https://doi.org/10.2352/ISSN.2470-1173.2018.06.MOBMU-116

Low-Cost Medical Infrastructure: Triage as intelligent decision support

Marius LIEFOLD [a]***, Dennis WAGNER*** [a]***, Alexander POKRAKA*** [a]***, Thomas SCHRADER*** [a]***;*** [a]***Technische Hochschule Brandenburg***

Abstract

The integration of telemedicine in primary care is a focus in industrial as well as developing countries. Only a few physicians are available in rural areas. With the strategy of service-levels, this problem is solvable: Nurses or medical streetworker are supported in their work by a telemedical system. A standardized and very fast input of symptoms via barcodes is the basis for an intelligent triage system. For each patient, the triage system gives feedback, whether an escalation is necessary. The triage system is adaptable for various use cases and medical domains.

Background

A significant problem in many rural regions of the world, especially in developing countries and emerging markets, is the fact that there are many sick people, but few doctors. This circumstance is amplified using outpatient care and often non-existent documentation of the medical history in rural regions. Exemplary for this is maternal mortality. The sub-Saharan region, which has been identified by the WHO as a metropolitan area, has a more than 100-fold increased maternal mortality rate (MMR) compared to Germany (3 MMR in Germany and > 500 MMR Cameroon on 100.000 live births) [18].

Many medical indications in developing and emerging countries have in common, that through the structured provision and monitoring the progress of the disease can be made recognizable and controllable promptly.

Developments in Telemedicine

The objectives for the provision of a telemedical service can be very different and have changed over time: starting with telemedical consultation services for teleradiology and telepathology, the focus is now on questions of regular and basic care for patients [1,2]. In spite of the focus on the care of patients with chronic illnesses, only a few projects are gaining ground from research into regular care [3].

A central concern for telemedicine is to provide medical services in regions where medical care can only be provided to a limited extent, at great expense or not at all for various reasons. Ultimately, it is a problem of allocating sufficient resources. One solution is to set up a process similar to that of service centers, with different service levels in the help desk area [4]. All simple medical and also partly diagnostic measures such as blood pressure measurement or determination of blood sugar can be carried out by medical streetworkers or health care personnel in nursing care. Only in the case of conspicuous values and critical conditions, the next service level is used. A critical point is that, due to the level of training or medical complexity, local staff may not be able to make a reliable decision as to when further assistance is required.

In medicine, various triage systems are used to determine the urgency of medical care, including the Manchester Triage System[5] and the Australian Triage Scale [6]. The result of a triage is an appropriate strategie for action. These triage systems can be used to differentiate between service levels and, if necessary, to signal the need for medical assistance.

Objectives of telemedicine in the context of basic and primary care

Telemedical projects can be divided into different groups according to their orientation and objectives. If the term telemedicine is very broadly defined, then all digital applications for capturing movement and other health data via apps can be included as wellness applications. In the developed countries, a fusion of wellness applications, medical treatment and personal health data takes place in the form of an electronic health record. The goals of these telemedical applications are primarily aimed at improving the healthy lifestyle of people themselves [7]. In developing and emerging countries, but also in rural regions, telemedicine projects are geared more towards achieving adequate basic care [8].

Telemedical care can now be understood as a multi-level concept with a flow of data and knowledge from and to humans respectively patients (Figure 1). By means of mobile applications, various data are collected, that are important for people themselves and their own health behaviour. However, this data may also contain useful information for the universal service.

The term "primary care" has emerged [9] to characterise the various aspects of basic health care. In developing and emerging countries it is difficult to secure basic services, and the allocation of resources is a major problem: often there is insufficient data available to make meaningful decisions on where to build up medical facilities and how they should be staffed. Data from the universal service can contain important knowledge at the administrative level, which can be used for decision support.

The medical data from personal health management as well as basic care are also used to generate knowledge and thus to improve the services for people (if necessary patients) in return.

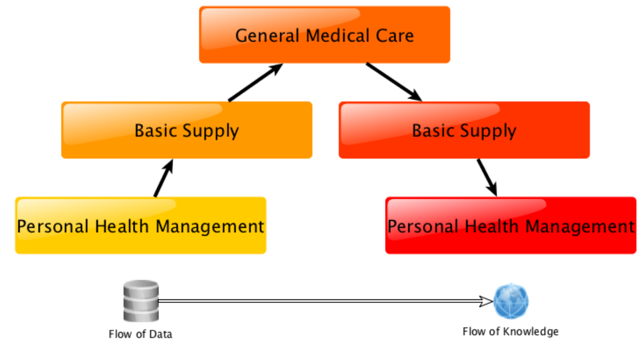

FIGURE 1: DATA AND KNOWLEDGE FLOW IN THE TELEMEDICAL CONTEXT

The concept of developing triage support for telemedicine care is based on three essential requirements to be met in the projects we have carried out in Cameroon on prenatal care and the treatment of non-communicable diseases in Southwest India:

1. The telemedical system should support medically educated persons (medical streetworkers) in their independent work.
2. The system should help to distinguish between high-risk and low-risk patients.
3. The data collected should enable better planning of resources.

Triaging is a tool to prioritize patient care and is often used in the initial assessment at first aid stations in German hospitals. The principle of classifying severity levels with the derivation of action measures is applied in basic care at various points, e. g. in estimating the risk of heart disease[10].

Material and Methods

The triaging software is part of a telemedical system developed at the Brandenburg University of Technology (Figure 2).

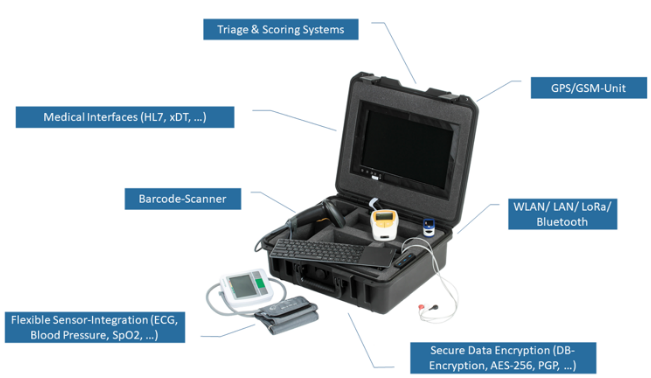

FIGURE 2: MOBILE TELEMEDICIN-SYSTEM NEVITA

Telemedical systems in developing and emerging countries must be mobile, simple, robust and flexible. The fundamental principle of the system is reduction and simplification as well as automation starting with the configuration up to the evaluation. True to the motto: „As simple as possible, good value as best as possible."

The system can be integrated into existing IT infrastructures or can depict efficient data management as a patient management system. Relevant data (symptoms, diagnoses and vital parameters) can not only be recorded and stored in a standardized manner but also processed and analyzed. It automatically detects emergency situations accordingly, and further procedures are proposed by the system.

As in the Help Desk area, different service levels are implemented for an efficient supply. All simple medical measures such as blood pressure measurement or the determination of the blood glucose can be performed by the health workers in nursing (Figure 3). Only in the case of conspicuous values and critical states, the next service level will be claimed. To reliably decide when further support must be essential, a triage system was developed. This system determines the urgency of medical care, also related to the individual service levels, and provides appropriate action strategies.

FIGURE 3: NURSE USING NEVITA

Two different control systems were initially used to implement triaging as a tool for prioritizing patients: the Kerala control system was developed for use in Southwest India to treat patients with non-communicable diseases (NCDs) such as chronic cardiovascular diseases. The WHO-ISH risk scale has been implemented to assess the risk of chronic heart disease [11]. As part of the further development, the extension of the use cases and the integration of the Manchester triage system [5] into the control system were started.

Fast and error-free input is a major challenge in daily work. In Germany, there is a maternity pass for prenatal care in which more than 70 different information and laboratory values can be entered. A simple 1:1 transfer to a user interface is technically possible, but the user acceptance and patience is very low even for long electronic questionnaires [12-14]. For this reason, data entry has been greatly simplified and is now based on reading in barcodes. The HAT concept was developed and implemented: HAT stands for the minimum inputs necessary for triage: History (health history, anamnestic data), Actual (Current symptoms) and finally the triage itself.

The development is based on the platform-independent programming language Python in version 3.6 [15], the data is stored in a local database (SQLite) [16]. The basic configuration can also be extended to a wide range of diseases and indications (infectious diseases, non-communication diseases, veterinary medicine, disaster management, etc.).

Results

Using the telemedical documentation system, the process of a medical visit was implemented by a medical streetworker: the barcodes for symptoms and diagnoses are systematically transferred to the system via customizable templates. After completion of the symptom input, triaging and feedback to the user takes place if necessary. It contains the corresponding triaging code as traffic light color (green-yellow-red) as well as a recommendation for further action and a period of time.

The system now allows the realization of different options for action: in problematic cases, the immediate information of the physician with data on vital signs, symptoms and triage status is already mobile. Later, all cases can be analysed by medical staff. Medical Streetworkers are therefore assisted in decision-making and emergency situations are identified according to the input and indication.

Implementation of Triaging

The implementation of different triaging systems is complicated by the fact that there are different data structure and triaging algorithms behind these systems. The Kerala system has a simple list of symptoms and value constellations. A triage consists of a number of these symptoms and examination values. If these are given, the corresponding rule is output.

The Manchester triage system [5] consists only of symptoms. Symptoms can have a hierarchical composite structure and form a component symptom, e. g. the symptom "hot baby" is made up of the individual symptoms "baby" and "hot". “Baby" is a symptom based on the age indication of less than one year, "hot" means a body temperature greater than 40.5°C. This means that measurements and the corresponding range of values must be transferred to symptoms and then searched for possible compound symptoms in a search run. Only when it is ensured that all laboratory values and corresponding symptom combinations have been combined can the rule be applied.

Measured values are transformed into symptoms and possibly combined to the component symptoms. If the list of symptoms and illnesses fulfils a triaging rule, it is displayed together with the recommendations for action.

The Triage Database Model

Due to the large number of possible triage structures, it was decided during development not to use a hierarchical database model according to the Entity Relationship Model. A high degree of flexibility and adaptability was important, but this does not require any changes to the database structure. Therefore, the triple model of the resource description framework was used.

All hierarchical relationships are mapped according to the subject, predicate, object (or resource property value) using these triple structures. This means that any other triaging structures can be inserted without any problems. The modeling of these rules has been shifted from database modeling and adaptation to the modeling of subject-predicate object relationships. The functions to be implemented with access to the database remain unchanged.

Discussion

The provision of triaging functionality is an important tool to support the independent work of medical staff, from medical street workers to trained nurses. This makes it possible to implement the service level concept from the help desk area. According to the Pareto Principle[17], at least 80% of all cases in the universal service can be treated independently and for 20% of cases with a higher priority, appropriate recommendations for action can be provided.

In addition to triaging, simple data entry is a major challenge. By using bar code lists, you can create and use adapted versions for the corresponding target and supply group. It can be used to map the workflow and systematically record symptoms and illnesses.

This data is a prerequisite for ensuring that it is available in a data quality required for statistical evaluation and decision support. The telemedicine system has a GPS module, so that the supply information is also linked to geo-information and allows a systematic analysis of supply routes and regions.

Summary

In the context of basic medical care, it is first and foremost a matter of providing the most comprehensive acute and chronic, but not life-threatening care to the sick. Telemedical applications in developing and emerging countries should support the independent work of medically trained personnel and illustrate it in one process. It makes sense to follow the concept of service levels so that the limited resources of medical staff can be used sensibly. This therefore requires that medical street workers can be guided and instructed in their work by decision-supporting tools, so that not every patient needs to be physician-contacted. Triagation, which can have different orientations depending on the objective and application, is a method that provides for a structured input and algorithmic processing of the supply power. The input can be organized and greatly simplified via barcode lists. The advantages of this input option are the simple integration of standards and standard terminology, the accuracy of the input itself and thus the direct use of the information for analysis, the fast adaptation to different languages and consideration of different applications.

Thanks

We would like to show our deep gratitude to the Department of Computer Science and Media of the Technische Hochschule Brandenburg University of Applied Science, especially to the vice president of research and education Mr. Prof. Dr.-Ing. Gerald Kell for patronizing this publication and project. The project is also financed by the EXIST funding program of the Federal Ministry of Economics and Energy of Germany and is co-financed by the European Social Fund (ESF).

References

[1] Groneberg DA, Rahimian S, Bundschuh M, Schwarzer M, Gerber A, Kloft B. Telemedicine – a scientometric and density equalizing analysis. J Occup Med Toxicol Lond Engl [Internet]. 24. Oktober 2015 [zitiert 9. April 2017];10. Verfügbar unter: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4619516/

[2] Wang Y, Zhao Y, Zheng J, Zhang A, Dong H. The evolution of publication hotspots in the field of telemedicine from 1962 to 2015 and differences among six countries. J Telemed Telecare. März 2017;1357633X17693749.

[3] AlDossary S, Martin-Khan MG, Bradford NK, Armfield NR, Smith AC. The Development of a Telemedicine Planning Framework Based on Needs Assessment. J Med Syst. Mai 2017;41(5):74.

[4] Beims M. IT-Service Management mit ITIL: ITIL Edition 2011, ISO 20000:2011 und PRINCE2 in der Praxis. 3., aktualisierte Aufl. München: Hanser; 2012. 350 S.

[5] Mackway-Jones K, Krey J, Herausgeber. Ersteinschätzung in der Notaufnahme: das Manchester-Triage-System. 3., überarb. und erg. Aufl. Bern: Huber; 2011. 229 S. (Ambulanz-/Notfallpflege).

[6] Ebrahimi M, Heydari A, Mazlom R, Mirhaghi A. The reliability of the Australasian Triage Scale: a meta-analysis. World J Emerg Med. 2015;6(2):94–9.

[7] Ernsting C, Dombrowski SU, Oedekoven M, O Sullivan JL, Kanzler M, Kuhlmey A, u. a. Using Smartphones and Health Apps to Change and Manage Health Behaviors: A Population-Based Survey. J Med Internet Res. 5. April 2017;19(4):e101.

[8] Casey M, Hayes PS, Heaney D, Dowie L, ÓLaighin G, Matero M, u. a. Implementing transnational telemedicine solutions: A connected health project in rural and remote areas of six Northern Periphery countries. Eur J Gen Pract. März 2013;19(1):52–8.

[9] Goroll AH, Mulley AG, Herausgeber. Primary care medicine: office evaluation and management of the adult patient. 7th edition. Philadelphia Baltimore New York London Buenos Aires Hong Kong Sydney Tokyo: Wolters Kluwer Health; 2014. 1674 S.

[10] Perk J, De Backer G, Gohlke H, Graham I, Reiner Ž, Verschuren M, u. a. European Guidelines on cardiovascular disease prevention in clinical practice (version 2012)The Fifth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of nine societies and by invited experts)Developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR). Eur Heart J. 1. Juli 2012;33(13):1635–701.

[11] WHO I. World Health organization/International Society of Hypertension (WHO/ISH) risk prediction charts [Internet]. 2007 [zitiert 14. Mai 2017]. Verfügbar unter: http://ish-world.com/downloads/activities/colour_charts_24_Aug_07.pdf

[12] Gordillo A, Barra E, Aguirre S, Quemada J. The usefulness of usability and user experience evaluation methods on an e-Learning platform development from a developer's perspective: A case study. In: 2014 IEEE Frontiers in Education Conference (FIE). Los Alamitos, CA, USA: IEEE Computer Society; 2014. S. 1–8.

[13] Lowdermilk T. User-centered design: [a developer's guide to building user-friendly applications]. First edition. Beijing: O'Reilly; 2013. 135 S.

[14] Upadhyaya B, Zou Y, Keivanloo I, Ng J. Quality of Experience: User's Perception about Web Services. IEEE Trans Serv Comput. 2015;8(3):410–21.

[15] Welcome to Python.org [Internet]. Python.org. [zitiert 16. Mai 2017]. Verfügbar unter: https://www.python.org/

[16] SQLite Home Page [Internet]. [zitiert 16. Mai 2017]. Verfügbar unter: https://www.sqlite.org/

[17] Pressman RS. Software engineering: a practitioner's approach. 7th ed. New York: McGraw-Hill Higher Education; 2010. 895 S.

[18] Global, regional, and national levels and trends in maternal mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic analysis by the UN Maternal Mortality Estimation Inter-Agency Group. WHO Press. Retrieved from http://www.thelancet.com/pb/assets/raw/Lancet/pdfs/S0140673615008387.pdf