TreC Diabetes: A Semantic Platform For Supporting The Self-management of Patients

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Abstract. The interest in designing a smart platform for supporting the self-management of chronic disease significantly growth in the last years. One of the chronic diseases that most attracted the attention of the research community is diabetes. Such a chronic disease is worthy of investigation, concerning the realization of smart platform, due to the possibility of (i) providing plans to patients about the monitoring activities, (ii) knowing the parameters involved in the monitoring process and the actions to trigger, and (iii) understanding possible barriers impeding patients to fulfill the self-monitoring. In this paper, we present the TreC-Diabetes system, a smart platform enabling the acquisition of patients data and integrating real-time reasoning of data streams about glycemic index, food intake, and performed sport activities. The platform is described and preliminary lessons learnt from our deployment have been reported.

Keywords: Healthcare · Diabetes · Semantic Technology · Self-management.

1 Introduction

Clinical Decision Support (CDS) may be defined as the provision of person-specific information, intelligently filtered, prioritized and presented at the right time to clinicians, patients, staff and others to enhance health and health care [3]. Outpatient diabetes CDS systems have been operative since 1983 [22], but meta-analyses indicate that although outpatient diabetes CDS systems often improve test ordering and preventive services, their impact on key diabetes care outcomes such as the control of glucose, blood pressure, tobacco use or appropriate aspirin use has generally been marginal or inconsistent [18].

On the contrary, there has been a major improvement in diabetes care delivery systems, in recent years. In the United States, recent national data indicate that the proportion of patients who have simultaneously achieved adequate levels of glucose, blood pressure, lipid and tobacco control and appropriate aspirin use has risen from 5% in 2002 to 25% nationally [1]. As care has improved, there have been dramatic decreases in the rates of heart attacks, strokes and end-stage diabetes complications due in large part to improved remote diabetes care [4].

In this paper, we present our experience with the development of the TreC-Diabetes CDS, a platform aiming to create a continuous link between clinicians and patients for supporting the self-management of diabetes. Here, semantic technologies are used for supporting real-time stream reasoning of information provided by patients to detect possible critical situations and to inform clinicians about them.

The remainder of the paper is structured as follows. Section 2 discusses the main work in the literature about CDS for managing diabetes. In Section 3, we present the TreC-Diabetes project, while in Section 4, we show the modules of the architecture we developed. Then, Section 5 discusses how the real-time stream reasoning has been integrated into the system and in Section 6, we reported the lessons we learnt from this experience. Finally, Section 7 concludes the paper.

2 Related Work

Many strategies have been shown in various studies to improve diabetes care, and there is evidence that multiple intervention strategies improve diabetes care more than single intervention strategies [4]. Diabetes CDS systems are generally compatible with and may often be integrated with other concurrent diabetes care improvement strategies such as pre-visit coaching of patients [11], opinion leader and other personalized educational interventions [20], case management [15], use of social media [17], or new and more effective approaches to provider and diabetes patient education [21].

CDS can improve the quality of diabetic care by using reminders and monitoring [14]. In chronic diseases like diabetes, documentation has an important role in disease management. The availability of a population-based registry system can be a solution for the health service providers, and a guidance to strengthen the diabetic CDS. Nonetheless, short and long-term potential benefits of a CDS should be weighed against the costs, because it needs the installation of the software and networking capabilities, which requires planning. Therefore, the effective use of CDS in clinical settings should be combined with changes in work processes such as changes in nursing roles and provision of health care providers to encourage the adoption of CDS in the clinical setting [6].

IT-based interventions along with usual care are associated with glycemic control improvement in diabetic patients. In [12] the authors demonstrated that the usage of CDS to support the management in primary care is feasible and the healthcare team considered it to be useful. A systematic review by [16] showed that information technology-based interventions along with usual care resulted in glycemic control improvement with various efficacy on clinical outcomes in individuals with diabetes. According to the study presented in [19], remote monitoring appears to be a good alternative to current therapy in diabetic care.

To the best of our knowledge, the TreC-Diabetes system is the first flexible system combining the possibility of monitoring both clinical and lifestyle situation of a patient to enable smarter reasoning on his/her data. The long-term objective of the platform is to provide a full-fledged solution for supporting the self-management of diabetes (but not limited to it) and at the same time to improve the lifestyle of patients.

3 The TreC-Diabetes Project

The development of the TreC-Diabetes platform was promoted by the Department of Health and Social Policies of the Autonomous Province of Trento (PAT) in collaboration with the Provincial Health Services Company (APSS) and carried out under the technical and scientific management of the Bruno Kessler Foundation (FBK). TreC-Diabetes is a system to support self-care and to communicate between healthcare professionals and diabetic patients, which APSS intends to use in an experimental phase within an organizational model supported by technology and aimed at improving taking care of the patient suffering from diabetes mellitus in the province. The fundamental principle of the project is based both on the "Plan of the Cronicity" of the Ministry of Health and on the agreement with the Regions, as the latter will have to define and promote new organizational models for the management, even personalized, of the chronicity. In the case of diabetes, personalized management is a systematic process focused on the interaction between doctor and patient, the frequent visualization of therapy results obtained through easily usable digital solutions and the correction of therapy (both pharmacology and non-pharmacology) earlier.

The general aim of the project is to improve the management and communications between operators and patients affected by Type 1 and Type 2 diabetes mellitus through the implementation of an organizational model for taking care of diabetic patients, supported by technology. The adoption of a specific technological platform, whose interface for patients is represented by a mobile application and for clinicians by a web dashboard, becomes the enabling factor to achieve three main study objectives:

- To integrate the TreC-Diabetes platform into the current organizational model.
- To intensify the clinician-patient and prevention relationship, being able to facilitate communication between clinicians and patients through the exchange of objective and subjective data, as well as a system of suggestions to the patient according to an educational and not management logic of emergencies.
- Encourage empowerment and self-management of patients regarding their pathology in everyday life.

4 System Architecture

The platform consists of a set of **Web Modules** composing the dashboard of clinicians and of **Mobile Application Modules** composing the tool available to patients. We provide below the description of each module with a particular emphasis on the knowledge-based component described in Section 5.

4.1 Web Modules (Physicians Dashboard)

Clinicians use a web dashboard that supports the remote supervision of the patient suffering from diabetes. The dashboard consists of several components, in turn composed of a series of functionalities. The dashboard components and their features are described in more detail in the next subsections.

Automatic configuration of patient's mobile application This module support clinicians concerning the manual registration, within the dashboard, of patient's initial profile information. Here, the patient's personal data are collected: information about his/her social status, therapies, history about the presence of complications or not, and lifestyle. The clinician can manually insert also the care plan that the patient can view on his/her mobile application. Such a care plan indicates the list of drugs that the patient must take, the periodic measurements that the patient must take to keep his glycemic index under control, and the schedule and results of laboratory tests that have to be performed periodically. Figure 1 shows the mobile application configuration dashboard.

Display of Reports Clinicians visualize the patient's data through two types of report:

- Periodic reports. With a fixed frequency or personalized according to the patient's clinical needs, clinicians receive reports containing information necessary for performing a clinical evaluation of the patient's health status. Each report contains: profiling data, the results of laboratory tests, a summary questionnaire on the state of recent health, and the data entered manually by the user in the mobile application.
- Extraordinary reports. These reports contain messages related to the patient's ill-management of the pathology and received by e-mail from the clinician. The latter indicates, during the activation of the mobile application, which events to consider for triggering the generation of an extraordinary report.

Figure 2 shows an example of a monitoring report.

Activation of the Interactive Module The Interactive Module (MI) allows the clinicians to view the data entered by the user continuously and for a limited period. During the activation of this module, the clinicians indicate the notifications he/she wants to receive in real-time for the manual data entry by the patient (e.g. hypoglycemia and hyperglycemia events). Upon receipt of these notifications, it is a clinicians' responsibility to contact the patient for ascertaining his/her conditions and, possibly, to provide any indications.

4.2 Mobile Application Modules (Patients)

The support to the self-management of patients and the possibility of sharing collected data with clinicians is performed through a mobile application provided to each patient. The mobile application is a tool to support diabetes management through a set of features activated or not based on the clinicians' decision. This mobile application enables the possibility to act on seven specific areas of self-management (Healthy Eating, Being Active, Monitoring, Taking Medication, Problem Solving, Reducing Risks, Health Coping) as indicated by the American Association of Diabetes Educators (AADE) [1] and, consequently, to develop intervention strategies for promoting patient empowerment.

[1] https://www.diabeteseducator.org/

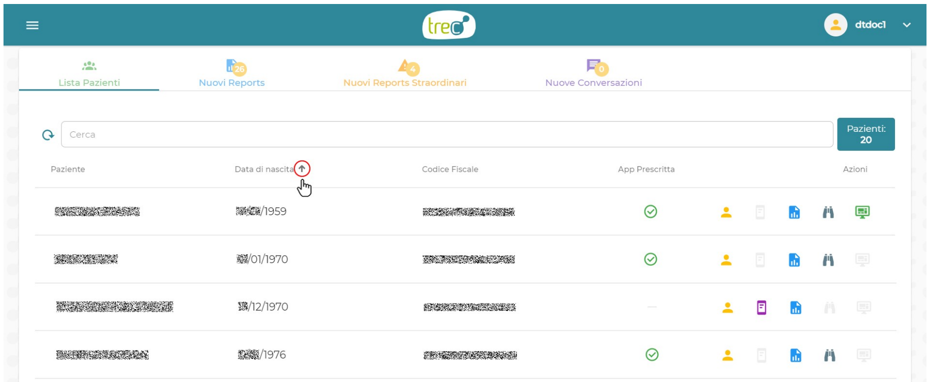

Fig. 1. Internal page displayed after access to the dashboard. The mouse pointer icon shows the reordering mode of the list of patients.

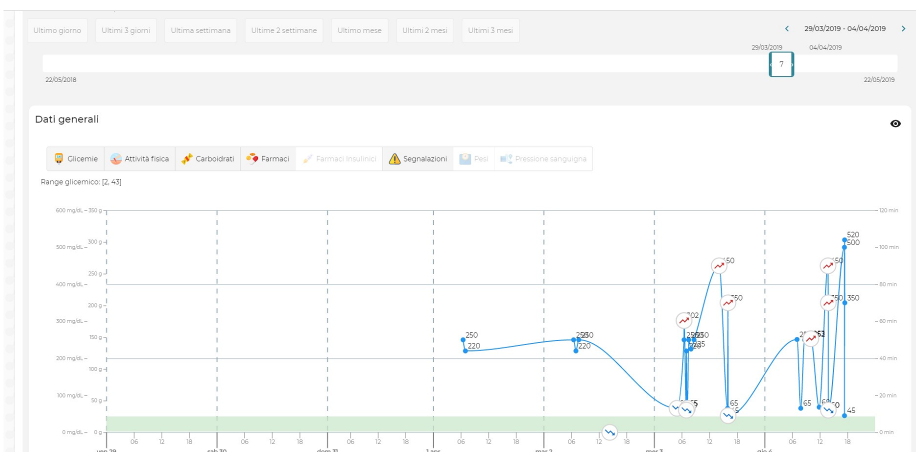

Fig. 2. Example of a graphic time display of data. The clinician can select the type of data he/she wants to see represented. The icon with the eye in the top right corner allows you to hide / display the single graphic.

Log module The Log module is the base of the mobile application since it allows to collect parameters and personal information of the patient through two different modes.

- Manual input of clinical data (such as blood glucose measurements). These parameters, such as weight and pressure, insulin therapy, drugs, and any symptoms, are collected through structured interfaces implemented as diary functionality.
- Manual input of the patient through a dialogue interface. Such input has been foreseen in the interactions between the patient and the chatbot for the profiling of the behaviors related to the specific AADE areas. Profiling consists of identifying the level of health literacy, preparation for change and self-efficacy in each area, to provide the most appropriate personalized intervention.

An example of this module is shown in Figure 3.

Display module This module contains the interfaces of the mobile application supporting the display of data entered in the diary by the user or sent by the system. Data are shown through well-structured representations, i.e. graphics, text messages, and images. An example of this module is shown in Figure 4.

Education module Education is performed through a mobile application in three different ways.

- Contextual educational modules: educational modules that are automatically activated in response to critic patient pathology management events (e.g. when hypoglycemia/hyperglycemia is recorded based on the data entered).
- On-demand educational modules: educational modules that the patient can activate on request to receive information related to the different aspects of diabetic pathology (micro-learning).
- Additional modules: educational modules that the clinician can propose for the patient on specific needs, e.g., the interactive modules developed according to an educational and reflective logic in a "personal experiment" approach, or the carbohydrate count in food.

Custom Feedback module This module deals with the processing of the parameters and the data tracked by the user. Consequently, the system generates personalized feedback based on both the collected data and the user profile. The TreC-Diabetes mobile application provides three types of personalized feedback:

- reminder messages/dialogues about actions suggested to the patient to perform. In particular they are reminders related to the taking of drugs, glycemia measurement, weight, pressure, medical examinations and laboratory tests, according to what is foreseen by the treatment plan set by the clinician when the mobile application is activated;
- personalized messages/dialogues to support the tracking and achievement of goals (specific, measurable, achievable, realistic and time-based);
- motivational messages/dialogues to provide personalized suggestions and information.

Fig. 3. Example of a list of data entered by the patient in the diary (Log module).

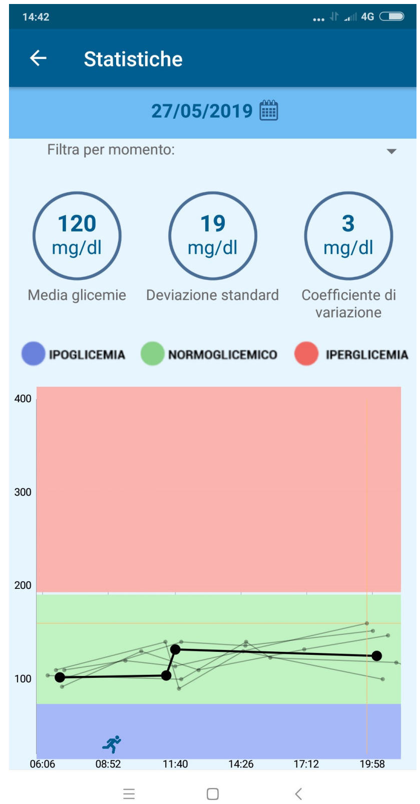

Fig. 4. Example of available statistics for blood glucose values.

Communication The Communication module allows the clinicians to start a chat with the patient. Through this channel the clinicians can get more information on the patient's health status and provide more precise and real-time information. The TreC-Diabetes platform supports also chat groups, moderated by experts, where patients can discuss together particular topics.

5 Reasoning Over Users' Data Streams

The semantic component of the TreC-Diabetes platform is represented by the real-time stream reasoner that is in charge of checking the data provided by patients for a set of rules that clinicians integrated into the system. Rules are described by following the ontological schema described in [8, 2]. The reasoning activity is performed by invoking the API of the HORUS.AI platform [10, 8, 9, 7, 13], a platform developed by the TreC-Diabetes team for other healthcare initiatives that have been re-used in this specific context. We implement reasoning by using RDFPro [5], a tool that allows us to provide out-of-the-box OWL 2 RL reasoning, supporting the fixed point evaluation of `INSERT... WHERE...` SPARQL-like entailment rules that leverage the full expressivity of SPARQL (e.g., `GROUP BY` aggregation, negation via `FILTER NOT EXISTS`, derivation of RDF nodes via `BIND`).

We organize the reasoning in two phases: *offline* and *online*. The *offline* phase consists of one-time processing of the static part of monitoring rules (examples of monitoring rules are reported in Table 1). This is performed to materialize the ontology deductive closure, based on OWL 2 RL and some additional pre-processing rules that identify the most specific types of each rule individual. Whereas, during the *online* phase, each time the reasoning is triggered (e.g., a piece of new information is entered), the user data is merged with the closed ontology and the deductive closure of the rules is computed. This process can be performed either on a per-user basis or globally on the whole knowledge base. The result of this process is a new individual stored back in the knowledge base containing all information about the detected critic situation.

Table 1 shows examples of rules integrated into the TreC-Diabetes platform.

Tags	**Rule (Values or Symptoms**	**Timing**	**Repeat**
Pregnancy	glycemia < 70	WAKEUP OR BEFORE-BREAKFAST	SINGLE
Pregnancy	glycemia > 95	WAKEUP OR BEFORE-BREAKFAST	3-DAYS
Pregnancy	glycemia $<= 50$	NIGHT	SINGLE
Pregnancy	glycemia < 90	NIGHT	2-DAYS
Pregnancy	glycemia > 140	90-MINUTES-AFTER-LUNCH	3-DAYS
Pregnancy	ketones > 4 AND vomit	ALWAYS	SINGLE
Pregnancy	ketones > 4 AND nausea	ALWAYS	SINGLE
Pregnancy	ketones > 4 AND glycemia > 250	ALWAYS	SINGLE
Pediatric, Adult	glycemia < 70	WAKEUP OR BEFORE-BREAKFAST	SINGLE
Pediatric, Adult	glycemia > 200	WAKEUP	3-DAYS
Adult	glycemia > 350	ALWAYS	SINGLE
Pediatric, Adult	glycemia > 300	WAKEUP	SINGLE
Pediatric	vomit	ALWAYS	SINGLE

Table 1. Excerpt of the rules integrated into TreC-Diabetes for supporting the real-time self-management of patients.

The first column contains one or more tags identifying the kind of patients associated with the rule. These tags are the same that can be found within the patients' profiles. The second column contains the parameters that are monitored by the system. Here, we have two kinds of parameters: the glycemic value (expressed in mg/dl) and the symptoms that a patient can hold. Parameters are expressed through simple logic expressions that are processed by the reasoner. The third column contains the timing of a rule, i.e. when a rule has to be evaluated. The timing is expressed using keywords that are processed by the reasoner. Each keyword corresponds to an individual modeled within the back-end knowledge base containing datatype properties describing timestamp information exploited by the reasoning for knowing if the rule has to be verified in a specific moment and which data as to be considered. Finally, the fourth column indicates how many times a rule has to be evaluated. Most of the rules are evaluated at a *SINGLE* stage, i.e. when a new data is provided by a patient, only those data are considered. Instead, other rules, even if violated after a specific event, do not generate a new alert, but they are evaluated again for a certain number of times. For instance, a rule with a *REPEAT* value of *3-DAYS* means that a new alert is generated only if such a rule is violated for three days in a row. As for the timing column, also the keyword contained within the repeat column correspond to individuals of the back-end knowledge base containing datatype properties describing timestamp information about when and how many times the rule has to be evaluated.

6 Lessons Learnt

The TreC-Diabetes experience allowed us to collect several lessons that will drive the improvement of the overall system.

Developing more effective provider and patient interfaces The provider interfaces provide estimates of absolute risk reduction related to potential clinical action in six domains (e.g. blood pressure, lipids, glucose, smoking and BMI). Patient interfaces are even more challenging because of the wide variation in health literacy and numeracy related to culture, education, language and other factors. Such interfaces need much more development and will need to be tailored to the preferences and needs of various patient subgroups. The patient interfaces were designed for low-literacy and low-numeracy patients and some providers give the provider interface to selected patients. A reasonable option may be to display CDS in various formats to meet the needs of a broad spectrum of patients and providers with very different learning styles and literacy.

Moving from disease-centered to patient-centered CDS At many primary care encounters, diabetes is only one of many chronic or acute problems that need to be addressed. In the primary care world, it will not be feasible to have a CDS system for each of the many chronic diseases or clinical domains. Rather, the goal is necessary to create a patient-centered CDS system that identifies, for each patient at a given point in time, all the evidence-based actions that may be of benefit. Thus, some sort of prioritization function is necessary to streamline the process and keep provider and patient attention focused on actions with the greatest potential benefit to the patient. Patients with diabetes may also benefit from better identification and management of comorbid conditions such as depression, heart failure, coronary heart disease, arthritis and lung disease. What is not apparent is how to accomplish accurate prioritization across multiple clinical domains.

Incorporating patient-reported data and data from wireless devices into CDS systems CDS algorithms now incorporate lab tests, vital signs, allergies, current treatment, comorbidities, distance from goal and clinical state, as well as other EHR data. However, most do not yet incorporate patient-reported data (e.g. symptoms of hypoglycemia, screening questions for depression) or data that are collected outside the encounter and can be transmitted wirelessly to the EHR or an associated website. The addition of such data, including data on physical activity from wearable devices or self-reported dietary intake, could considerably expand the scope of diabetes-related CDS systems. For example, home glucose data could be processed through algorithms that suggest specific insulin adjustments in response to certain glucose test patterns or the cardiovascular benefits of lifestyle changes such as more physical activity could be compared with the benefits of certain pharmacological interventions to reduce cardiovascular risk. In settings with access to pharmacy fill data, assessment of medication adherence may also be possible and further enhance the ability of providers and patients to make informed decisions about medication management.

Expanding the applications of CDS technology Evidence-based algorithms that operate within CDS systems can be modified rapidly in response to advances in knowledge, new consensus guideline recommendations, or the introduction or removal of drugs from the care-path. This is a major paradigm shift in clinical care. Advances in secure communication of data between EHRs and websites open up new possibilities for large-scale and efficient regional or national approaches to CDS, provided large numbers of providers and care systems can agree on the content of treatment algorithms.

An exciting future application of EHR-linked CDS is to create a map of care quality at the provider level by mapping the clinical decision space for diabetes care in previous work to clinics or individual data that can be ranked alongside their peers, such as the percentage of patients with uncontrolled diabetes with an insulin start; timely intensification of lipid, glucose or blood pressure medications.

7 Conclusions

In this paper, we presented the TreC-Diabetes platform, a system designed for supporting (i) the self-management of patients suffering from diabetes, (ii) their real-time health status, and (iii) the work of clinicians for controlling them remotely. The components of the deployed platform have been described with a focus on the real-time stream reasoning component that is in charge of detecting critic situations. Finally, lessons learnt from our experience have been reported to highlight the main aspects that will drive the technological improvement of the platform.

References

1. Ali, M.K., Bullard, K.M., Saaddine, J.B., Cowie, C.C., Imperatore, G., Gregg, E.W.: Achievement of goals in us diabetes care, 1999–2010. New England Journal of Medicine **368**(17), 1613–1624 (2013)
2. Bailoni, T., Dragoni, M., Eccher, C., Guerini, M., Maimone, R.: Healthy lifestyle support: The perkapp ontology. In: Dragoni, M., Poveda-Villalón, M., Jiménez-Ruiz, E. (eds.) OWL: - Experiences and Directions - Reasoner Evaluation - 13th International Workshop, OWLED 2016, and 5th International Workshop, ORE 2016, Bologna, Italy, November 20, 2016, Revised Selected Papers. Lecture Notes in Computer Science, vol. 10161, pp. 15–23. Springer (2016). https://doi.org/10.1007/978-3-319-54627-8_2, https://doi.org/10.1007/978-3-319-54627-8_2
3. Berner, E.S.: Clinical decision support systems: state of the art. AHRQ publication **90069** (2009)

4. Bodenheimer, T., Wagner, E.H., Grumbach, K.: Improving primary care for patients with chronic illness: the chronic care model, part 2. Jama **288**(15), 1909–1914 (2002)
5. Corcoglioniti, F., Rospocher, M., Mostarda, M., Amadori, M.: Processing billions of RDF triples on a single machine using streaming and sorting. In: SAC. pp. 368–375. ACM (2015)
6. Crosson, J.C., Ohman-Strickland, P.A., Cohen, D.J., Clark, E.C., Crabtree, B.F.: Typical electronic health record use in primary care practices and the quality of diabetes care. The Annals of Family Medicine **10**(3), 221–227 (2012)
7. Dragoni, M., Bailoni, T., Eccher, C., Guerini, M., Maimone, R.: A semantic-enabled platform for supporting healthy lifestyles. In: Seffah, A., Penzenstadler, B., Alves, C., Peng, X. (eds.) Proceedings of the Symposium on Applied Computing, SAC 2017, Marrakech, Morocco, April 3-7, 2017. pp. 315–322. ACM (2017). https://doi.org/10.1145/3019612.3019835, https://doi.org/10.1145/3019612.3019835
8. Dragoni, M., Bailoni, T., Maimone, R., Eccher, C.: Helis: An ontology for supporting healthy lifestyles. In: Vrandecic, D., Bontcheva, K., Suárez-Figueroa, M.C., Presutti, V., Celino, I., Sabou, M., Kaffee, L., Simperl, E. (eds.) The Semantic Web - ISWC 2018 - 17th International Semantic Web Conference, Monterey, CA, USA, October 8-12, 2018, Proceedings, Part II. Lecture Notes in Computer Science, vol. 11137, pp. 53–69. Springer (2018). https://doi.org/10.1007/978-3-030-00668-6_4, https://doi.org/10.1007/978-3-030-00668-6_4
9. Dragoni, M., Bailoni, T., Maimone, R., Marchesoni, M., Eccher, C.: HORUS.AI - A knowledge-based solution supporting health persuasive self-monitoring. In: van Erp, M., Atre, M., López, V., Srinivas, K., Fortuna, C. (eds.) Proceedings of the ISWC 2018 Posters & Demonstrations, Industry and Blue Sky Ideas Tracks co-located with 17th International Semantic Web Conference (ISWC 2018), Monterey, USA, October 8th - to - 12th, 2018. CEUR Workshop Proceedings, vol. 2180. CEUR-WS.org (2018), http://ceur-ws.org/Vol-2180/paper-14.pdf
10. Dragoni, M., Rospocher, M., Bailoni, T., Maimone, R., Eccher, C.: Semantic technologies for healthy lifestyle monitoring. In: International Semantic Web Conference (2). Lecture Notes in Computer Science, vol. 11137, pp. 307–324. Springer (2018)
11. Greenfield, S., Kaplan, S., Ware Jr, J., Yano, E., Frank, H.: Patients participation in medical care: Effects on blood sugar control and quality of life in diabetes. Journal of General Internal Medicine **3**, 448–457 (1988)
12. Maia, J.X., de Sousa, L.A.P., Marcolino, M.S., Cardoso, C.S., da Silva, J.L.P., Alkmim, M.B.M., Ribeiro, A.L.P.: The impact of a clinical decision support system in diabetes primary care patients in a developing country. Diabetes technology & therapeutics **18**(4), 258–263 (2016)
13. Maimone, R., Guerini, M., Dragoni, M., Bailoni, T., Eccher, C.: Perkapp: A general purpose persuasion architecture for healthy lifestyles. Journal of Biomedical Informatics **82**, 70–87 (2018). https://doi.org/10.1016/j.jbi.2018.04.010, https://doi.org/10.1016/j.jbi.2018.04.010
14. McGlynn, E.A., Asch, S.M., Adams, J., Keesey, J., Hicks, J., DeCristofaro, A., Kerr, E.A.: The quality of health care delivered to adults in the united states. New England journal of medicine **348**(26), 2635–2645 (2003)
15. Norris, S.L., Nichols, P.J., Caspersen, C.J., Glasgow, R.E., Engelgau, M.M., Jack Jr, L., Isham, G., Snyder, S.R., Carande-Kulis, V.G., Garfield, S., et al.: The effectiveness of disease and case management for people with diabetes: a systematic review. American journal of preventive medicine **22**(4), 15–38 (2002)
16. Riazi, H., Larijani, B., Langarizadeh, M., Shahmoradi, L.: Managing diabetes mellitus using information technology: a systematic review. Journal of Diabetes & Metabolic Disorders **14**(1), 49 (2015)
17. Ronda, M.C., Dijkhorst-Oei, L.T., Rutten, G.E.: Patients experiences with and attitudes towards a diabetes patient web portal. PloS one **10**(6), e0129403 (2015)

18. Roshanov, P.S., Fernandes, N., Wilczynski, J.M., Hemens, B.J., You, J.J., Handler, S.M., Nieuwlaat, R., Souza, N.M., Beyene, J., Van Spall, H.G., et al.: Features of effective computerised clinical decision support systems: meta-regression of 162 randomised trials. Bmj **346**, f657 (2013)
19. Siriwardena, L.N., Wickramasinghe, W.S., Perera, K.D., Marasinghe, R.B., Katulanda, P., Hewapathirana, R.: A review of telemedicine interventions in diabetes care. Journal of telemedicine and telecare **18**(3), 164–168 (2012)
20. Smith, D.H., Kramer, J.M., Perrin, N., Platt, R., Roblin, D.W., Lane, K., Goodman, M., Nelson, W.W., Yang, X., Soumerai, S.B.: A randomized trial of direct-to-patient communication to enhance adherence to β-blocker therapy following myocardial infarction. Archives of internal medicine **168**(5), 477–483 (2008)
21. Sperl-Hillen, J., OConnor, P.J., Ekstrom, M.H.L., Rush, W.A., Asche, M.S.E., Fernandes, M.O.D., Apana, M.D., Amundson, M.G.H., Johnson, P.E., Curran, M.D.M.: Educating resident physicians using virtual case-based simulation improves diabetes management: a randomized controlled trial. Academic medicine: journal of the Association of American Medical Colleges **89**(12), 1664 (2014)
22. Thomas, J.C., Moore, A., Qualls, P.E.: The effect on cost of medical care for patients treated with an automated clinical audit system. Journal of medical systems **7**(3), 307–313 (1983)