept, a nationwide system rollout becomes possible, which enables a first-time full-level support for EMS.

The way more efficient and target-oriented utilization of the resource "EMS physician" is a direct approach to counter the estimated EMS physician deficit forecasted for the near future – this deficit is already clearly present within rural regions of Germany. The new professions of a tele-EMS physician as well as the new area of operation described by the teleconsultation center are leading the way toward a new era of emergency medicine. The expansion of the concept enables the creation of new working places in a variety of different fields, e. g., operation, logistics, support, maintenance, distribution of the technical equipment.

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References

1. Behrendt, H., R. Schmiedel, and K. Auerbach. 2009. Review of the performance of the rescue service in the Federal Republic of Germany in 2004 and 2005. *German Interdisciplinary Journal of Emergency Medicine* 12 (5): 383–388.
2. Schuster, M., M. Pints, and M. Fiege. 2010. Duration of mission time in prehospital emergency medicine: Effects of emergency severity and physicians level of education. *Emergency Medicine Journal* 27 (5): 398–403.
3. Adams, George L., Paul T. Campbell, John M. Adams, David G. Strauss, Karen Wall, Janet Patterson, Kathy B. Shuping, Charles Maynard, Dwayne Young, Craig Corey, Alan Thompson, Benjamin A. Lee, and Galen S. Wagner. 2006. Effectiveness of prehospital wireless transmission of electrocardiograms to a cardiologist via hand-held device for patients with acute myocardial infarction (from the Timely Intervention in Myocardial Emergency, NorthEast Experience [TIME-NE]). *The American Journal of Cardiology* 98 (9): 1160–1164.
4. Maria Sejersten, Martin Sillesen, Peter R. Hansen, Søren Loumann Nielsen, Henrik Nielsen, Sven Trautner, David Hampton, Galen S. Wagner, and Peter Clemmensen. 2008. Effect on treatment delay of prehospital teletransmission of 12-Lead electrocardiogram to a cardiologist for immediate triage and direct referral of patients with ST-segment elevation acute myocardial infarction to primary percutaneous coronary intervention. *The American Journal of Cardiology* 101 (7): 941–946.
5. Ziegler, V., A. Rashid, M. Müller-Gorchs, U. Kippnich, E. Hiermann, C. Kögerl, C. Holtmann, M. Siebler, and B. Griewing. 2008. Mobile computing systems in preclinical care of stroke. Results of the Stroke Angel initiative within the BMBF project PerCoMed. *Anaesthesist* 57 (7): 677–685.

6. Xiong, Wei, Aaron Bair, Christian Sandrock, Sophia Wang, Javeed Siddiqui, and Nathaniel Hupert. 2012. Implementing telemedicine in medical emergency response: Concept of operation for a regional telemedicine hub. *Journal of Medical Systems* 36 (3): 1651–1660.
7. Schneiders, Marie-Thérèse, Daniel Schilberg, and Sabina Jeschke. 2011. A Joint Organizational and Technical Development of a Telematic Rescue Assistance System for German Emergency Medical Services. eTELEMED 2011, The Third International Conference on eHealth, Telemedicine, and Social Medicine, 150–155.
8. Protogerakis, Michael, Arno Gramatke, and Klaus Henning. 2009. A System Architecture for a Telematic Support System in Emergency Medical Services. 3rd International Conference on Bioinformatics and Biomedical Engineering (ICBBE 2009), 1–4.
9. Skorning, Max, Christian Herrmanns, Stefan Beckers, Daniel Rörtgen, Sebastian Bergrath, Michael Protogerakis, Tadeusz Brodziak, Jörg Brokmann, and Rolf Rossaint. 2009. Med-on-ix: Aachener Forschungsprojekt zur Verbesserung der Patientenversorgung in lebensbedrohlichen Situationen. In *Telemedizinführer Deutschland*, ed. A. Jäckel, vol. 10, 323–326. Bad-Nauenheim: Minerva.
10. Schneiders, M.-T, S. Herbst, D. Schilberg, I. Isenhardt, S. Jeschke, H. Fischermann, S. Bergrath, R. Rossaint, and M. Skorning. 2012. Telenotarzt auf dem Prüfstand: Evaluation des Projekts Med-on-ix aus Sicht der Rettungsassistenten. *Notfall + Rettungsmedizin* 15 (5): 410–415.
11. Rörtgen, Daniel, Sebastian Bergrath, Rolf Rossaint, Stefan K. Beckers, Harold Fischermann, In-Sik Na, David Peters, Christina Fitzner, and Max Skorning. 2013. Comparison of physician staffed emergency teams with paramedic teams assisted by telemedicine: A randomized, controlled simulation study. *Resuscitation* 84 (1): 85–92.
12. Meyer, Brett C., Rema Raman, Thomas Hemmen, Richard Obler, Justin A. Zivin, Ramesh Rao, Ronald G. Thomas, and Patrick D. Lyden. 2008. Efficacy of site-independent telemedicine in the STRokE DOC trial: A randomised, blinded, prospective study. *The Lancet Neurology* 7(9): 787–795.
13. Lin, Chin-Feng. 2012. Mobile telemedicine: A survey study. *Journal of Medical Systems* 36(2): 511–520.
14. (US) LifeBot DREAMS. The most advanced telemedicine systems. http://www.lifebot.us.com/dreams/. Accessed 27 Sept 2012.
15. (Denmark) Viewcare. Viewcare pre-hospital telemedicine system. http://viewcare.com/index.php/da/praehospital. Accessed 23 Oct 2013.
16. Thelen, Sebastian, Marie-Thérèse Schneiders, Daniel Schilberg, and Sabina Jeschke. 2013. A Multifunctional Telemedicine System for Pre-hospital Emergency Medical Services. eTELEMED 2013, The Fifth International Conference on eHealth, Telemedicine, and Social Medicine, 53–58.
17. Ian Sommerville. 2007. *Software engineering*. 8th ed. Pearson Education: Harlow, Essex.
18. Büscher, Christian, Harold Fischermann, Frederik Hirsch, Marie-Therese Schneiders, Jörg Christian Brokmann, Daniel Schilberg, and Sabina Jeschke. 2012. Standard operating procedures for telemedical care in emergency medical services. In *Global telemedicine and eHealth updates: Knowledge resources*, ed. M. Jordanova and F. Lievens, vol. 5, 292–296. Luxembourg.
19. Katzenmeier, Christian, and Stefania Slavu. 2009. *E-Health in der Notfallmedizin: Rechtsgutachten: "Rechtsfragen des Einsatzes der Telemedizin im Rettungsdienst: Eine Untersuchung am Beispiel des Forschungsprojektes Med-on-ix"*. Köln.
20. Bergrath, Sebastian, Marie-Thérèse Schneiders, Frederik Hirsch, Bernd Siegers, Rolf Rossaint, Daniel Wielpütz, Michael Czaplik, Sebastian Thelen, Christian Büscher, Stefan K. Beckers, and Jörg C. Brokmann. 2012. Telemedizinische Unterstützung von Rettungsassistenten: erste Ergebnisse aus dem Forschungsprojekt TemRas. 1. Symposium ICT in der Notfallmedizin (NotIT 2012), 83–86.
21. Czaplik, Michael, Sebastian Bergrath, Rolf Rossaint, Sebastian Thelen, Tadeusz Brodziak, Bernd Valentin, Frederik Hirsch, Stefan K. Beckers, and Jörg C. Brokmann. 2014. Employment of telemedicine in emergency medicine: Clinical requirement analysis, system development and first test results. *Methods of Information in Medicine* 53 (2): 99–107.

22. Bergrath, Sebastian, Michael Czaplik, Rolf Rossaint, Frederik Hirsch, Stefan Beckers, Bernd Valentin, Daniel Wielpütz, Marie-Thérèse Schneiders, and Jörg Brokmann. 2013. Implementation phase of a multicentre prehospital telemedicine system to support paramedics: feasibility and possible limitations. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine (SJTREM)* 21 (1): 54.