Telemedicine support to patients with chronic diseases for better long-term control at home

Izvajanje telemedicinske podpore bolnikom v domačem okolju za boljše obvladovanje kronične bolezni

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Abstract

Authors in many scientific publications suggest that the telemonitoring of health parameters is a useful tool for supporting patients with long-term conditions staying at home and their self-management of the disease. Those patients are likely to benefit from timely and adequate response to deteriorated conditions detected by the telemedicine system. Almost all of the studies state that telemedicine provided as telemonitoring can be an effective add-on tool in the hands of patients and medical experts for the self-management of patients with, for example, heart failure or diabetes. In this paper the principles of patient telemonitoring are presented as applied within a telemedicine service provided by the Centre for Telehealth (CEZAR) at the General Hospital Slovenj Gradec (Slovenia). The centre supports patients with diabetes mellitus type 2 and/or with chronic congestive heart failure. The service was set-up in 2014 as part of a European project called UNITED4HEALTH. Since then over 550 patients from the Carinthia and Saleška regions (Slovenia) have been receiving telemedicine support for more than two years. The clinical outcomes of the telemedicine service published elsewhere prove that the selected telemedicine service model is adequate and the implemented technological solution is acceptable for all service users: the patients and the clinicians.

Izvleček

Avtorji številnih znanstvenih objav navajajo, da je spremljanje parametrov zdravja na daljavo uporabno orodje pri podpori kroničnim bolnikom, ki sami, ob ustrezni medicinski podpori, skrbijo za svojo bolezen. Tem bolnikom pravočasen odziv in ukrepanje ob poslabšanju bolezni, ki ga omogoča telemedicinska storitev, izboljša izid zdravljenja. Rezultati vseh tovrstnih raziskav nakazujejo, da je lahko telemedicinska storitev v obliki spremljanja parametrov zdravja na daljavo (telemonitoring) učinkovito dodatno orodje v rokah bolnika in zdravstvenih oz. medicinskih strokovnjakov pri samooskrbi sladkorne bolezni in/ali srčnih bolezni. V članku predstavljamo princip telemedicinskega spremljanja, kot se uporablja v telemedicinski storitvi, ki jo ponuja Center za zdravje na daljavo (CEZAR), ki deluje v okviru Splošne bolnišnice Slovenj Gradec. Center nudi storitve bolnikom s sladkorno boleznijo tipa 2 in/oz. bolnikom s kroničnim srčnim popuščanjem. Storitev smo vzpostavili v letu 2014 v okviru evropskega projekta UNITED4HEALTH – Združeni za zdravje. Od začetka dela je center nudil storitve že 550 bolnikom koroške in saleške regije. Nekateri od njih prejemajo storitev že dve leti. Klinični rezultati telemedicinskega spremljanja, objavljeni drugje, potrjujejo, da so avtorji uporabili ustrezen model storitve in da je izvedba tehnične rešitve primerna in sprejemljiva za vse uporabnike storitve: za bolnike in za vključene zdravstvene delavce.

Background

Europe is facing a challenge of delivering quality healthcare to all its citizens at an affordable cost. Prolonged medical care for the ageing society, the costs of managing chronic diseases, and the increasing demand by citizens are major factors that contribute to the problem of delivering quality healthcare (1). The emerging situation calls for a change in the way healthcare is delivered and the way medical knowledge is managed and transferred to clinical practice (2). The European Commission sees the implementation of new services, based on new models implementing new information and telecommunication technologies (ICT), which have the potential of being more efficient than the current established models (1), as a way of solving these problems. They should empower the user in their home environment in the self-management of their disease. Services to support patients with long term conditions e.g. diabetes mellitus (DM) or chronic heart failure (CHF) in their living environment are inevitable for the European as well as Slovenian healthcare system in the future.

Support to patients with DM and/or CHF in their home environment aims at empowering the user in his self-management of the disease thus preventing the deterioration of a person's health condition, avoiding medical complications and minimising secondary consequences of the illness. Those patients are likely to benefit from timely and adequate response by health care providers to deteriorated conditions detected by the telemedicine system upon the received data. DM patients should keep their blood glucose level within the determined interval. CHF patients should take care to maintain adequate blood pressure, heart rate and body weight values. The professional challenge for DM and CHF clinicians is to successfully conduct therapy in physically absent patients. In order to provide telemedicine service to patients at home, an adequate service infrastructure and the service provision model to support medical intervention at a distance need to be developed and established.

Services are based either on TV, teleconferencing, telemetry, SMS messaging, emails and other means of communication. There are different telemedicine service infrastructures (3,4) as well as organisational models in place (5). Differences arise from local circumstances and the availability of resources, but they all have the same goal: all should result in a higher quality of life of the remotely monitored patients.

An applied telemedicine (TM) service model has to prove its efficiency by positive clinical outcomes. In the literature there are several reports on the successful implementation of home telemedicine based on telemonitoring when implementing an adequate response system to the detected changes in health status. Meta-analysis of Nakamura et al. (6) confirms that telemonitoring could be an effective add-on tool for managing elderly patients with DM and/or CHF. Remote monitoring in CHF patient management may have a significant protective clinical effect on patients in comparison with those receiving regular care (7). Similarly, studies of remote monitoring in DM2 patients show positive effects e.g.an improvement (lowering) in HbA1c levels (8,9).

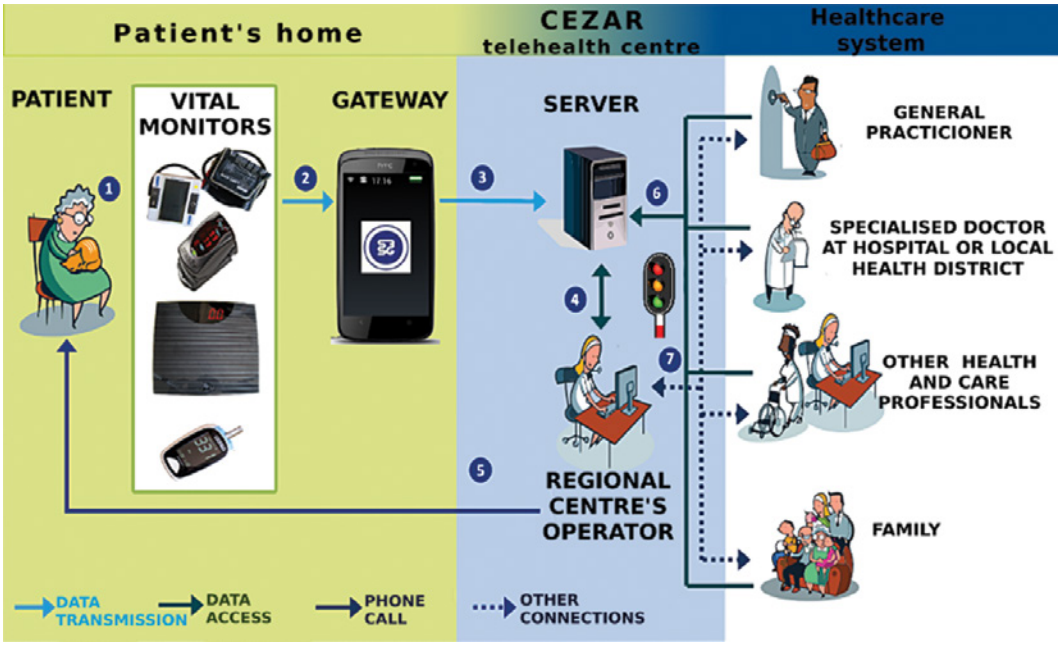


Figure 1: Telemedicine service model implemented at the CEZAR telemedicine centre to support DM2 and CHF patients at home. See text for details.

Telemonitoring service at the General Hospital Slovenj Gradec

In this paper the principles of patient telemonitoring are presented as applied within a TM support service provided by the Regional Centre for Telehealth (CEZAR) located at the General Hospital Slovenj Gradec, Slovenia (GH-SG) (10). The service was set up in 2014 as part of a European project called UNITED4HEALTH–UNIversal Solutions in Telemedicine Deployment for European HEALTH care (11). In the period of 2013–2015 the GH-SG, the Healthcare Centre (HC-Ravne) and a supporting organisation, MKS Electronic Systems Ltd., Ljubljana (MKS Ltd.) participated in the UNITED4HEALTH project that is considered to be the largest European R&D telemedicine project in terms of the number of patients involved. The aim of the project is to spread a TM model and evaluation criteria set up within another EU project called Renewing Health (12), to countries that have not yet introduced TM services. Fifteen partners in ten EU member states piloted projects in their regions offering TM service for at least a year to almost 6,000 patients suffering from CHF, diabetes, chronic obstructive pulmonary disease or hypertension.

At the start of the UNITED4HEALTH project, Slovenia did not have any type of operational home telemonitoring service. For this reason, GH-SG, HC-Ravne and MKS Ltd. decided to set up its own TM service to support 400 patients with DM type 2 (DM2) and 200 patients with CHF to reach the project target set out for Slovenia. Since April 2014 the CEZAR regional centre for telehealth has been providing telemedical support to DM2 and CHF patients in the Carinthia region of Slovenia. In the article, the TM service is presented through its mode, infrastructure, service delivery pathway and a clinical portal built to support the TM service. The patient recruitment process, the clinical results of the

telemonitoring and user satisfaction are not within the scope of this paper.

Telemonitoring service model and infrastructure

A basic technological solution for the TM service implemented at the GH--SG is presented in Figure 1. It is built on the UNITED4HEALTH project service model (3). The Slovenian UNITED4HEALTH team upgraded it with an organisational infrastructure.

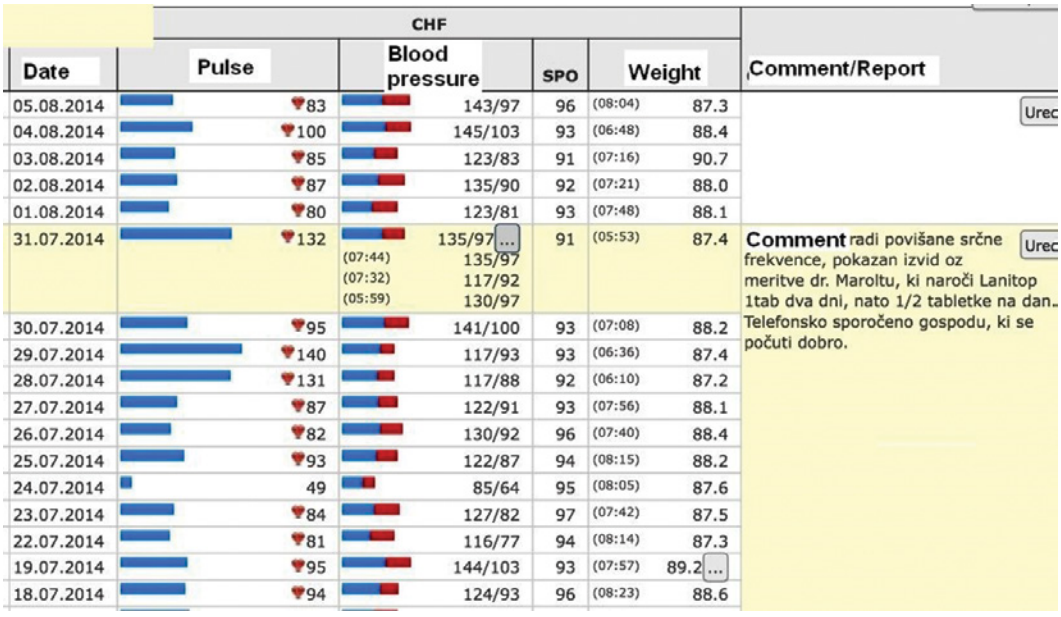
A PATIENT (No. 1 in Figure 1), as a TM support service user, takes measurements of health related data at home using VITAL MONITORS. A DM2 patient uses a glucometer to measure his blood glucose level and a CHF patient measures his blood pressure using a blood pressure meter with an incorporated heart rate meter, body weight using a scale, and oxygen saturation using a pulse oximeter. Each measured value is sent from each of the devices through a Bluetooth (No. 2) link to a GATEWAY that is a mobile smart phone. Data is forwarded to the regional TM centre through a mobile network (No. 3). There, the data is passed on to a broadband Local Area Network (LAN) and stored on the TM service SERVER. A REGIONAL CENTRE OPERATOR monitors the patient's data (No. 5) when alerted, and responds (primary level interventions), e.g. by calling the patient when the measured data is out of his/her personally specified range. A DM2 and/or CHF specialist (SPECIALISED DOCTOR) or other healthcare professional on duty is alerted by the OPERATOR (No. 4) when a second level intervention is required. FAMILY members are also informed by the regional centre operator (No. 7) when their assistance is needed, e.g. to take their relative to see a DM or CHF SPECIALIST. All of the involved parties send their feedback to the REGIONAL CENTRE OPERATOR (No. 7) using standard means of communication (phone, e-mail, SMS, written reports). A GP is not part of the response system, as the cardiologists at SB-SG cover both secondary and primary healthcare needs. The PATIENT has an optional communication channel (5) to contact the REGIONAL CENTRE OPERATOR by phone. The same channel (No. 6) is used by the REGIONAL CENTRE OPERATOR when the PATIENT is contacted.

The TM-collected data are securely saved on the SERVER behind a firewall of the TM service provider (GH/SG). Authorised medical staff has an access to the data through a Virtual Private Network (VPN) channel (6).

The technological solution and the equipment were provided by a German company Health Insight Solution (13) in cooperation with a Slovenian company MKS Ltd. (14).

Telemedicine service description

A patient using the TM service at home takes daily measurements of his/her blood sugar (DM2 patients) or weight, blood pressure, heart rate and oxygenation (CHF patients) following the recommendation of his/her specialist regarding the time and frequency of the measurements. The measuring devices are provided by the TM service provider. This also includes a mobile phone serving as the gateway. The gateway and the measurement devices are matched and personalised before being passed on to the patient. After the measurement is taken, within a minute the patient's data is automatically sent from the measuring device to the gateway and then further to the server in GH-SG without any intervention by the patient.



CHF						
Date	Pulse	Blood pressure	SPO	Weight		Comment/Report
05.08.2014	83	143/97	96	(08:04)	87.3	Urec
04.08.2014	100	145/103	93	(06:48)	88.4	
03.08.2014	85	123/83	91	(07:16)	90.7	
02.08.2014	87	135/90	92	(07:21)	88.0	
01.08.2014	80	123/81	93	(07:48)	88.1	
31.07.2014	132	135/97 ... (07:44) 135/97 (07:32) 117/92 (05:59) 130/97	91	(05:53)	87.4	**Comment** radi povišane srčne frekvence, pokazan izvid oz meritve dr. Maroltu, ki naroči Lanitop 1tab dva dni, nato 1/2 tabletke na dan. Telefonsko sporočeno gospodu, ki se počuti dobro. Urec
30.07.2014	95	141/100	93	(07:08)	88.2	
29.07.2014	140	117/93	93	(06:36)	87.4	
28.07.2014	131	117/88	92	(06:10)	87.2	
27.07.2014	87	122/91	93	(07:56)	88.1	
26.07.2014	82	130/92	96	(07:40)	88.4	
25.07.2014	93	122/87	94	(08:15)	88.2	
24.07.2014	49	85/64	95	(08:05)	87.6	
23.07.2014	84	127/82	97	(07:42)	87.5	
22.07.2014	81	116/77	94	(08:14)	87.3	
19.07.2014	95	144/103	93	(07:57)	89.2 ...	
18.07.2014	94	124/93	96	(08:23)	88.6	

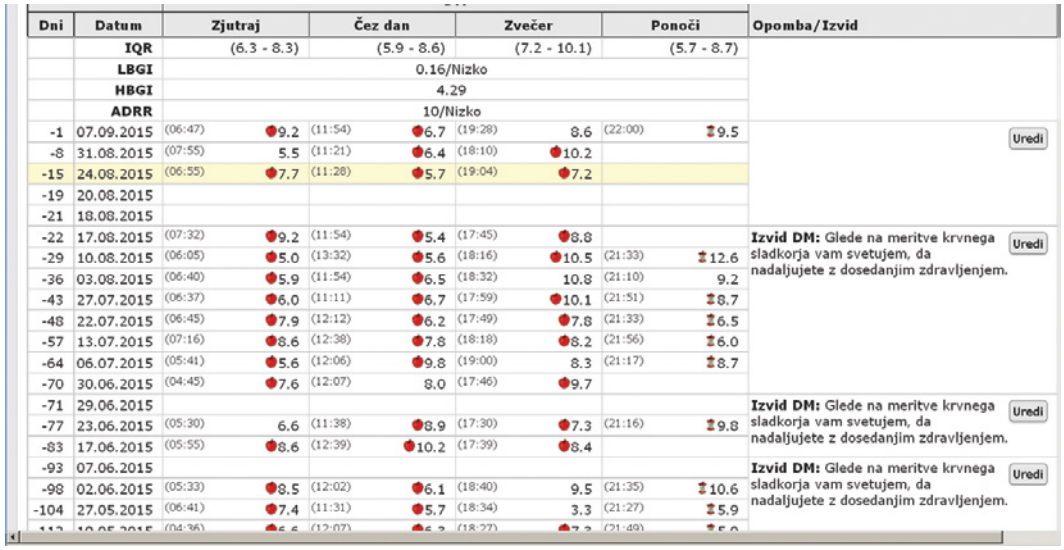
Figure 2: A screenshot from the clinical portal presenting daily collected data for one of the CHF patients.

The TM service server compares the measured data to the pre-set personalized values for each data type. If the measured value exceeds the threshold limit set individually by the medical specialist, the TM centre coordinator (a nurse) receives a warning email. The coordinator calls the patient by phone to get more information on the background of the out-of-range data values. The measurements are repeated if there is any doubt as to the reliability of the data. If the measurements confirm a deteriorated condition, or they are indicated by the patient him/herself, the coordinator consults the specialist on duty and informs him/her on the findings. The specialist decides on the action to be taken by the patient. This could be advice, a change in medication / treatment, a visit to his/her GP, a visit to the hospital clinic during regular working hours, or an emergency visit to the hospital. The information is conveyed to the patient by the coordinator by phone, and later on as a written report by surface mail. Every phone call, advice, change in therapy, home visit or other action is registered as a comment in the patient's record on the clinical portal. The response system was organised during the morning shift only.

Presentation of TM collected data for DM2 and CHF patients

A web-based portal was designed for clinicians by the Slovenian team enabling the medical staff to manage the patient's data. In Figure 2 a screenshot from the clinical portal presents daily collected data for one of the CHF patients. Values for heart rate (pulse), blood pressure, oxygen saturation (SPO) and body weight are shown in columns. The comments recorded at medical intervention or made when contacting the patient are in the right column (Comment/Report). The heart symbol in the numeric values for pulse indicates an arrhythmia detected by the blood pressure meter.

In Figure 3 a screenshot from the clinical portal presents weekly collected numerical data of blood sugar level values measured over a four-month peri-



Dni	Datum	Zjutraj	Čez dan	Zvečer	Ponoči	Opomba/Izvid
	IQR	(6.3 - 8.3)	(5.9 - 8.6)	(7.2 - 10.1)	(5.7 - 8.7)	
	LBGI	0.16/Nizko				
	HBGI	4.29				
	ADRR	10/Nizko				
-1	07.09.2015	(06:47) 9.2	(11:54) 6.7	(19:28) 8.6	(22:00) 9.5	Uredi
-8	31.08.2015	(07:55) 5.5	(11:21) 6.4	(18:10) 10.2		
-15	24.08.2015	(06:55) 7.7	(11:28) 5.7	(19:04) 7.2		
-19	20.08.2015					
-21	18.08.2015					
-22	17.08.2015	(07:32) 9.2	(11:54) 5.4	(17:45) 8.8		Izvid DM: Glede na meritve krvnega sladkorja vam svetujem, da nadaljujete z dosedanjim zdravljenjem. Uredi
-29	10.08.2015	(06:05) 5.0	(13:32) 5.6	(18:16) 10.5	(21:33) 12.6	
-36	03.08.2015	(06:40) 5.9	(11:54) 6.5	(18:32) 10.8	(21:10) 9.2	
-43	27.07.2015	(06:37) 6.0	(11:11) 6.7	(17:59) 10.1	(21:51) 8.7	
-48	22.07.2015	(06:45) 7.9	(12:12) 6.2	(17:49) 7.8	(21:33) 6.5	
-57	13.07.2015	(07:16) 8.6	(12:38) 7.8	(18:18) 8.2	(21:56) 6.0	
-64	06.07.2015	(05:41) 5.6	(12:06) 9.8	(19:00) 8.3	(21:17) 8.7	
-70	30.06.2015	(04:45) 7.6	(12:07) 8.0	(17:46) 9.7		
-71	29.06.2015					Izvid DM: Glede na meritve krvnega sladkorja vam svetujem, da nadaljujete z dosedanjim zdravljenjem. Uredi
-77	23.06.2015	(05:30) 6.6	(11:38) 8.9	(17:30) 7.3	(21:16) 9.8	
-83	17.06.2015	(05:55) 8.6	(12:39) 10.2	(17:39) 8.4		
-93	07.06.2015					Izvid DM: Glede na meritve krvnega sladkorja vam svetujem, da nadaljujete z dosedanjim zdravljenjem. Uredi
-98	02.06.2015	(05:33) 8.5	(12:02) 6.1	(18:40) 9.5	(21:35) 10.6	
-104	27.05.2015	(06:41) 7.4	(11:31) 5.7	(18:34) 3.3	(21:27) 5.9	

Figure 3: A screenshot from the clinical portal presenting weekly collected numerical data for blood sugar of one of the DM patients over a four-month period.

od by one of the DM patients. An apple symbol indicates the time of a blood sugar measurement in relation to food intake: a full apple symbol indicates that the measurement was done before a meal and the half-eaten one marks the post meal measurement. The comments recorded during a medical intervention or by contacting the patient are in the right column (Comment/Report).

In Figure 4 the measured blood glucose level values are presented graphically. The graph is a screenshot from the clinical portal presenting weekly collected data of the blood glucose level of one of the DM2 patients in the last 12 months. The data is separated according to morning, mid-day, evening and night measurements. The values are compared to a line at 10 mmol/L of blood glucose. The green triangle symbols above the top graph indicate medical interventions or contacts with the patient.

Discussion

Several approaches have been reported in the literature that is available on setting-up a telemedicine service to support patients at home (9,15,16). They differ from one medical discipline to another by using different methods and tools. No common rules exist as to what a TM solution model should look like. Also in almost every European country research and development groups have been piloting TM services thus seeking their own sustainable telemedicine model. TM services in the European member states are at different level of implementation (17). Different TM approaches and models are also used within pilots and projects supporting the same group of patients. This is reflected in a document resulting from the UNITED4HEALTH project and published by the EU Commission "*Telehealth in Practice–Care Delivery Models from 14 Regions in Europe*" (3) where nine different TM service models were used to support DM patients in nine European regions and four to support CHF patients at home in four European regions. A TM service model should be a response to patients' needs, taking into account the existing clinical practice and available resources.

The Slovenian partners in the UNITED4HEALTH project started building

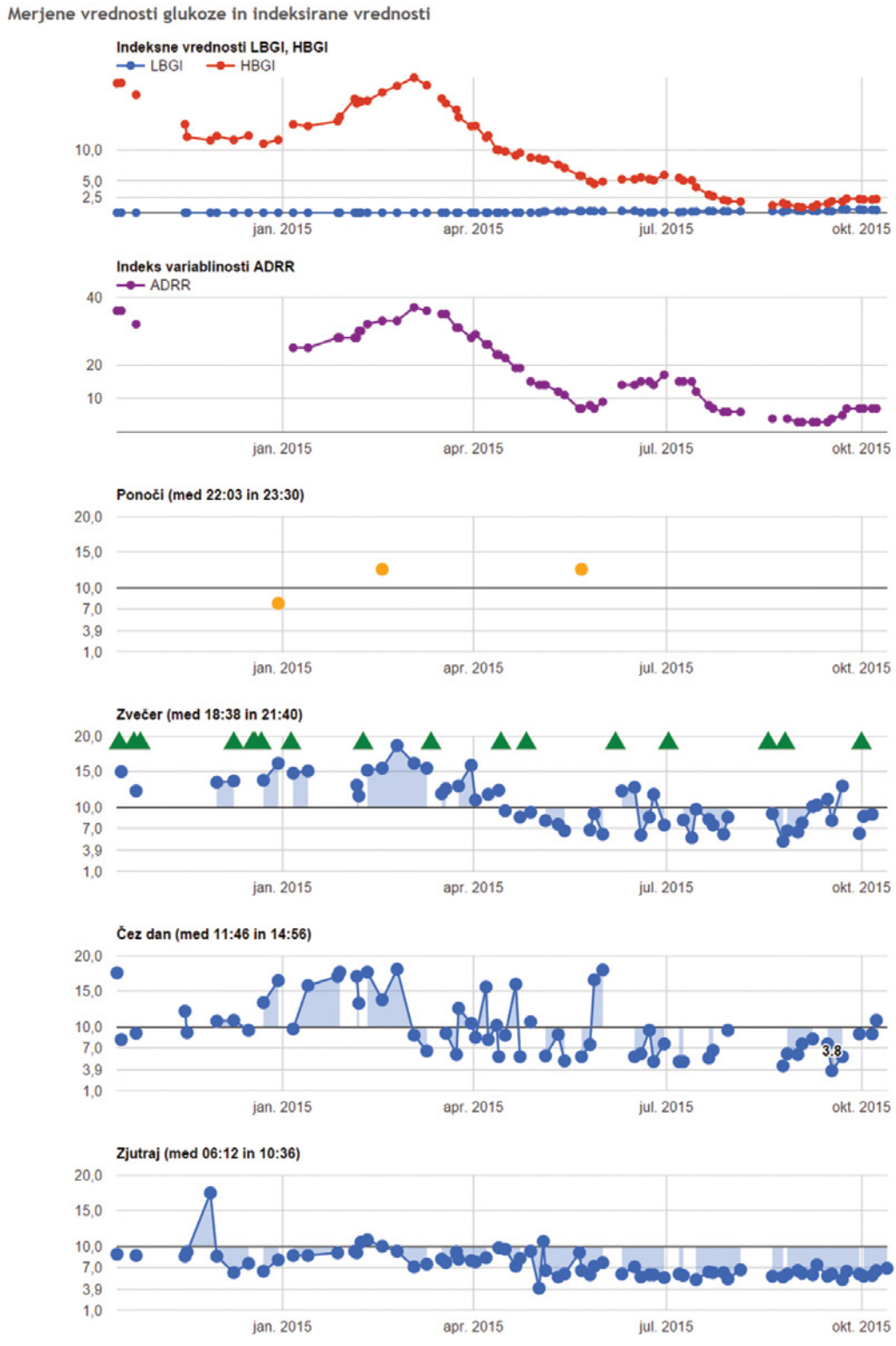


Figure 4: A screenshot from the clinical portal graphically presenting weekly collected data of blood sugar measurements of one of the DM patients in the last 12 months.

their TM service from a "green field", so they were unrestricted in their approach as to how to realise the suggested UNITED4HEALTH service model for DM2

and CHF patients. They decided to implement a technical solution based on telemonitoring that is completely mobile and does not require any patient intervention when taking measurements. The implemented service model proved to be functional, effective, reliable and useful. Also, the equipment used by the patient completely satisfied the functional requirements. There were several technical and organisational measures taken in which the system performed reliably, e.g. measured data aggregated in the mobile phone if a mobile signal was not available. Data was transferred to the hospital when the network was once again available. Additionally, technical support was organised at three levels to support patients and the staff at the regional TM centre CEZAR. On the organisational level, steps were taken to minimise potential difficulties in using the TM service, e.g. potential TM users and their caregivers were trained prior to enrolment to manage the devices and instructed on how to act in case of difficulties. Consequently, using the new ICT based TM support service was not a burden to any person involved.

The medical response system that was in place was effective and reassured the patients supported at home. They would get a phone call, advice to change their therapy or were visited at home. In addition to the TM service, standard pathways were also available to access medical help in potentially critical situations. For the patients the most important features of the service were the easy use of the equipment (technical issue) and that they were contacted by the TM centre staff every time the data provided by the TM system indicated a potential deterioration of their disease-related health condition (organisational issue).

The medical professionals involved in the TM support service (one TM centre operator, two DM and one CHF specialists) recognised the usefulness and the effectiveness of the TM service for them and for the supported patients. They were surprised at the simplicity of the use of the technological solution that provides objective data on the observed patient's health indicators. For them the most valuable part of the solution was the clinical portal with aggregated patient's personal, medical and TM data. The portal was custom designed to support their work with patients. It contains several other modules with tools for operational work, e.g. for the management of a patient's personal and health-related data, to report to patients, to document the TM data in the patient's personal records, to notify the patients' GPs on their patient involvement in the TM service, and for sending SMS notices to the patients. Other modules for the operational running of the TM centre were also established, e.g. an assets management module and data analysis and a presentation module, etc.

Our service was set-up in 2014 as part of a European project called UNITED-4HEALTH. Since then, over 550 patients from the Carinthia and Saleška regions (Slovenia) have received telemedicine support. The results of the implementation of the presented TM service are outside the scope of this paper and have been published elsewhere (8,18-23). However, according to the published literature, the selected TM service model is adequate and the implemented technological solution is useful and acceptable for both the patients and clinicians.

Conclusions

The implemented service model has proven to be functional, effective, and reliable when providing TM support to DM2 and CHF patients.

The TM system provided objective data on the observed patient's health indicators (blood glucose level, blood pressure, heart rate, body weight, oxygen saturation) and the completely mobile technical solution of the service at the patient's side was adequate and easy for the patients to use. There was an efficient support service in place to help them resolve potential difficulties with regard to the use of the equipment.

The medical professionals involved in the TM service recognised its value for their clinical work and for the supported patients. In addition, cooperation with the patients strengthened and patients were empowered at self-care in their home environment.

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Details of ethics approval

The National Medical Ethics Committee of the General Hospital of Slovenj Gradec approved the study on 18 October 2013. An informed consent was obtained from each patient before being enrolled in the project.

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