EJBI 2014 ISSN 1801 - 5603

European Journal for Biomedical Informatics

Volume 10 (2014), Issue 2

Special Topic

Using Information to Improve the Quality of Care in Type 2 Diabetes in Primary Care

Editor

Štěpán Svačina

An Official Journal of the European Federation for Medical Informatics

www.ejbi.eu

Aims and Scope

The **European Journal for Biomedical Informatics** reacts on the great European need to share the information in the multilingual and multicultural European area. The journal publishes peer-reviewed papers in English and other European languages simultaneously. This opens new possibilities for faster transfer of scientific-research pieces of knowledge to large international community of biomedical researchers, physicians, other health personnel and citizens. From time to time, the journal publishes articles on particular focus themes as part of a journal's issue.

The generally accepted translations of the English version of the abstract and keywords or full paper are to the European languages, which can be found at `http://www.ejbi.org/en/about/`.

Publisher

EuroMISE s.r.o.
Paprsková 330/15
CZ-14000 Praha 4
Czech Republic
EU VAT ID: CZ25666011

Office

EuroMISE s.r.o.
Paprsková 330/15
CZ-14000 Praha 4
Czech Republic

Contact

Karel Zvára
zvara@euromise.com

Instructions to Authors

Please access http://www.ejbi.org/en/instructions/

EJBI Online

The online version of the full volume is available at http://www.ejbi.org/en/ejbi/.

Instructions to Authors

General Remarks

This journal follows the guidelines of the International Committee of Medical Journal Editors (http://www.icmje.org/index.html) and the Committee on Publication Ethics (http://www.publicationethics.org).

Authors should especially be aware of the following relevant issues in these guidelines:

Authorship

All authors should have made

(1) substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data;

(2) drafting the article or revising it critically for important intellectual content; and

(3) final approval of the version to be published.

Conflicts of interest

All authors must disclose any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their actions.

Protection of human subjects and animals in research

Authors who submit a manuscript on research involving human subjects should indicate in the manuscript whether the procedures followed were in compliance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the World Medical Association Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects (http://www.wma.net/en/30publications/10policies/b3/).

European Journal for Biomedical Informatics does not publish material that has already appeared elsewhere. Submitted manuscripts should not be submitted in parallel to any other journal.

Manuscript preparation

Authors are kindly requested to carefully follow all instructions on how to write a paper. In cases where the instructions are not followed, the paper will be returned immediately with a request for changes, and the editorial review process will only start when the paper has been resubmitted in the correct style.

Authors are responsible for obtaining permission to reproduce any copyrighted material and this permission should be acknowledged in the paper.

Authors should not use the names of patients. Patients should not be recognizable from photographs unless their written permission has first been obtained. This permission should be acknowledged in the paper.

In general the manuscript text (excluding summary, references, figures, and tables) should not exceed 5 000 words.

Kindly send the final and checked source and PDF files of your paper to `manuscripts@ejbi.org`. You should make sure that the LaTeX and the PDF files are identical and correct and that only one version of your paper is sent. Please note that we do not need the printed paper.

Where appropriate, the paper should be organised into the following sections: *Abstract, Introduction, Objectives, Methods, Results, Discussion, Conclusions, Acknowledgments and References.* Apart from the main headings, subheadings should be used and may be numbered.

Authors are strongly encouraged to use LaTeX 2_ε for the preparation of manuscript. The LaTeX template `ejbi_template.tex` can be downloaded from www.ejbi.org/en/instructions/.

When you are not able to use LaTeX, please use MS Word or OO Writer and send us the unformatted text. Kindly follow just instructions about preparing figures, tables and references. We are going to convert your text into LaTeX instead of you.

If you use LaTeX together with our template file, `ejbi_template.tex`, your text is typeset automatically. Please do *not* change the preset fonts. Do not use your own macros, or styles.

Please use the commands `\label` and `\ref` for cross-references and the commands `\bibitem` and `\cite` for references to the bibliography, to enable us to create hyperlinks at these places.

Title page

The first page of the article should contain: title of the paper (also the shorter version for running heads), initials and last name of each author, to be followed with their institutional affiliations, the name, address, e-mail address and telephone of the corresponding author.

Abstract and Keywords

The abstract should summarize the contents of the paper and should not exceed 250 words. Authors are requested to write a structured summary, adhering to the following headings: Background (optional), Objectives, Methods, Results, Conclusions.

At the end of the Abstract, the contents of the paper should be specified by, at most, five keywords. We recommend using MeSH keywords.

Headings

Headings should be capitalized (i.e. nouns, verbs, and all other words except articles, prepositions, and conjunctions should be set with an initial capital) and should be aligned to the left. Words joined by a hyphen are subject to a special rule. If the first word can stand alone, the second word should be capitalized.

Figures and Tables

Attach figures and tables as separate files. Do not integrate them into the text. Do not save your table as an image file or insert a table into your manuscript text document as an image. Figures and tables should be referenced in the manuscript by their numbers.

Annotations belong in a (self-)explanatory legend, do not use headings in the figure, explain abbreviations in the legend. Label all axes. Use a uniform type size (we recommend Arial 10 point), and avoid borders around tables and figures.

Submit graphics as a sharp printout as well as a file. The printout and the file must be identical. Submit the image file with clear labelling (e.g. Fig_1 instead of joint_ap).

Image resolution is the number of dots per width of 1 inch, the "dots per inch" (dpi). Printing images require a resolution of 800 dpi for graphics and 300 dpi for photographics.

Vector graphics have no resolution problems. Some programs produce images not with a limited number of dots but as a vector graphic. Vectorisation eliminates the problem of resolution. However, if halftone images ("photos") are copied into such a program, these images retain their low resolution.

If screenshots are necessary, please make sure that you are happy with the print quality before you send the files.

In the printed volumes, illustrations are generally black and white (halftones), and only in exceptional cases, and if the author is prepared to cover the extra cost for colour reproduction, are coloured pictures accepted. Coloured pictures are welcome in the electronic version free of charge. If you send coloured figures that are to be printed in black and white, please make sure that they really are legible in black and white. Some colours as well as the contrast of converted colours show up very poorly when printed in black and white.

Formulas

Displayed equations or formulas are centred and set on a separate line (with an extra line or halfline space above and below). Displayed expressions should be numbered for reference. The numbers should be consecutive within each section or within the contribution, with numbers enclosed in parentheses and set on the right margin.

Footnotes

The superscript numeral used to refer to a footnote appears in the text either directly after the word to be discussed or – in relation to a phrase or a sentence – following the punctuation sign (comma, semicolon, or period). Footnotes should appear at the bottom of the normal text area, with a line of about 2 cm set immediately above them.[1]

Program Code

Program listings or program commands in the text are normally set in a typewriter font, e.g. CMTT10 or Courier.

Acknowledgements

Scientific advice, technical assistance, and credit for financial support and materials may be grouped in a section headed Acknowledgements that will appear at the end of the text (immediately after the Conclusions section). The heading should be treated as a subsubsection heading and should not be assigned a number.

In case that a financial support of the paper development (e.g. sponsors, projects) is acknowledged, the fee of 50 EUR will be charged by Publisher. The accepted peer-reviewed papers with an acknowledgement of a financial support, where the fee was not paid, will be published free of charge, but the financial acknowledgement will be withdrawn.

References

The list of references is headed "References" and is not assigned a number. The list should be set in small print and placed at the end of your contribution, in front of the appendix, if one exists. Please do not insert a pagebreak before the list of references if the page is not completely filled. For citations in the text please use square brackets. In the text number the references consecutively in the order in which they first appear. Use the style, which is based on the formats used by the US National Library of Medicine in MEDLINE (sometimes called the "Vancouver style"). For details see the guidelines from the International Committee of Medical Journal Editors (http://www.nlm.nih.gov/bsd/uniform_requirements.html).

Examples:

[1] Schwartze J, HaarbrandtB, Fortmeier D, Haux R, Seidel C. Authentification systems for securing clinical documentation workflows. Methods Inf Med 2014; 53 (1):3-13.

[2] Kalina J, Seidl L, Zvára K, Grünfeldová H, Slovák D, Zvárová J. Selecting relevant information for medical decision support with application in cardiology. European Journal for Biomedical Informatics 2013; 9 (1): 2-6. Available from: http://www.ejbi.org/img/ejbi/2013/1/Kalina_en.pdf

[3] Hasman A, Blobel B, Zvárová J, editors. Data and Knowledge for Medical Decision Support. Amsterdam: IOS Press; 2013.

[1] The footnote numeral is set flush left and the text follows with the usual word spacing.

Multilingual Issue

The authors are asked to translate English version of Abstract and Keywords to at least one European languege. The translated versions of Abstract and Keywords should be send to `manuscripts@ejbi.org`

Checking the PDF File

Kindly assure that the Contact Volume Editor is given the name and email address of the contact author for your paper. The contact author is asked to check through the final PDF files to make sure that no errors have crept in during the transfer or preparation of the files. Only errors introduced during the preparation of the files will be corrected.

If we do not receive a reply from a particular contact author, within the timeframe given, then it is presumed that the author has found no errors in the paper.

Copyright Transfer Agreement

The copyright form may be downloaded from http://www.ejbi.org/en/downloads/. Please send your signed copyright form to the Contact Volume Editor, either as a scanned pdf or by fax or by courier. One author may sign on behalf of all the other authors of a particular paper. Digital signatures are acceptable.

EuroMISE Copyright Permission Policy

Written permission is required to reproduce material from EuroMISE s.r.o. publications in other publications, electronic products, or other media. To obtain a copyright permission please contact Jana Zvárová: zvarova@ejbi.org, fax: +420 241471337. You may fax or e-mail your request along with the full citation of the journal in which the paper appears in with volume number and page number(s) as well as what you are requesting to use the material for. Use of copyrighted material always requires proper citation.

Creative Commons Attribution-NonCommercial-NoDerivs (CC-BY-NC-ND): for non-commercial purposes, lets others distribute and copy the article, and to include in a collective work (such as an anthology), as long as credit the author(s) and provided they do not alter or modify the article.

Contents

Using Information to Improve the Quality of Care in Type 2 Diabetes in Primary Care

Štěpán Svačina[1]

[1] 3rd Medical Department of General University Hospital and Charles University -1st Medical faculty, Prague, The Czech Republic

Dear reader,

You are opening the special topic issue "Using Information to Improve the Quality of Care in Type 2 Diabetes in Primary Care" of the European Journal for Biomedical Informatics. This issue contains the contributions presented at the workshop organized on the occasion of the European Federation of Medical Informatics special topic conference (STC) "Data and Knowledge for Medical Decision Support" held in Prague, Czech Republic, on April 16th 2013.

The WS3 workshop entitled "Using Information to Improve the Quality of Care in Type 2 Diabetes in Primary Care" was organized by EFMI Working group PCI - Primary Care Informatics, by 1st Faculty of Medicine of Charles University in Prague and by The Society of General Practice of Czech Medical Association J. E. Purkyně. The workshop was chaired by me and by prof. Simon de Luisignan from Great Britain.

In case of diabetes the quantitative and technological support is of great importance. First mathematical models in diabetology had been used in 1950s. 20 years later the information systems to support the clinical care for diabetic patiens were used and simultaneously first consultation and expert systems for diabetes diagnostics and treatment were proposed. During last 30 years many technologies to support care for diabetes have been introduced, e.g. blood glucose monitoring systems , insulin delivery pumps, imaging technologies for diabetic retinopathy, close loop systems for diabetes treatment. To cover all these topics the annual conferences "Computers in diabetes" on the occasion of European Diabetes Society Congress were organized up to the end of 1990s.

Today most activities in this field are organized by the Diabetes Technology Society. It is a nonprofit organization committed to promoting development and use of technology in the fight against diabetes. It was established in 2001 by David C. Klonoff, Professor of Medicine at University of California, San Francisco. Annual meetings are organized by the society - this year in Bethesda, USA. European activities are also organized by this society, e.g. Certified European Diabetes Technician course in Copenhagen this year.

Many articles in the field of medical informatics are published in the important Journal of Diabetes Science and Technology. It is a bi-monthly, peer-reviewed scientific journal published by the Diabetes Technology Society, which covers all aspects of diabetes technology including glucose monitoring; insulin and metabolic peptide delivery; the artificial and bioartificial pancreas, telemedicine; software for modeling; physiologic monitoring; technology for managing obesity; diagnostic tests of glycation; and the use of bioengineered tools, new biomaterials, and nanotechnology to develop new sensors to be applied to diabetes. Articles cover both basic research and clinical applications of technologies being developed to help people with diabetes. First issue was published in January 2007.

Computers and technologies have been moving from special centers and clinics to the offices of General Practitioners. Therefore we have chosen this theme for the Prague Workshop and for this special issue of EJBI. Presenters have sent the majority of presented lectures to this issue and so I hope you will enjoy this very interesting part of Biomedical Informatics.

Pharmacoeconomy of Diabetes Mellitus and its Implications for Organization and Quality of the Care in the Czech Republic

Pavel Horák[1], **Milan Kvapil**[2]

[1] 3rd Dept. of Internal Medicine, 1st Medical Faculty, Charles University, Prague

[2] Dept. of Internal Medicine, 2nd Medical Faculty, Charles University, Prague

Abstract

Introduction: Organization of the care is important factor for success, cost effectiveness and quality of the care for large scale chronic diseases such as diabetes mellitus. Valid data are needed for decision support.
Aim: To calculate real prevalence of diabetes in the population from incomplete data sources originally created for billing to the insurance company, to establish how these patients are treated and collect markers of quality of the care.
Methods: In data sources diabetic patients were identified by combining diagnoses from coded procedures with data about medical prescription and procedures directly linked to diabetes.
Results: 6% increase in real incidence rate of diabetes mellitus patients since 2002 was observed as well as 23% (2003-2009) decrease in mortality rate (50% decrease between 1980 to 2009). Data also show not only higher average expenses for treatment of patients with diabetes mellitus compared to average expenses incurred for treatments of all other diagnoses, but also a crucial relationship of costs with presence or absence of diabetes mellitus complications.
Conclusion: Study overcame disadvantage of data sources which would otherwise lead to underestimation of numbers of diabetic patients. Our analysis bring additional information and showed possible financial impact for the future, if problem with prevention, regional differences in the care and incomplete adherence to guidelines will not be properly addressed.

Keywords

Diabetes mellitus, pharmacoeconomy, quality of the care, organization of the care

Correspondence to:

Pavel Horák
3rd Dept. of Internal Medicine, 1st Medical Faculty,
Charles University, Prague
Address: U Nemocnice 2, Prague 2, Czech Republic
E–mail: Pavel.Horak@vfn.cz

EJBI 2014; 10(2):2–7
received: September 23, 2013
accepted: December 10, 2013
published: March 31, 2014

1 Introduction

From 8 to 10 percent population in developed countries suffer from diabetes mellitus. Illness tied together with ample nutrition, sedentary lifestyle, stress of any kind, civilization habits and of course to genome of population. Diabetes presents not only burden for rich developed countries, but it spreads all over the globe, to developing countries with very large groups of very poor people included. There, diabetes is also on the surge because of eating habits imported from the developed world. Much more financially vulnerable health care systems in those countries thus also face serious threat of financial devastation.

But the same is true for health care systems in developed countries. In those countries sophisticated medicines and treatment options are used. As an example we frequently transplant kidneys to diabetics and this diagnosis presents number one indication for this costly procedure. Human insulin's are used for substitution of insulin deficiency and to overcome insulin resistance and thanks to that, our patients live longer. Despite the fact, that diabetes is still shortening the life of the patient, this all means tens of years of expensive care. Increase of incidence and from better treatment resulting increasing prevalence of diabetes pose major challenge to the financial stability and sustainability of health care systems of developed countries with their universal coverage and equal access to the up to date care for all patients as well. Costs to treat average uncomplicated diabetic patient are two times higher compare to average non healthy patient with non diabetic diagnoses. What is important, for diabetic patients with complications (renal failure is to be mentioned on the first place) costs are ten times higher than average.

It has to be added, that also cooperation with diabetic patients may be far from ideal. To change their eating habits, to correct obesity, to achieve regular self administration of treatments (especially in young patients), this all in illness which does not ache and which usually does not present an imminent threat to the patient life is difficult and we are not always successful in it.

Also health care system has its substantial reserves in organization of the care for chronic patients. Many patients do not know about their condition up to the moment when first complication arrives. Education targeted both to groups at risk and to the wide population, comprehensive prevention and screening programs, this all can bring patients in time to the appropriate care. Early enough either to prevent occurrence of illness or at least to delay its onset or prevent major complications. Efficient coordinated care can prevent occurrence of costly episodes which not only endanger and shorten patient life, but also challenge availability of adequate resources to treat all diabetic and non diabetic patients in the society. Good data analysis is very important and helpful tool for those who organize care at the national level.

2 Experience in the Czech Republic

National Health Service of former regime in the Czech Republic twenty years ago required mandatory registration and follow up of diabetic patients. Care for them and also for other patients with diseases perceived to be threat to the national health was hierarchically organized with gate keeping primary care physicians which referred patients to the specialists. Because of growing number of patients, new medical specialty was created, and as a result of this, until present, diabetologists are in the Czech Republic taken care of diabetics and not endocrinologists like in most, maybe all other countries.

Nowadays liberally organized health care system exists in our country. There is no gate keeping role of primary care physicians, those are often used to refer all, or most diabetic patients to the diabetologists, because they are afraid of expenses and higher intensity of care. Patients have free access to all physicians. They can choose almost any care giver they want. But in the outpatient sector most care givers are self employed fee for service reimbursed private physicians. From obvious reasons this leads to duplicate and unnecessary care which wastes resources. But there are also patients who seek care unsuccessfully or decide to be a “no show”. This presents high risk of complications of diabetes in years to come and also more frequent hospitalizations because of emergences resulting from poor compensation of the illness. From the organizer of care point of view, it is very difficult to get good data about incidence and prevalence of diabetes and data about treatments, utilization of resources and quality and outcomes of the care for diabetics. This is a chance for medical informatics and up to date means of getting and analyzing data in order to improve the quality of the care.

3 Data collection and analysis

3.1 Aim of the Study

- To detect as many diabetics as is possible in population of largest medical insurance company (VZP - with more than 6 millions insured from total of 10 million population of the Czech Republic) and make good extrapolation of total numbers of diabetics in the country.
- To establish how and by whom these patients are treated and collect as many as possible markers of quality of the care.
- To present results obtained to the medical societies and to the Ministry of the Health with hope that appropriate measures to increase quality and organization of the care will be discussed and adopted.

3.2 Data collection

Data of the largest insurer in the Czech Republic VZP (General Health Insurance Company) were used. We were aware of some important challenges we had to meet:

- Primary care physicians in the Czech republic are paid by capitation and are not required to report individual services rendered (and also diagnoses) of the patient to the insurance company. To detect diabetics among their patients we had to use information about medical prescriptions in their offices (insulin, medical devices, pumps, strips, oral antidiabetic agents) and specialized services ordered - laboratory tests – glycosylated hemoglobin, referrals to the diabetologists which contain diagnosis, etc.)
- Specialist, if they diagnose or treat the patient, have to report service and diagnosis, but often are used to report diagnosis related to their specialty and not other diagnoses. For example nephrologists treating diabetic patients with chronic renal failure would for billing to the insurance company rather use this diagnosis and not diagnosis of diabetes. The same will be true for specialized services ordered (e.g. some functional test or CT, NMR studies). Similarly, cardiologist treating chest pain would probably for billing of stress test use diagnosis of angina pectoris and not diabetes.

- Hospitals because being paid by DRG (Diagnoses Related Groups), where diabetes is a condition usually having beneficial impact on reimbursements, have tendency to over report this diagnosis (for example if higher blood glucose is found at admission of acute patient, which can be caused by many other reasons then diabetes). Diabetes is also a frequent diagnosis, its code know all physicians by heart, so it is simpler and easy to use this diagnosis for reporting instead for looking for the more appropriate in the manual.

- Data from one year are clearly insufficient. There are patients who do not visit physician during the one calendar year period (or they visit only GP for small checkup which is not reported to the insurance company). To identify patients with diabetes we search databases from all years and we pick individuals with clear marker of this diagnosis – diagnosis reported by diabetologist, repeated reporting of this diagnosis by others, specific treatments, tests, medical devices, procedures with clear association with diabetes and after that, complete dataset of these patients (the whole account from insurer) from all years searched, was used for further analysis (Figure 1).

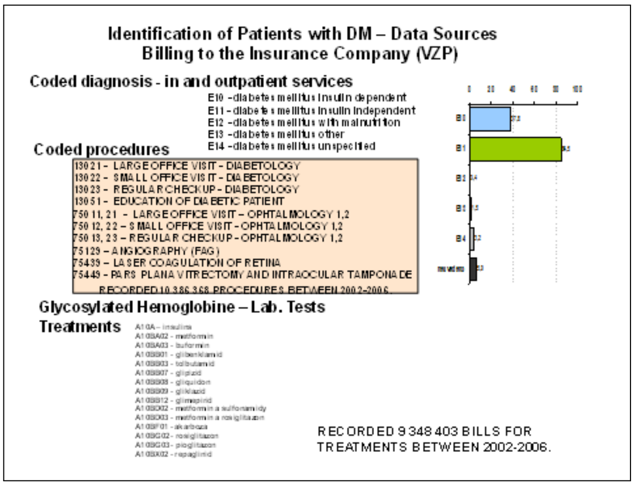

Figure 1: Diagnoses, procedures, treatments used to detect patients with diabetes.

On Figure 2 input of different medical specialties used to identify patients with diabetes. No other data from other specialties were used.

On Figure 3 overview of all possible combination of markers of diabetes (in individual patients) used in the study is given.

Picture shows, that all used flags for diabetes displayed 44.5% of patients (of course there are also patients who do not receive therapy yet, so it was impossible to achieve this in all patients) and for example, that 2.5% diabetics were identified only by therapy (probably those only treated by primary care physicians).

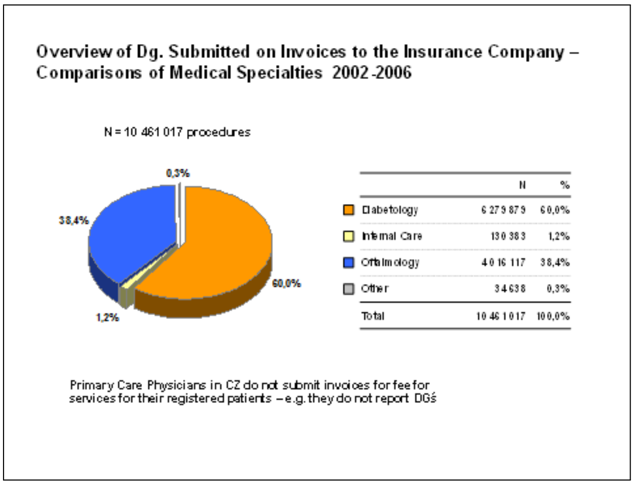

Figure 2: Presence of dg. diabetes mellitus on invoices to the insurance company – comparison of different specialties.

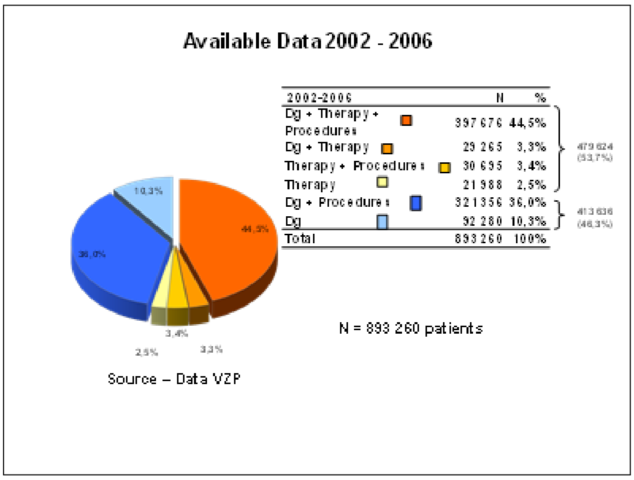

Figure 3: Overview about how patients with diabetes were detected.

4 Results

Table 1 shows number of patients detected to be diabetic and calculated percentages of diabetic patients in the population.

For patients collected during the study, their medical accounts at the insurance company were analyzed. Costs for medicines (insulin, peroral antidiabetic drugs separately), for medical devices (prescribed in outpatient setting and used during hospitalization, if they are separately billed to the insurance company) and fees for medical services were recorded. Only costs directly linked to the diabetes and its complications were included. Drugs, services, medical devices used for other purposes or in the primary care were not included. Results are displayed in Figure 4.

Results clearly show rise in direct costs between 2000 to 2007, from 1.5 billion Czech Crowns (CZK) which corresponds approximately to 75 mil. US dollars (USD), to 2.5 billion CZK (125 mil. USD). This is 66% increase (9.4% annually, which is approximately double the rate

Table 1: Number of diabetics in the Czech Republic 2002-2007.

Year	2002	2003	2004	2005	2006	2007
Total of insured in mil	6.96	6.85	6.73	6.65	6.56	6.53
Dg. of DM coded (a)	494 249	485 761	484 566	483 888	485 100	492 960
Dg, Th, procedures (all flags for DM) coded (b)	618 011	606 090	599 006	591 025	582 120	-
Percentage of DM (a)	7.1	7.08	7.2	7.27	7.39	7.54
Percentage of DM (b)	8.88	8.84	8.90	8.88	8.87	-

of the increase in overall health care costs in the Czech Republic)

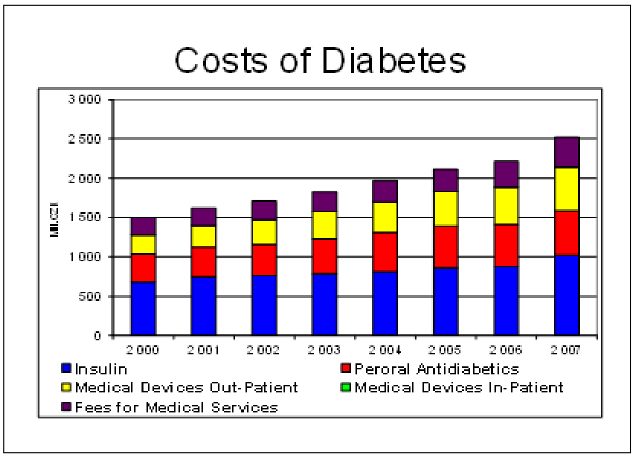

Figure 4: Direct costs of diabetes in the Czech Republic between 2000-2007.

On the Figure 5 all cost to treat diabetic patients were recorded. To this comparison, all expenses, which are attributable to the individual patient with diabetes were used.

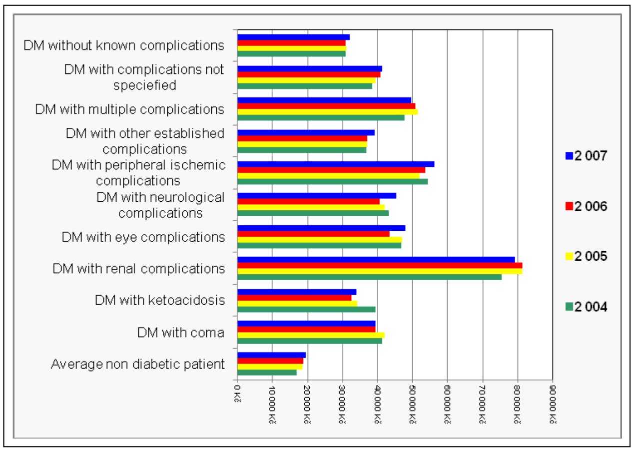

Figure 5: All costs to treat patients with diabetes 2004 - 2007.

Data show, that even without detected complications, patients with diabetes are 2times more costly to treat, than average non diabetic patient (healthy patients without any treatments and costs – except for prevention, immunizations etc. were excluded from the calculations). Patients with renal complications of diabetes are 4 times more expensive and those from them treated with hemodialysis more than 10 times. For comparison to other countries average cost for hemodialysis in the Czech republic is 370 580 CZK/year (approx. 18 500 USD/year) and average total cost for the patient in the hemodialysis program is 673 300 CZK/year (33 600 USD/year).

To know more about how the system works, it was interesting for us to know how many patients are treated resp. how many visits are done by specialists –diabetologists (Figure 6). We found, that this percentage is relatively stable, ranging from 68 to 71%.

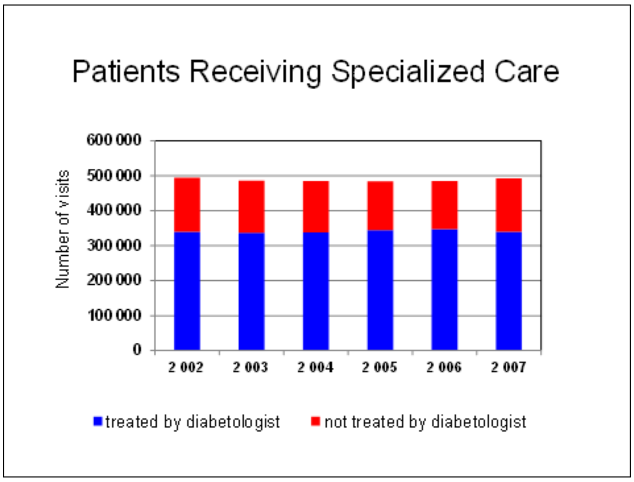

Figure 6: Visits to diabetologists and to other physicians – patients with diabetes.

One of markers of quality of the care we used was a number of patients who get glycosylated hemoglobin test according to the guidelines [1]. It should be once a year, but of course not calendar year is in question but test should be performed in approximately each 12 months period. When interpreting results depicted in Figure 7 this has to be taken into account. Another aspect analyzed were regional differences in this value, this is shown in Figure 8. Results are important inputs to medical societies and to responsible bodies of organizers and payers of the care.

If we look for trends, number of tests is slightly increasing over the years. But still it is a substantial number of patients who do not get it and on the other hand there are many patients where this test was administered repeatedly. Not surprisingly the highest utilization of services is in the capital city of Prague and in the more industrial parts of the country (and the same can be seen almost for all other services) with more rural regions on the other side of the frequency. Interestingly, the difference in percentage of patients receiving the test differs not so much (from 46 to 64%) compare with the difference in number of test per patient, which ranges from 1,4 to 4,3 showing clearly overutilization of services in big cities.

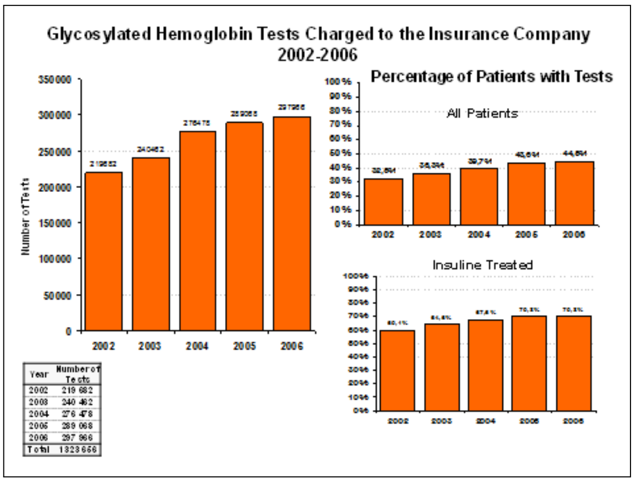

Figure 7: Glycosylated hemoglobin tests performed in diabetics in 2002-2006.

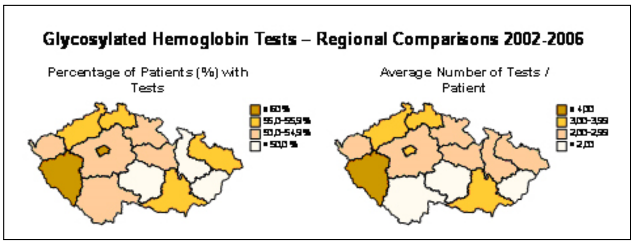

Figure 8: Regional comparisons in indication of glycosylated hemoglobin tests.

There were still more than 40% of patients with no medication, on so called "diet" (from our experience with not very high compliance rate) and this has to be goal for physicians to adopt new standards proposing metformin to be the drug of choice for those patients (Figure 9). Diabetes is very often associated with abnormal levels of serum cholesterol, triglycerides and other blood lipids. This condition is supposed to be treated, because present together with diabetes itself a potent risk factor for cardiovascular disease and death. On Figure 10 we can see that hypolipidemic therapy received less than 40% of patients in Germany [2] and about the same amount also patients in the Czech Republic. This data (data from 2005) show, that care in the Czech republic (both yellow columns) is fully comparable to the care in Germany (at least in this single aspect) but also show that expected treatments receives less than 50% of patients (target value is of course not 100% because not all patients require this therapy).

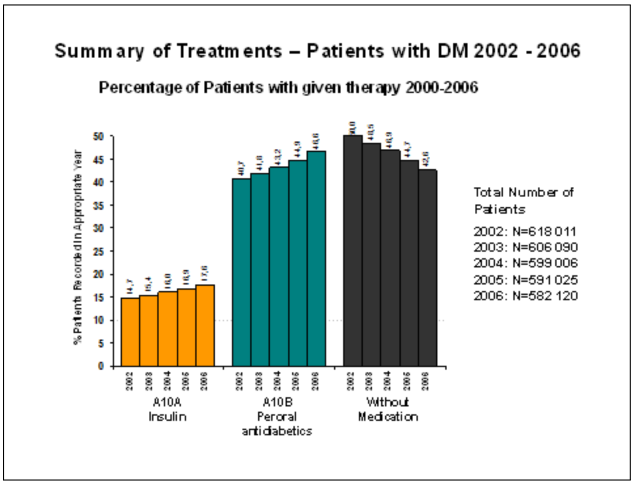

Figure 9: Treatment groups in diabetic patiens (insulins, peroral agents, no medication).

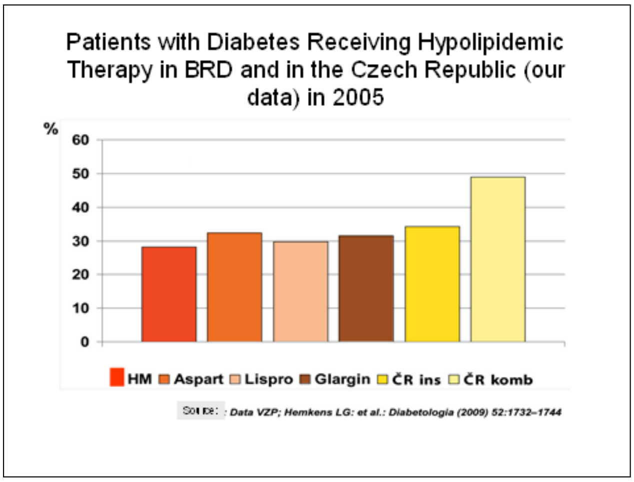

Figure 10: Comparison of percentage of patients treated with hypolipidemic drugs with various treatments of diabetes in BRD (human insulin, short and long acting insulin analogs) in comparison with data from the Czech Republic in two groups (insulin treated and insulin and oral antidiabetics used in combination).

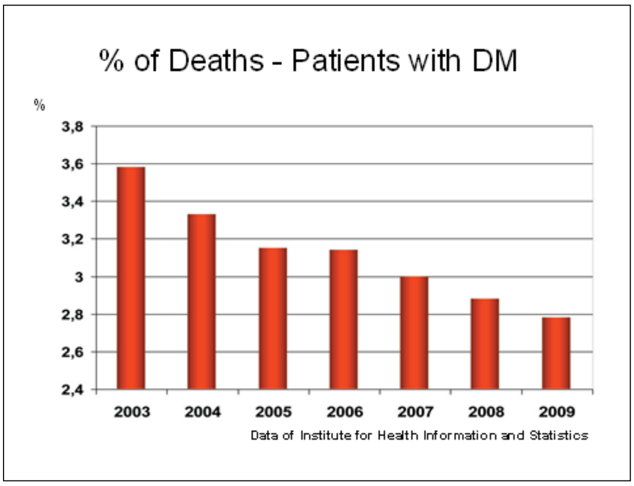

Figure 11: Percentage of deaths of diabetics among all deaths is given for year 2003 to 2009.

Despite the limited resources, better treatments in the last decade result in lower mortality of our patients. On Figure 11, percentage of deaths with known history of diabetes is given. Every year, data are improving and percentage of deaths of patients with diabetes is declining. In Figure 12 the comparison with the situation in Germany is given showing that also in this aspect are outcomes of the care in the Czech Republic comparable to the outcomes in Germany.

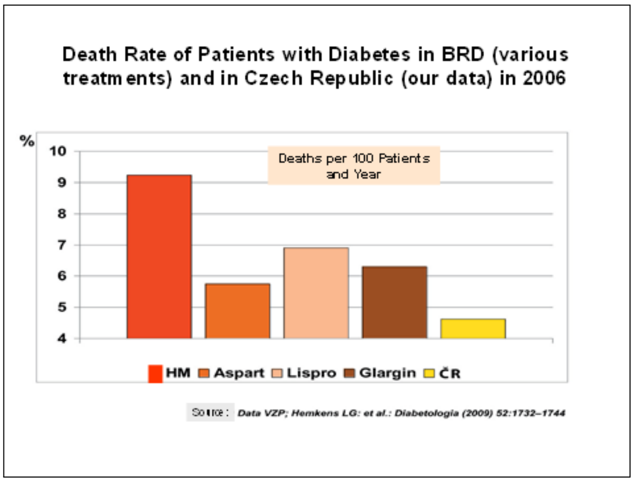

Figure 12: Death Rate of Patients with Diabetes in BRD (various treatments) and in Czech Republic (our data) in 2006.

5 Conclusion

This analysis was done in cooperation with General Health Insurance Company and its goal was not only to give valid data to the policy makers in the Czech Ministry of the Health and in Czech Medical Association, but also to bring attention to the weaknesses of the current organization of the care. From this point of view problem of unequal access to care due to regional situation and to the type of provider who is taking care about the patient is important. Study overcame disadvantage of data sources (from Institute of Health Care Information and Statistics and from medical insurance companies) which were originally obtained or created for other purposes (billing). This would otherwise lead to underestimation of numbers of diabetic patients. Prevalence of diabetes was despite reports from medical community and from situation abroad considered by authorities to be lower. Our analysis bring additional information showed possible financial impact for the future, if problem with prevention, regional differences in the care and incomplete adherence to guidelines will not be properly addressed. We bring attention to the fact, that medical statistics obtained in the settings of national health service (like in the past in the Czech Republic), differs from the statistics of national multi payer insurance system. We showed not only beneficial impact of liberal better funded medical insurance system on outcomes of the care and achievements of the Czech Republic in the care for diabetics in last ten years but we showed also challenges we face now in better coordination and organization of care.

References

[1] Nathan D.M., Buse J.B., Davidson M.B. et al. Management of hyperglycemia in type 2 diabetes: A consensus algorithm for the initiation and adjustment of therapy: A consensus statement from the American and the European Association for the Study of Diabetes. Diabetes care 29 (2006), 1963-1972.

[2] Hemkens L.G. et al. Risk of malignancies in patients with diabetes treated with human insulin or insulin analogues: a cohort study. Diabetologia 52 (2009), 1732–1744.

A Collaborative Approach to Care Coordination: Maccabi case study

Pavel Kubů[1], **Rachelle Kaye**[2], **Mariana Waksman**[1], **Mark N. Blatt**[1], **Tony Corrigan**[1]

[1] Intel Corporation

[2] Maccabi Healthcare Services

Abstract

Cost pressures, new payment models, and demographic trends are creating a global economic crisis as health systems struggle to care for an aging population of sicker patients. Funds available for healthcare are constrained, and they're being wasted by inefficient, uncoordinated healthcare services. Reflecting the importance of collaboration in caring for patients with chronic conditions, nearly 80 percent of the scoring criteria for the National Committee for Quality Assurance's (NCQA) Recognition Program for Physician Practice Connections (PPC) Patient-Centered Medical Home (PCMH) relate to information sharing and teamwork. New payment models are forcing delivery networks to share the risks and potential cost savings of caring for these patients. By imposing direct or indirect financial consequences, these models incentivize organizations to emphasize prevention, deliver care in the lowest-cost appropriate setting, and reduce readmissions, Emergency Department (ED) visits, acute-care admissions, and bed days of care. Maccabi's core belief is that all IT investments are business investments that should support strategic priorities and deliver a sustainable advantage to the organization. Among other clinical benefits of collaborative approach to care coordination in Maccabi implementation of Health IT tools supporting care coordination resulted in 13% increase in the number of diabetic patients who had a regular HbA1c and 8% increase in the number of diabetic patients whose HbA1c results indicated that the disease was stable.

Keywords

Correspondence to:

Pavel Kubů
Intel Czech Tradings, Inc.
Address: Pobřežní ulice 620/3, 18600 Prague
E–mail: pavel.kubu@intel.com

EJBI 2014; 10(2):8–11
received: July 28, 2013
accepted: March 9, 2014
published: March 31, 2014

1 Introduction

The leadership of Maccabi concluded in 1983 that the healthcare IT system of the future would require sophisticated information and communication technology for efficient management of the healthcare system, as well as effective and innovative healthcare IT services delivery. Maccabi leadership also recognized the need for top management to be hands-on, solve problems and commit resources to the project. In 1990, implementation of the Electronic Health Records (EHR) system began.

Across the nations of the OECD, health expenditures consume an average of 9 percent of Gross Domestic Product, and real per capita healthcare expenditures grew more than 4% annually during 1997-2007.1 In the UK, the NHS wastes GBP 330 annually by treating patients as emergency hospital admissions when they could be seen by their GP.2

An oft-cited study shows that in the U.S. in 2003-2004, almost one in five hospitalizations of Medicare fee-for-service patients resulted in a readmission within 30 days of discharge; three-quarters of these could have been prevented by better coordinated care, and the cost to Medicare for these readmissions was USD 15 billion.3 Even traditional fee-for-service practitioners are under financial duress, with the U.S. Small Business Administration reporting that SBA-backed loans to physicians' offices grew more than tenfold from 2000 to 2011.4

Controlling costs starts with better management of patients with multiple chronic diseases, and it puts a premium on coordination and collaboration. Medicare patients with multiple chronic illnesses see an average of 13 different physicians in the course of a year,5 and their full treatment team can easily include another dozen professionals and paraprofessionals.

Maccabi invested in health information technology (HIT) even though there was a lack of empirical and quantitative evidence regarding return on investment back in nineties, particularly in the area of cost containment. Establishing a governance structure for the development and management of the IT system was a key success factor in that it provided integrated responsibility and accountability amongst stakeholders. Clearly identifying concrete needs and goals provided direction to the Maccabi leadership and enabled focus on particular solutions to clinical problems. This process helps to establish standardized workflows and a platform to build on as understanding improves and increased integration of care becomes possible.

2 A collaborative process

The Maccabi ICT systems are designed to serve independent contractors, doctors and health care providers. Maccabi had to adapt to their needs and work flows instead of expecting them to adapt to the new system Maccabi created. Maccabi's success in adapting to ICT-based health delivery is based on stimulating and promoting collaboration with strategic partners both nationally and internationally, particularly in the areas of:

- ICT in healthcare
- Managing chronic disease and care of the elderly
- Economic analysis and research
- Telemedicine
- Mobile health

2.1 Incentivizing members

To incentivize end users and members, Maccabi issued a health ID card to all its members, to be presented at every point of service, thereby enabling the system to capture all of the members' transactions with the healthcare delivery system. From 2001 and on, Maccabi patients had access to their own medical information (via kiosks, web portal and mobile devices) – much of what was available to the doctor was made available to the patient including doctor visits, test results, medications prescribed, feedback on risk factors, as well as online guidance for chronic disease management and health promotion. Maccabi members also benefit from knowing that their complete health record is available wherever they engage with the health system enabling fast and accurate care delivery.

2.2 Incentivizing physicians to participate

Successful health IT investments are characterized by the willingness of physicians to engage in new processes and to make changes in the way they work. Clinician barriers such as high initial costs, uncertain financial benefits, investments in time, difficulties with technology and lack of integration with other care services can undermine any health IT initiative. Maccabi addressed these issues by providing incentives for meeting organizational objectives that are embedded into ongoing organizational processes. One of the reasons that there was such rapid uptake among the doctors was that Maccabi offered financial incentives and simultaneously reduced the financial burden of computerization. Incentives included a two percent increase in quarterly capitation fees, negotiating significant group discounts on the purchase of hardware, providing interest-free loans for purchasing hardware with convenient repayment conditions, and providing the software at no charge to the physician. The uptake of the EHR was gradual, beginning with doctors who volunteered to pilot the system. After a successful pilot stage, it was agreed that using the EHR would be voluntary for doctors currently under contract but mandatory for new doctors. This continued until the majority of doctors were in the system, at which point it became a condition of 'doing business' in Maccabi.

3 Mobilizing and empowering the ecosystem

3.1 Kiosks

Maccabi provides kiosks at all of its branches and the major government hospitals. The kiosks increase the accessibility of personal medical information and empower the member. Kiosks provide self-service medical information services similar to those at Maccabi online.

3.2 The Maccabi Hotline and customer relations management (CRM) center

Maccabi has established a 24 hour a day, seven days a week call center to provide around the clock services to its members. This consists of informationon all services, including who is actually receiving patients at the time of the member's inquiry, information on member privileges and benefits, making appointments, and telephone consultation with a nurse and/or physician. In order to make this service even more responsive to members' needs, a new CRM program has been installed, which enables the customer agent to see relevant member information, so that he can provide personally tailored service on the spot. The system also records all encounters. It is also being installed in all of Maccabi's anch offices and will operate in a totally integrated fashion nationwide.The encounter with the nurse can also occur through video conference.

3.3 Patient portal self-management

Maccabi has transformed its information system into a tool for patient collaboration, education and communication predominantly via a secured patient internet site that can be accessed by the Maccabi member. The member receives their own unique user name and password which grants access to their own information and provides tools to review medical records, access medical information and receive individual medical feedback.

The patient can manage his medical records in this website, can scan documents from other sources and enter measurements he takes himself, such as blood pressure. As a result, the entire health record is in one place. These computer-based tools and services save members unnecessary trips to Maccabi offices and allow members to perform numerous online activities from their homes, including scheduling appointments, purchasing travel insurance, modifying personal details and automatic billing through members' bank accounts.

4 Initial Benefits for Patients and Physicians

In Maccabi, the physician was able to perceive four benefits within a very short time after implementation:

- The insertion of the member health ID card into the physician's computer automatically populated the screen with the patient's demographic information, saving the physician time in writing or entering the information
- The insertion of the membership card and the validated authentication details of the clinician generated an online connection to the Maccabi database. The clinician could then verify the patient's eligibility to receive services, guaranteeing that the doctor would be paid for the visit
- The initial screen presented the doctor with a summary of the medical information on the patient, including major problems, diagnoses, allergies and medications
- Once the doctor entered a diagnosis for the visit, the information was transmitted and the claims adjudication process was initiated, saving additional entry and paperwork for billing

4.1 Optimized processes

Financial savings have and continue to be realized primarily through optimized processes that take advantage of shared electronic health records. Less time is spent in administration and more on care delivery. Physicians have been able to eliminate their use of transcription services, which has contributed substantially to paying for use of the EHR.

4.2 Avoiding adverse drug events

One of the most common types of medical error is the adverse drug event. Maccabi's use of ICT and decision support systems has significantly reduced the potential for a patient to have an adverse reaction from being administered an inappropriate medication. For example the laboratory reporting system was modified to provide physician alerts regarding potassium testing. A nightly batch file checked pharmacy diuretic purchases against the patient's potassium blood test status. On-screen computer-generated reminders were sent to physicians of patients lacking a recent potassium test. Reminders to physicians increased potassium testing by 9.8 percent.

As the system has become more sophisticated, more benefits have been realized. For example, in evaluating the effect of online prescription screening in community pharmacies and physician offices for Maccabi, it was found that computerized prescription entry coupled with drug interaction screening software in the community caused a 62.8 percent reduction in pharmacy-dispensed prescriptions with severe drug interactions.

4.3 Duplicate lab test

The accuracy of the health record minimizes waste within Maccabi, for example unnecessary laboratory tests. Prior to the introduction of the health record, physicians would often have an incomplete patient history and consequently may not know what previous diagnoses have been made. Consequently physicians would potentially order inappropriate tests or tests that were unnecessary. When Maccabi introduced the decision support system, it took just two months to observe a 35 percent reduction in ordering of lab tests.

4.4 Covered patients

Identifying which patients presenting at clinics are Maccabi patients is important for physicians in order that they can be appropriately reimbursed. By using the magnetic card, it has become simple for physicians to instantly identify the patient and also to access their health record, saving time and ensuring payment.

4.5 Administrative savings

Maccabi members have access to their health record online. Maccabi provide web and mobile access to test results, appointments and general information on-demand to members. By enabling members to service their own information needs, Maccabi benefits from reduced administrative costs.

4.6 On-site dispensing

The EHR has enabled Maccabi to contract 700 private pharmacies in addition to its own 53, to directly service the needs of its members. Physicians save nonrevenue generating time dealing with pharmaceutical issues, such as contra-indications. There is no need to phone or fax inquiries due to illegible handwriting or obtaining authorization for refills. Significant benefits have been realized from on-site dispensing and promoting this to Maccabi members.

5 Coordinated Care realizes Clinical and Economic Benefits

Over a three year period to 2009, Maccabi achieved the following results:

- 17 percent increase in the number of women above age 50 who had a breast exam with mammography
- 17 percent increase in the number of members over 65 who received a pneumovax vaccination
- 13 percent increase in the number of diabetic patients who had a regular HbA1c
- 8 percent increase in the number of diabetic patients whose HbA1c results indicated that the disease was stable

Maccabi can control the prescribing of drugs centrally, so that physicians are directed to the most cost effective and appropriate drugs. In 2001, medical policy encouraged the use of statin drugs for treatment of high cholesterol. Now when lab results showing high cholesterol arrive electronically in a doctor's computer, the decision support system asks if he wishes to prescribe a statin drug. Maccabi can designate a preferred drug, which the physician is directed towards. Despite the very impressive increase in the overall number of patients receiving statin therapy resulting in healthier patients (lowered LDL levels), because of the use of the Maccabi preferred drug, Maccabi actually realized a very significant decrease in drug expenditures for statins. The amount saved, for the years 2004-2006 was $5 million USD in statin drug expenditures. In addition, due to the improvement in patient outcomes and reduced complications, the average hospital stay for this cohort declined from 0.7 days in 2000 to 0.5 days in2006. This amounts to 76,000 avoided hospitals days with a cost savings of $32 million USD.

Despite an increase in the number of patients taking statins, the use of the preferred drug resulted in a decrease in drug expenditures for statins. The cost saving in expenditures on statin drugs among patients with cardiovascular disease, for 2004 - 2006 alone, was $5 million USD.

References

[1] OECD Health Data 2009. www.oecd.org/health/healthdata.

[2] Ian Blunt, Martin Bardsley and Jennifer Dixon, Trends in Emergency Admissions in England, 2004-2009. July 2010. http://www.nuffieldtrust.org.uk/publications/detail.aspx?id=145PRid=714.

[3] S.F. Jencks, M.V. Williams, and E.A. Coleman, E.A. Rehospitalizations among patients in the Medicare fee-for Service Program. New England Journal of Medicine. 2009, 360(14), 1418-1428.

[4] Reported by CNN Money, http://money.cnn.com/2012/01/20/smallbusiness/doctor_loans/index.htm.

[5] Testimony of Gerard F. Anderson, Ph.D., Johns Hopkins Bloomberg School of Public Health, Health Policy and Management, before the Senate Special Committee on Aging, The Future of Medicare: Recognizing the Need for Chronic Care Coordination, Serial No. 110-7, pp. 19-20 (May 9, 2007).

Concept of knowledge-based self-management pathways for the empowerment of diabetes patients

Holger Schmuhl[1], **Hans Demski**[1], **Ilias Lamprinos**[2], **Asuman Dogac**[3], **Manuela Ploessnig**[4], **Claudia Hildebrand**[1]

[1] Helmholtz Zentrum München, Institute for Biological and Medical Imaging, Laboratory for Medical Information Systems, Munich;

[2] Intracom Telecom, Telco Software Depertement, Athens;

[3] Software Research, Development and Consultation Ltd., Ankara;

[4] Salzburg Research Forschungsgesellschaft, Knowledge and Media Technologies, Salzburg

Abstract

Introduction: Diabetes requires a high level of disease management to be executed by the patient himself in order to succeed in treatment and for improving or at least preserving his health status.
Aim: The main objective of the presented project is to design and implement a web technology based application framework. It shall provide sufficient means for self-management and enable patient empowerment within the treatment process. Its underlying concept will be outlined in this work.
Methods: Common techniques on requirements' engineering have been applied to derive an initial concept. It is based on a comprehensive state of the art analysis drawn from literature and web search.
Results: A service-oriented architecture could be drafted that enables interoperability with existing eHealth systems on a technical and semantic level. Pilots will be deployed in Germany and Turkey. Pilot specific requirements can be address as well due to its modular architecture.
Conclusion: The given concept gives a high level description of the envisaged approach. An initial prototype has been implemented. A second prototype is well on the way offering all major functionality and will be deployed within the pilot regions.

Keywords

Patient empowerment, self-management, pathways, decision support, medical records, diabetes, semantic integration

Correspondence to:

Claudia Hildebrand
Helmholtz Zentrum München, Institute for Biological and Medical Imaging, Laboratory for Medical Information Systems
Address: Ingolstädter Landstraße 1, D-85764 Neuherberg
E–mail: hildebra@helmholtz-muenchen.de

EJBI 2014; 10(2):12–16
received: July 25, 2013
accepted: March 10, 2014
published: March 31, 2014

1 Introduction

Within the widespread diseases especially Diabetes requires a high level of disease management to be executed by the patient himself in order to succeed in treatment and for improving or at least preserving his health status.

In the scope of the European EMPOWER project [1] a modular and standard-based patient empowerment framework is being developed which will facilitate self-management [2, 3] for diabetes type 1 and 2 patients. Research and development efforts focus on knowledge-based self-management pathways for diabetes patients. These are realized through a combined use of the following services:

- Monitoring of vital, physical, and mental parameters as well as physical and lifestyle activities. Parameters can be recorded within EMPOWER's Personal Health Record (PHR) [4].

- Generating patient-specific recommendations. Taking into account the monitored health parameters of a specific patient, relevant recommendations are generated based on expert knowledge such as diabetes guidelines. They are then revised and amended by the health professional.

- Definition of goals and corresponding actions to accomplish given recommendations. The patient can define goals and plan specific actions in her/his individual action plan to fulfil the recommendations.

- Support of the patient's self-dependent execution of actions to facilitate changes of behaviour according to individual diabetes-specific health care needs. By means of intuitive and self-explanatory data visualization, motivating reminders and reward mechanisms, patients will be empowered to achieve their personalized goals.
- Seamless, consistent and standard-based integration of relevant data originating from existing systems like Electronic Medical Records (EMR) [5] of participating health care institutions, Electronic Health Records (EHR) [5], PHRs and Personal Health Applications, (PHA) for example in form of Mobile Apps.

The EMPOWER core services will be implemented in two pilot deployments to ensure the generalizability and applicability of the project's overall outcome. One pilot system will be implemented in Turkey in cooperation with the Turkish Ministry of Health [6] on a national level. The second pilot will be deployed in the region of Ingolstadt, Germany in cooperation with the Network of Practices GOIN ("Praxisnetz GOIN e.V.") [7].

Although both pilots share the common goal to empower, support and guide diabetes patients by providing EMPOWER services, they are substantially different regarding the overall technical setup of integrated data sources and the country specific characteristics. This work highlights pilot specific differences and discusses resulting challenges that are addressed in underlying concept.

2 Methods

A comprehensive literature review and Internet research has been conducted in order to assess state of the art technologies and architecture relevant to the EMPOWER project.

Common requirements engineering activities have been carried out. These included requirements analysis, specification and system modeling in order to come up with a detailed requirements specification and design concept.

In the process of doing so regular discussions with experts' involving the consortium's partners and domain specialists like doctors and nutritionists have been conducted to clarify the initial setup.

Intermediate work results have been condensed and summarized by means of abstraction in order to provide a convenient overview in form of this concept.

3 Results

3.1 Technical integration of data sources

Data originating from health care institutions is integrated using country specific approaches. Within the German pilot (as shown in Figure 1) so far no regional or national EHR has been established in which aggregated health data could be accessed directly.

As a result the EMRs of the participating health care institutions must be interfaced one by one. As primarily general practitioners and case managers are treating diabetes patients in that region, their referring Practice Information Systems (PIS) must be interconnected with the EMPOWER services. According to previous research those systems offer limited integration capabilities [8] and may even be interconnected only with systems of the same vendors due to proprietary interfaces. To address this short-coming an alternative, archetype-based approach has been defined [9] and is being implemented in cooperation with an exemplary vendor.

In Turkey - in contrast to Germany - a nation-wide EHR is available that serves aggregated data from treating health care institutions and supports common interoperability standards, see Figure 2.

On the technical interoperability level data exchange within both pilots will be based on IHE profiles as defined

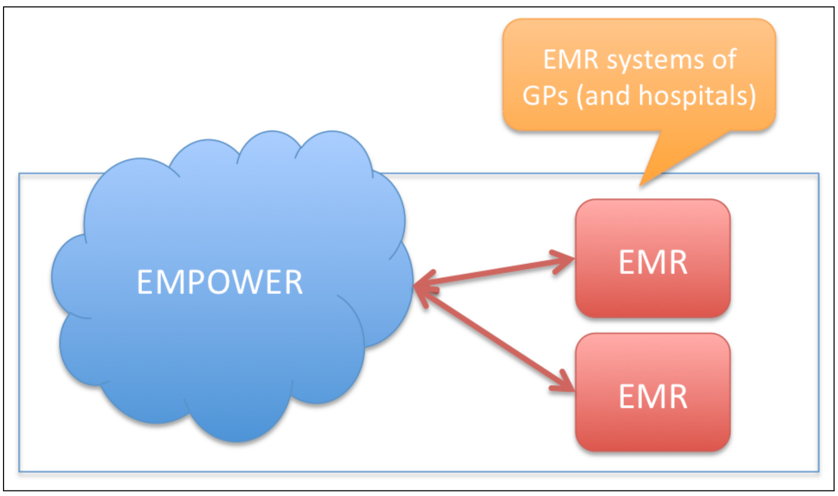

Figure 1: Integrating data sources of health care institutions in the German pilot.

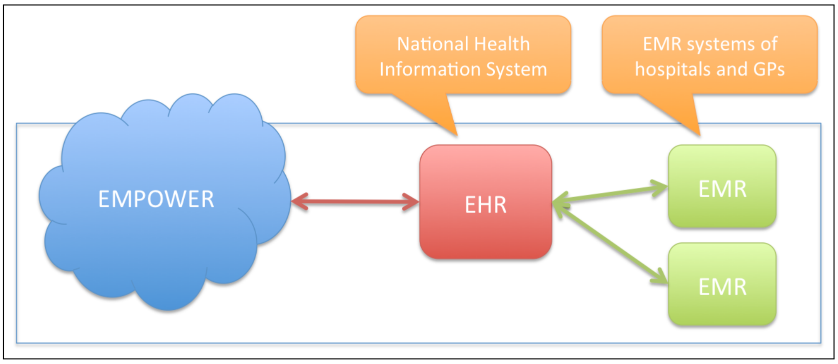

Figure 2: Integrating data sources of health care institutions in the Turkish pilot.

in the IT Infrastructure Technical Framework [10] and the Patient Care Coordination Technical Framework [10] that are commonly used in regional or national EHR projects.

Data originating from the patients will be integrated using the same approach in both pilots, see Figure 3. Patients may own a PHR of an external provider and/or decide to use EMPOWER's PHR. Furthermore, they may start to use or may already be using a PHA to record and monitor personal health data. Additionally we aim at importing biometrical measurements directly from connected medical devices like blood glucose meters or via PHAs that are already paired with the device. Technical interoperability will be based on the IHE profile XPHR [10] supported by an IHE XDS-based sharing framework [10], although especially the connectivity to medical devices may require a different interfacing due to proprietary vendor-specific protocols.

3.2 Semantic integration of data sources

Data collected by the patient (e.g. observations of daily living like weight and mood) and by health professionals (e.g. diagnoses and medication) must be consolidated for mutual information sharing to enable a seamless, cross-sectoral electronic exchange of patient data.

The prevalent lack of agreed and implemented standards impede the transfer of detailed healthcare information in a way that supports full integration of that data within the receiving systems [11]. In order to process EHR data safely, semantic interoperability is required, meaning that computational services are enabled to reliably interpret clinical data that has been integrated from various sources [12].

EMPOWER utilizes appropriate standards from HL7 and IHE (like XPHR and XDS-MS [10]), as well as ISO 13606/openEHR information models [13, 14] to enable semantic interoperable data exchange.

Observations of daily living [15] are being specified using openEHR information models (a.k.a. archetypes) for the usage within PHR systems and PHAs in a patient-centric approach rather than strictly for use by healthcare actors during their observation collection. Archetype based data modeling (including data schemas and corresponding rules) is an open and flexible approach that

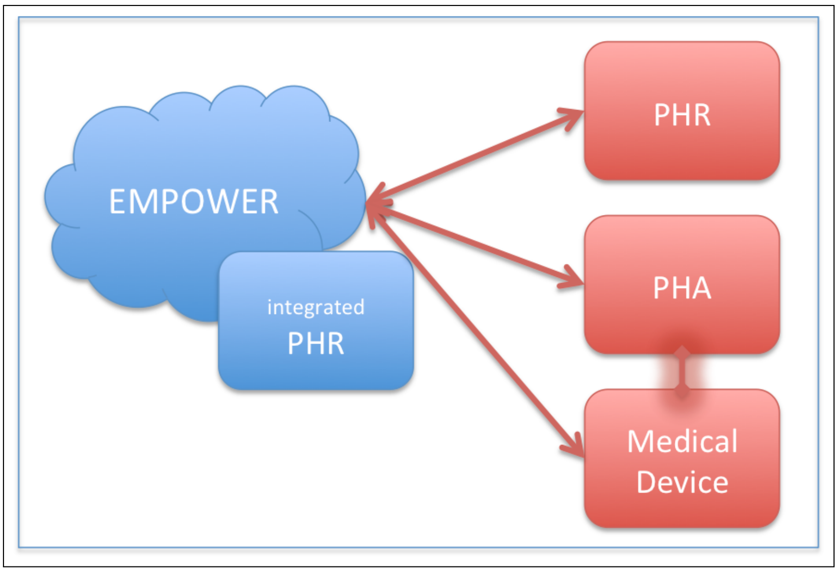

Figure 3: Common approach to import data provided by patients.

avoids application lock-in, as the knowledge models are made publicly available. OpenEHR supports this with the Clinical Knowledge Manager [16] that provides a platform for a collaborative development of clinical archetypes.

Standard Terminologies will be used for semantic binding (mapping to terminology codes) and value binding (specific value sets). A central transformation service will be provided that converts these data to a common format thus facilitating the import of data from legacy systems and medical devices that use proprietary data schemas.

3.3 Service Oriented Architecture

In order to offer a maximum of flexibility and extensibility a modular, service-oriented architecture was drafted, see Figure 4. Beside services providing the primary EMPOWER functionalities as described in the introduction, also additional services are required to ensure consistent data privacy and security, continuous auditing and logging mechanisms, seamless integration of heterogeneous data sources and end-user delivery of EMPOWER services to multiple platforms like smartphone, tablets and desktop computers.

Four layers were defined to offer convenient interaction and integration capabilities at the different levels of abstraction.

3.4 Support of pilot/country specific requirements

A unique feature of the EMPOWER system is that multiple localization environments will be supported. The health care system, diabetes treatment process, underlying medical guidelines, involved actors and further constraints are significantly different in both EMPOWER pilot applications. In order to address these country specific requirements whilst relying on single, commonly developed core services and components, multiple levels of abstraction need to be implemented.

In the area of data and knowledge handling convertible and adaptable models are being designed based on established standards for data communication and information representation as described before. Data will be processed based on standardized terminologies, ontologies and coding systems like LOINC [18] and UMLS [19].

Medical guidelines issued by professional societies or administrations are being computerized by the utilization of clinical guideline definition languages and can thus be easily adjusted to national guidelines and scenarios. Diverse treatment processes at health care institutions must also be equally supported by the EMPOWER systems. To do so the underlying business logic is being modeled by utilizing the Business Process Model and Notation (BPMN) [20] that is being transformed into computer-interpretable instructions.

Finally, comprehensive requirements arise in the fields of identity and data management in respect to identification schema, data privacy and security. For example,

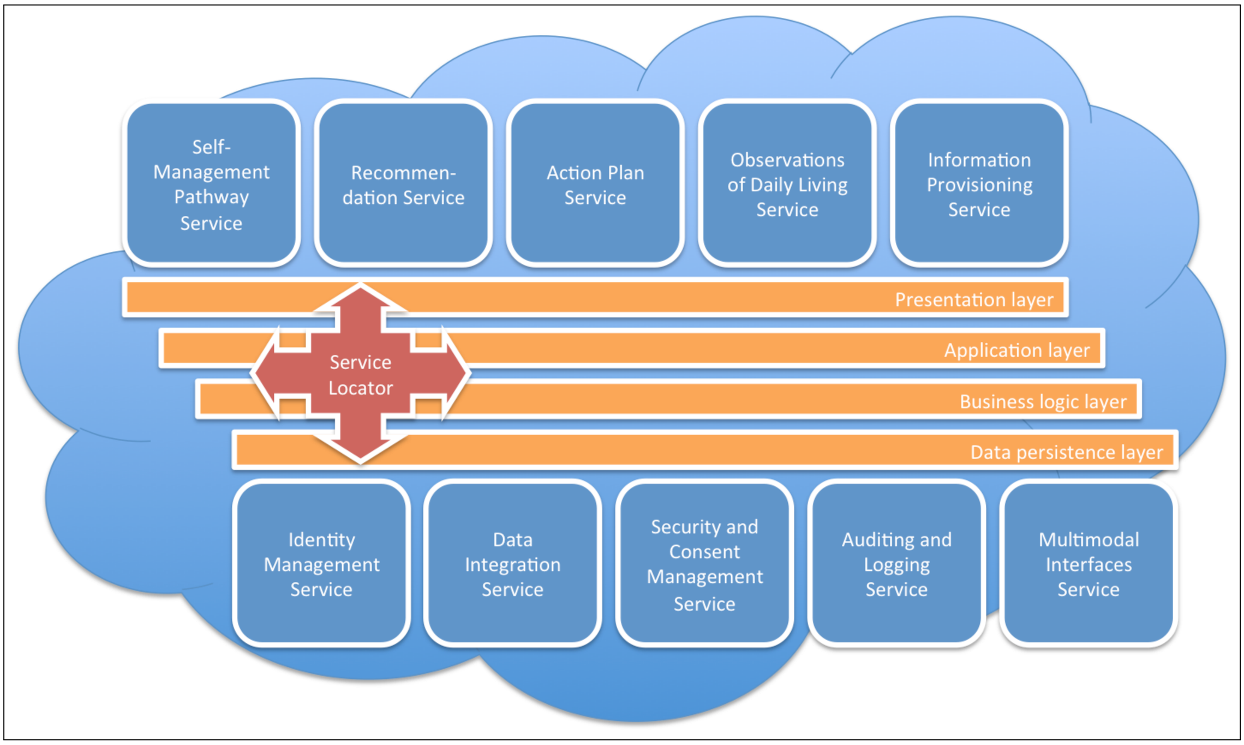

Figure 4: Overview of EMPOWER's core architecture of services and abstraction layers.

in Turkey a country-wide unique patient identifier was established whereas in Germany it has been introduced only recently in form of the "Gesundheitskarte" [21] that is currently being issued to the wider public. Country-specific legal regulations and the different pilot setups require comprehensive, convenient and adjustable security and privacy services for the management of patients' consent, access control and overall system auditing capabilities.

4 Discussion

Implementation works such as early prototyping and component integration have recently started and aim to verify adequacy and practicability of the proposed concept.

The drafted modular and service oriented architecture offers a maximum of flexibility and extensibility not only for the development and integration efforts within the actual project term. The resulting patient empowerment and self-management framework could even be reused and advanced to support other non-communicable diseases beyond the scope of the EMPOWER project.

On the long-term data exchange between both pilots could also be examined. Although it is not a defined use case within EMPOWER, our outcome in combination with the results of epSOS [22] should enable a straightforward implementation of the inter-pilot connectivity, at least on a technical level.

To sum up – by the innovative and interdisciplinary combination of the latest methodical and technological advancements, EMPOWER breaks new ground in the field of patient-centered, data- and knowledge-based medical decision support systems.

Acknowledgement

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement No 288209, EMPOWER Project.

References

[1] Empower Project Homepage. Available from: http://www.empower-fp7.eu, last visited 24.10.2012.

[2] Alpay L, van der Boog P, Dumaij A. An Empowerment-Based Approach to Developing Innovative E-Health Tools for Self-Management. Health informatics journal. 2011 Dec;17(4):247-55. PubMed PMID: 22193825.

[3] Tsalatsanis A, Gil-Herrera E, Yalcin A, Djulbegovic B, Barnes L. Designing Patient-Centric Applications for Chronic Disease Management. Conference proceedings : Annual International Conference of the IEEE Engineering in Medicine and Biology Society IEEE Engineering in Medicine and Biology Society Conference. 2011;2011:3146-9. PubMed PMID: 22255007.

[4] Committee HPHRS. Himss Personal Health Records Definition and Position Statement. Available from: http://www.himss.org/content/files/phrdefinition071707.pdf, last visited 24.10.2012.

[5] HIMSS Analytics. Electronic Medical Records Vs. Electronic Health Records: Yes, There Is a Difference. Available from: http://www.himss.org/content/files/WP_EMR_EHR.pdf, last visited 24.10.2012.

[6] Turkish Ministry of Health. Available from: http://www.saglik.gov.tr/EN/, last visited 24.10.2012.

[7] Go in Integrationsmanagement- Und Beteiligungs-Gmbh Im Gesundheitswesen. Available from: http://www.goin.info/, last visited 24.10.2012.

[8] Heinze O, Schmuhl H, Bergh B. Gp Connector - a Tool to Enable Access for General Practitioners to a Standards-Based Personal and Electronic Health Record in the Rhine-Neckar Region. Studies in health technology and informatics. 2011;169:344-8. PubMed PMID: 21893770.

[9] Demski H, Hildebrand C, Brass A, Jedamzik S, Engelbrecht R. Improvement of Cross-Sector Communication in the Integrated Health Environment. Studies in health technology and informatics. 2010;155:95-100. PubMed PMID: 20543315.

[10] Ihe Technical Frameworks. Available from: http://www.ihe.net/technical_framework/, last visited 24.10.2012.

[11] Kalra D. Deliverable 4.1 - Barriers, Approaches and Research Priorities for Semantic Interoperability in Support of Clinical Care Delivery (Semantichealth). 2007, last visited 29.10.2012.

[12] V Stroetman DK, P Lewalle, A Rector, J Rodrigues, K Stroetman, G Surjan, B Ustun, M Virtanen, P Zanstra. Semantic Interoperability for Better Health and Safer Healthcare2009 29.10.2012 29.10.2012]. Available from: http://ec.europa.eu/information_society/activities/health /docs/publications/2009/2009semantic-health-report.pdf.

[13] En 13606 Association. Available from: http://www.en13606.org, last visited 24.10.2012.

[14] Openehr Foundation. Available from: http://www.openehr.org/, last visited 24.10.2012.

[15] HealthDesign P. Health in Everyday Living. Robert Wood Johnson Foundation; 2009, last visited

[16] OpenEHR. Clinical Knowledge Manager Available from: http://openehr.org/knowledge/, last visited 24.10.2012.

[17] International H. Hl7 Reference Information Model. Available from: http://www.hl7.org/implement/standards/rim.cfm, last visited 24.10.2012.

[18] Institute R. Logical Observation Identifiers Names and Codes (Loinc®). Available from: http://loinc.org, last visited 24.10.2012.

[19] Health NIo. Unified Medical Language System (Umls). Available from: http://www.nlm.nih.gov/research/umls/, last visited 24.10.2012.

[20] OMG. Business Process Model and Notation. Available from: http://www.bpmn.org, last visited 24.10.2012.

[21] Bundesministerium für Gesundheit. Elektronische Gesundheitskarte. Available from: http://www.bmg.bund.de/krankenversicherung/elektronische-gesundheitskarte.html, last visited 24.10.2012.

[22] EpSOS – the European Ehealth Project. Available from: http://www.epsos.eu, last visited 24.10.2012.

Personalized Dietary Counseling System Using Harmony Rules in Tele-Care

István Vassányi[1], **István Kósa**[2], **Balázs Pintér**[1], **Balázs Gaál**[1]

[1] University of Pannonia, Medical Informatics RD Center, Veszprém, Hungary

[2] Cardiac Rehabilitation Institute of Military Hospital, Balatonfüred, Hungary

Abstract

Introduction: Lifestyle assessment, especially nutrition counseling may have a great impact on the health state of everybody. The MenuGene expert system provides services for the logging and assessment of nutrition and physical activity.
Aim: This paper focuses on how the harmony of a dietary log can be analyzed using harmony rules. Such an assessment can be used to assess a log as well as drive an evolutionary search process that constructs a personalized menu.
Methods: Expert knowledge is formalized in two parts, sets of foods and dishes and rules that fire at a pre-defined pattern of sets. To tackle the large rule search space, a simple conflict resolution strategy is used.
Results: We implemented several hierarchies of sets to support the definition of rules, and also an Android based lifestyle assistant application. We validated the completeness of the dietary database in a survey.
Conclusion: The system may prove very useful for a real improvement of the quality of life and general health state especially for patients with chronic diseases like diabetes. We plan to conduct clinical trials to prove this early next year.

Keywords

Dietary menu planning, harmony rules, nutrition counseling

Correspondence to:

István Vassányi
University of Pannonia,
Dept. of Electrical Engineering and Information Systems
Address: H-8200 Veszprém, Egyetem u. 10, Hungary
E–mail: vassnaiy@almos.vein.hu

EJBI 2014; 10(2):17–22
received: July 27, 2013
accepted: March 10, 2014
published: March 31, 2014

1 Introduction

Nutrition has severe impact on the probability of cardio-vascular ant other diseases, so bringing tailored advice to the general population on nutrition and lifestyle, including physical activity can improve life expectancy. An important task of personalized lifestyle counseling is dietary menu planning and analysis. The paper describes the architecture and results produced by an automated dietary menu generator MenuGene, applied now in a diabetes home monitoring project. Our solution is intended to support, not to substitute the human dietary expert.

Computer-aided menu planning and analysis is a traditionally hard problem since it is characterized by i) a very large search space and ii) hard-to-formalize expert dietary knowledge on the harmony assessment of a menu. Human experts probably build better meal plans than computers even now, although research on computerized methods has been ongoing since the 1960's. In 1964 Balintfy developed a linear programming method for menu optimization [1], while Eckstein used random search to satisfy numerical nutrient constraints [2]. Later more advanced artificial intelligence methods were developed using Case-Based Reasoning (CBR) or Rule-Based Reasoning (RBR) or by combining the two methods with other techniques [3]. A web based system called DietPal has been built in Malaysia that models the workflow of dietetic experts in order to support their work [4]. There are solutions for parts of a nutrition counseling expert system, but so far there were no complete solutions published and validated. Our system implements all aspects of this area in a user friendly and effective way.

For the first problem i.e. search satisfying numerical constraints, we apply multi-level, multi-objective genetic algorithms that calculate the fitness of candidate solutions using personalized target values of various nutrients. The objectives for the menu planning process are obtained from personal medical data, entered manually

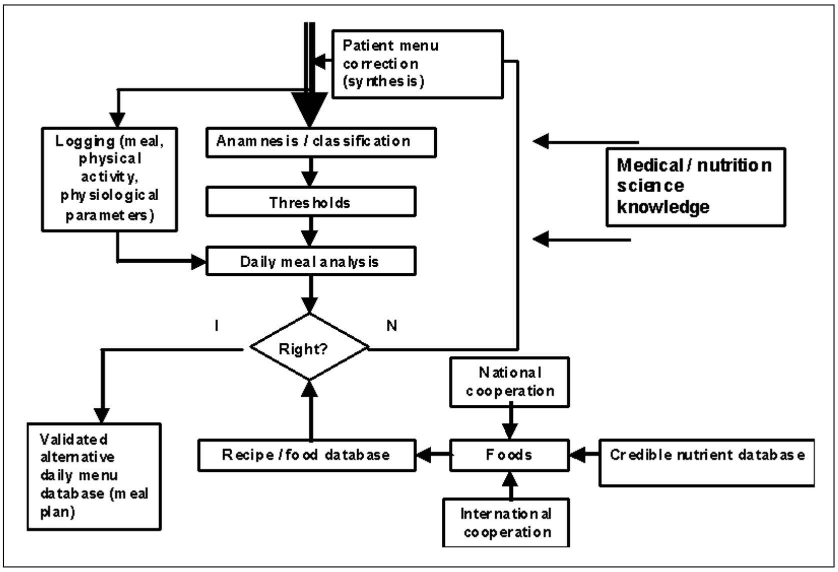

Figure 1: Work flow of the dietary log assessment process.

or measured by sensors of the tele-care system. Another source of information is the aim of the patient like "losing weight" and the user's daily dietary log (essentially a smart phone application) which can be analyzed for food composition and completeness. Then we apply general nutritional guidelines to compute the personalized numerical constraints at different levels. An example constraint is the daily minimum, optimum and maximum value for carbohydrate content. For the details of the Genetic Engine, see [5]. A similar approach based on evolutionary computing is reported in [6]. In this paper, however, we will focus more on the second problem, i.e. on the representation of the dietary expert knowledge.

2 Methods

For the assessment of harmony, we defined dietary concept sets e.g. 'fruits with a high glycemic index', and we use a simple mechanism for enforcing harmony rules over them. The rules are used to score candidate solutions e.g. a daily menu, and the score is combined with the numerical fitness of the solutions at different levels (dish, meal, daily menu). Rules assign a positive or negative score to a co-occurrence pattern of two or more sets. Positive scores mean recommended patterns, like "muesli and any drink for breakfast", while negative scores mean detrimental combinations, like "beer and water-melon in the same meal". The fitness value of a candidate solution is multiplied by the factor that appears in the consequence part of the applied rule, so "negative" scores mean fitness factors in the range of 0..1. Fig. 1 shows an overview on the dietary log assessment process.

We support harmony rules on the meal, daily and weekly level. The condition part of a rule may contain one or more sets in an AND construct. For a meal level rule, this means that the rule will be fired if the meal contains all of these sets, or dishes/foods in their subsets. For example, the set "fruits" contains the set "fruits with a high glycemic index" so if the rule contains "fruit" in the condition part, then all elements of the set "fruits with a high glycemic index" will match, such as ripe banana.

Due to this generalized method of rule matching, several (contradicting) rules may match a meal or a day, so conflict resolution is inevitable. Our strategy is based on the following principles.

- Rules with a more elements in their condition part are preferred over simpler rules because they match the actual meal/day/week more precisely
- Concrete rules with less general sets in their condition parts are preferred over more general rules, for the same reason. For the case of ripe banana, the set "fruits with a high glycemic index" is a stronger reference, than "fruits".
- If two or more rules have the same complexity or generality, we apply the stricter one. A rule is stricter if in the consequence part it contains a lower fitness factor in the case of a negative rule or a higher fitness factor in the case of a positive rule.

When assessing a weekly menu, or alternative weekly menus, the harmony factors of a lower level can be expressed as a vector. The computational complexity of the calculation of this vector is exponential in time in the function of the number of the slots (n), because each subset of the objects associated with slots should get evaluated according to harmony. The harmony of each subset will be expressed through the harmony payloads. Not including the empty set, the number of subsets is 2n ? 1, and this many checks are needed to calculate the value of each harmony payload. This makes the proof of the decision problem 'whether the assignment's payloads are within the constraints' verifiable in exponential time. For NP

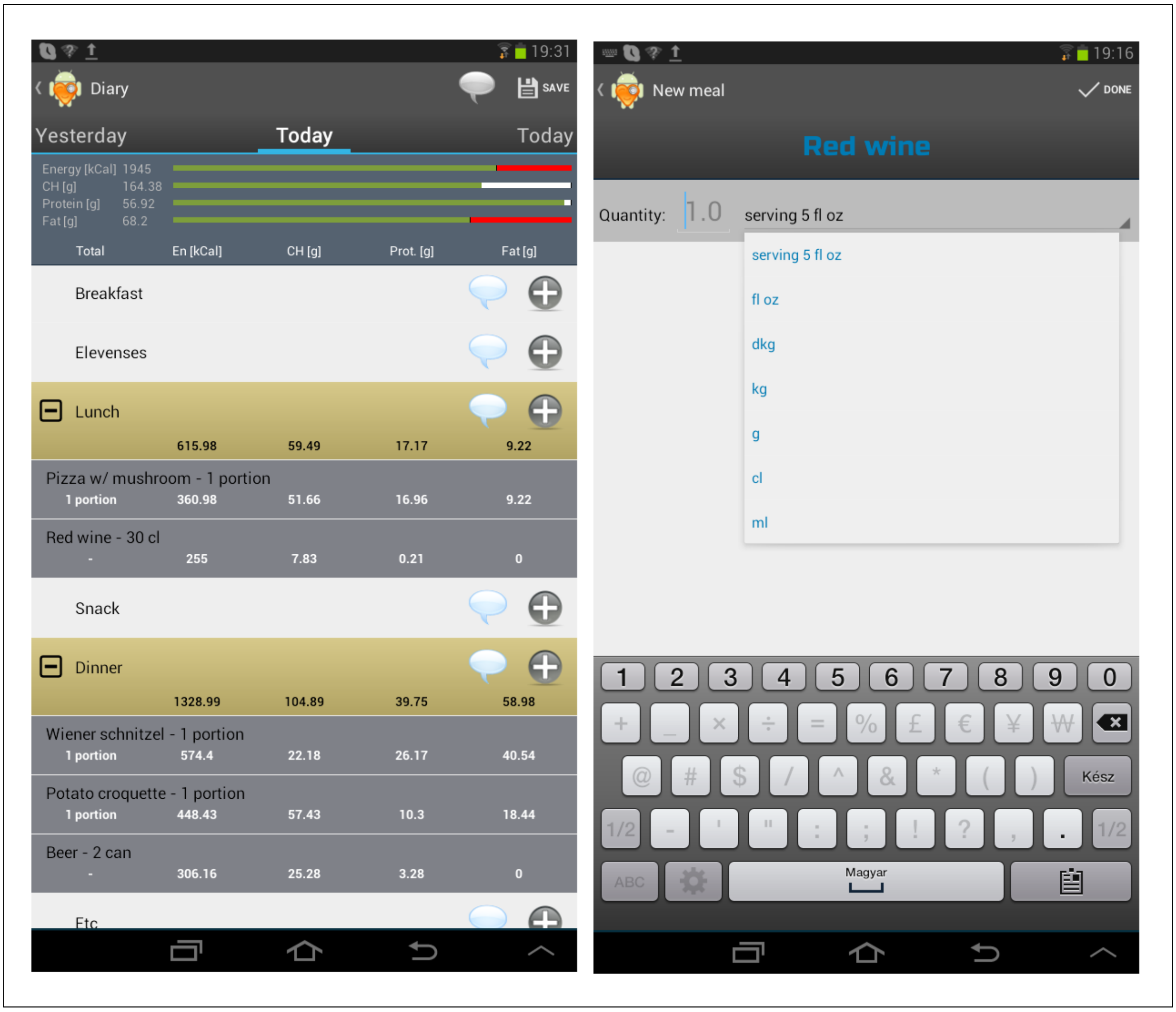

Figure 2: Logging example screen shots of the Lavinia lifestyle mirror application.

complexity the proof would have to be verifiable in polynomial time by a deterministic Turing machine. Therefore, the introduction of harmony makes the decision problem harder than NP, a good candidate for evolutionary solving methods. A similar extension of the Mixed Integer Linear Problem with first-order logic is presented in [7].

Due to the large number of concrete or general, possibly applicable rules for every single meal, we store the sets and the rules in a pre-processed form that can be searched easily. The final goal of the development is to ensure real time harmony assessment of user-logged of system generated menus.

3 Results

The Hungarian version of the MenuGene data base currently stores 9500 food items along with their nutrient contents and 1373 dishes composed from the foods, but on the user interface we show only the most important 299 dishes and 360 foods, organized in 195 sets, to simplify the search. In a recent survey, we evaluated the completeness of our food and dish data base by manually entering 110 days of menu planned by human dietetians in a Hungarian rehabilitation hospital. The results showed that the database contained ca. 74% of the total 194 dishes that occurred in the menus, but most of the missing dishes occurred rather rarely, so if we consider the dish coverage by food diary item, the coverage ratio is 84%. This means that we could support the most common items. For the foods, these ratios are 84% and 96.5%, respectively. For this trial, we used the Lavinia lifestyle mirror application with an android based GUI (Figs. 2 and 3). This application uses the central MenuGene database and related services in a service oriented open architecture. A distinguishing feature of Lavinia compared to other lifestyle logger applications e.g. [8, 9, 10] is its integration with physiological sensors and its enhanced medial intelligence.

The set hierarchy was developed manually by our dietitian expert such that it should be in line with recent professional recommendations and also support the easy construction of harmony rules. We now have a total of 1409 sets in several hierarchical structures or ontologies.

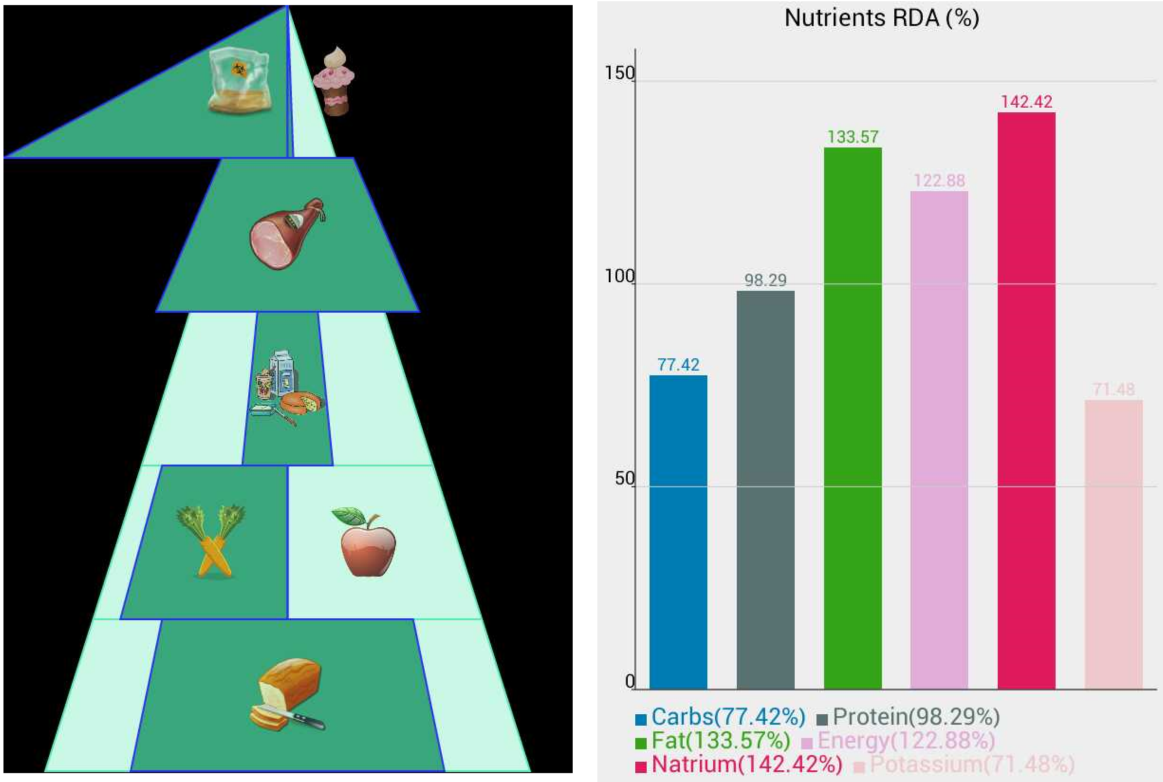

Figure 3: Evaulation example screen shots of the Lavinia lifestyle mirror application.

The reason of using multiple ontologies is the need to support different grouping and classification aspects of foods and dishes. The depth of the deepest hierarchy is 7 levels (Fig. 4).

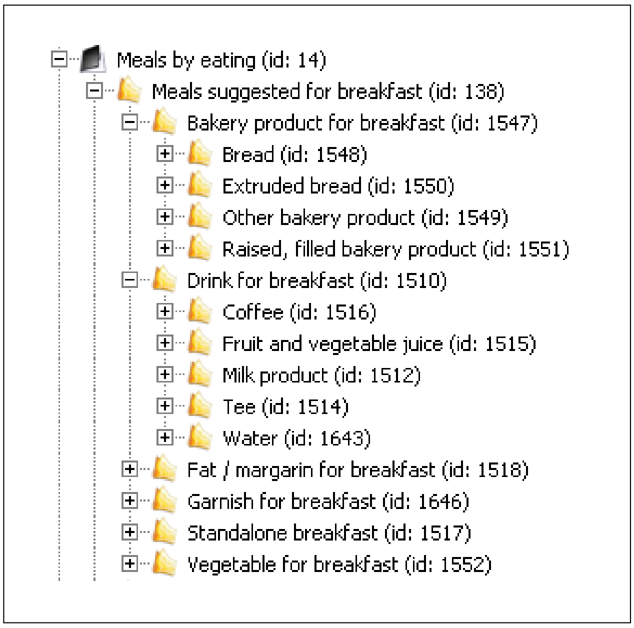

Figure 4: Part of the set hierarchy.

We implemented the concept of the harmony rules described above as a plug-in in the MenuGene expert GUI. Figure 5 shows a positive rule that defines the possible sets of a 2 component standard breakfasts, like “a food from the Muesli/cereal set and a drink from the set of breakfast drinks”. Sets are also used to generate warning messages for the users with specific needs or illnesses. The MenuGene system currently supports 21 chronic illnesses like Crohn disease or diabetes, and various combinations of these provided the number of concurrent illnesses does not exceed 7. The interplay of illnesses is considered for the personalized RDA limits and additionally, users with certain illnesses receive a warning when logging certain types of food. For example, a user with diabetes will receive a warning when logging coke, even if she is within her RDA. Figure 6 shows the expert GUI for defining such message rules.

Another module that will allow the trace back of the rule firing process after the assessment of a menu is also in preparation.

4 Conclusion

The paper presented the MenuGene lifestyle assessment expert system with an emphasis on the rules expressing dietary harmony. A simple rule model, based

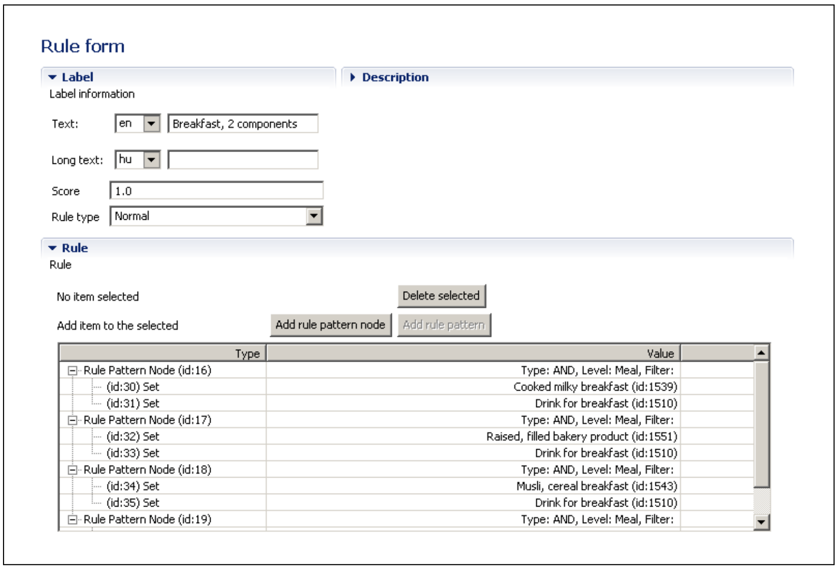

Figure 5: A breakfast structure based on sets.

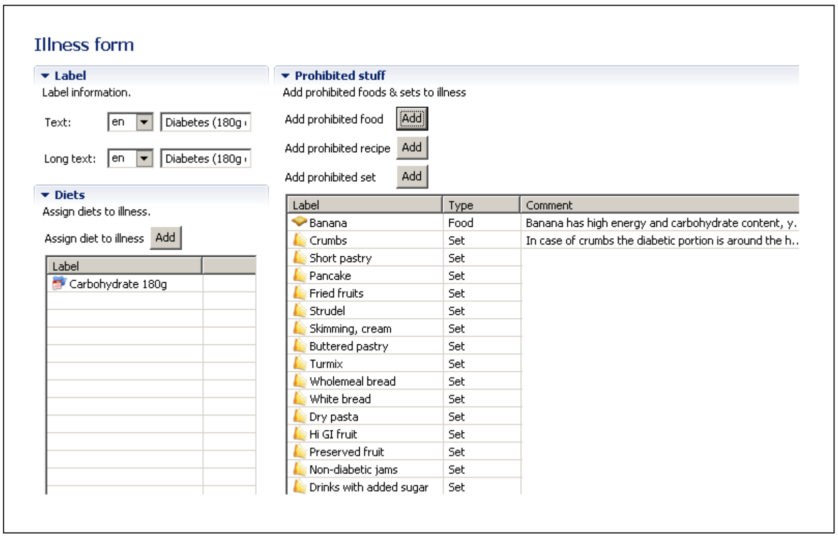

Figure 6: Sets used for generating warning messages on the expert GUI.

on a hierarchy of sets is used to represent domain knowledge. The system has an android-based user interface that supports logging and automated lifestyle assessment. We have already performed some trials to check the completeness of the data base and the usability of the user interface. We also plan to execute clinical trials early next year to examine whether the use of such services really improves patients' everyday life and general state of health, especially in such areas as diabetes and chronic kidney disease.

Acknowledgments

The work presented was supported by the European Union and co-funded by the European Social Fund, project title: "Telemedicine-focused research activities in the field of Mathematics, Informatics and Medical Sciences", project number: TÁMOP-4.2.2.A-11/1/KONV-2012-0073.

References

[1] Balintfy, J. L. (1964 April) 'Menu Planning by Computer' Communications of the ACM, vol. 7, no. 4, pp. 255-259.

[2] Eckstein EF. (1967 Dec) 'Menu planning by computer: the random approach'. J Am Diet Assoc;51(6):529-533.

[3] C.R. Marling, G.J. Petot, L.S. Sterling (1999) 'Integrating Case-Based and Rule-Based Reasoning to Meet Multiple Design Constraints'. Computational Intelligence, Volume 15, Number 3

[4] Noah S, Abdullah S, Shahar S, et al. (2004) 'A Web-Based Dietary Menu-Generating and Management System'. J Med Internet Res 2004;6(1):e4

[5] B. Gaál, I. Vassányi, G. Kozmann (2005) ‘A Novel Artificial Intelli-gence Method for Weekly Dietary Menu Planning’. Methods Inf Med 2005 (Vol. 44): Issue 5 2005, pp 655-664

[6] Seljak, B.K. (2006) ‘Dietary Menu Planning Using an Evolutionary Method’. Proc. Int. Conf. on Intelligent Engineering Systems, London, UK, 26-28 June 2006, pp. 108-113.

[7] G. J. Gordon, S. A. Hong, and M. Dud´?k, “First-order mixed integer linear pro-gramming,” in Proceedings of the 25th Conference on Uncertainty in Artificial Intelligence (UAI), 2009.

[8] V. Roesler, C. Iochpe, A. Bordignon, L. Tizatto. Mobilicare: AHealth Monitoring System for Chronic Patients. proc. Med-e Tel 2013, Luxembourg, pp. 74-78.

[9] Diet Assistant. https://play.google.com/store/apps /details?id=com.aportela.diets.view

[10] My Diet Diary Calorie Counter. https://play.google.com /store/apps/details?id=org.medhelp.mydiet

Technologies Supporting Care for Diabetes in Primary Care in the Czech Republic

Štěpán Svačina[1], **Igor Karen**[2], **Cyril Mucha**[2], **Jan Hendl**[3], **Martin Matoulek**[1]

[1] 3rd Medical Department of General University Hospital and Charles University, 1st Medical faculty, Prague, Czech Republic

[2] The Society of General Practice, Czech Medical Association J. E. Purkyně, Czech Republic

[3] Faculty of Social Science, Charles University, Prague, Czech Republic

Abstract

Introduction: Since January 1st, 2010 the care for uncomplicated diabetic patients has moved from the diabetes specialists in the Czech Republic and it can be provided by the general practitioners henceforth. We refer about the technologies supporting this new system of care.
Aim and methods: This paper reports on the information systems used to support the diabetes care in GP office and on the technologies connected to this system.
Results: There have been two types of information systems in use: PC DOKTOR, and MEDICUS. Two Internet standards: "Diabetes", and "Prediabetes", have been published and regularly updated. In the offices, there have been several laboratory devices for laboratory measurements used and directly connected to the information system.
Conclusion: The technical support for diabetes care has enabled a complex care for diabetic patient at the general practitioner's office even in the critical situation when the number of diabetic patients is extremely increasing.

Keywords

General practitioner, Information system, Diabetes care, HbA1c measurement, Diabetic patient record

Correspondence to:

Štěpán Svačina and Martin Matoulek
General University Hospital, 3rd Dept. of Internal Medicine
Address: CZ-1208 Prague 2, U Nemocnice 2, Czech Republic
E–mail: mmato@lf1.cuni.cz

EJBI 2014; 10(2):23–25
received: March 17, 2014
accepted: March 30, 2014
published: March 31, 2014

1 Introduction

In the past, the care for diabetic patients in the Czech Republic was organized by the Czech Diabetology Society and the patients were treated by the diabetes specialists. The number of diabetic patients has increased from 2% to 8%. Perhaps another 2-3% of diabetics stay unrecognized and about 5% of patients have the prediabetes. To solve this problem the Ministry of Health and the General health insurance company decided to move the part of diabetes care to general practitioners. Since January 1st, 2010 the care for uncomplicated diabetic patients in the Czech Republic has moved from the diabetes specialists and it can be provided by the general practitioners. The history of computer support of diabetes treatment in the Czech Republic is very long [1, 2]. Nowadays, two new problems have to be solved: new training of general practitioners (GP) and the technological support of this new system of care.

2 Methods

To support the care for diabetic patients in the GP office the following tasks have to be solved:

1. To find and adopt some information systems to support diabetes care in the GP office,
2. To educate general practitioners about the diabetes,
3. To introduce new laboratory devices to GP office and to connect them to the information system.

3 Results

In most offices, there have been two types of information systems in use: PC DOKTOR [3], and MEDICUS [4].

The PC DOKTOR website [3] also includes a demonstration video of the system. The module for GPs includes:

- Automatic detection of diabetic patients,
- Forming of dispensarisation group,
- Filling of patient's data,
- Checking of frequency of clinical and laboratory investigations,
- Generation of reports for an insurance company,
- Insurance code generation,
- Sorting of diabetic patients,
- Prescription of drugs,
- Yearly summary of diabetes care for the Ministry of Health.

The system can minimize the losses made at the insurance reimbursement for the health care, as well as optimize the income of office. It also sets the correct frequency of investigations.

Fig. 1 The screen for investigation of diabetic patient in the PC DOKTOR system (4 parts):

- investigations to be done at each consultation,
- investigations to be done every 6 months,

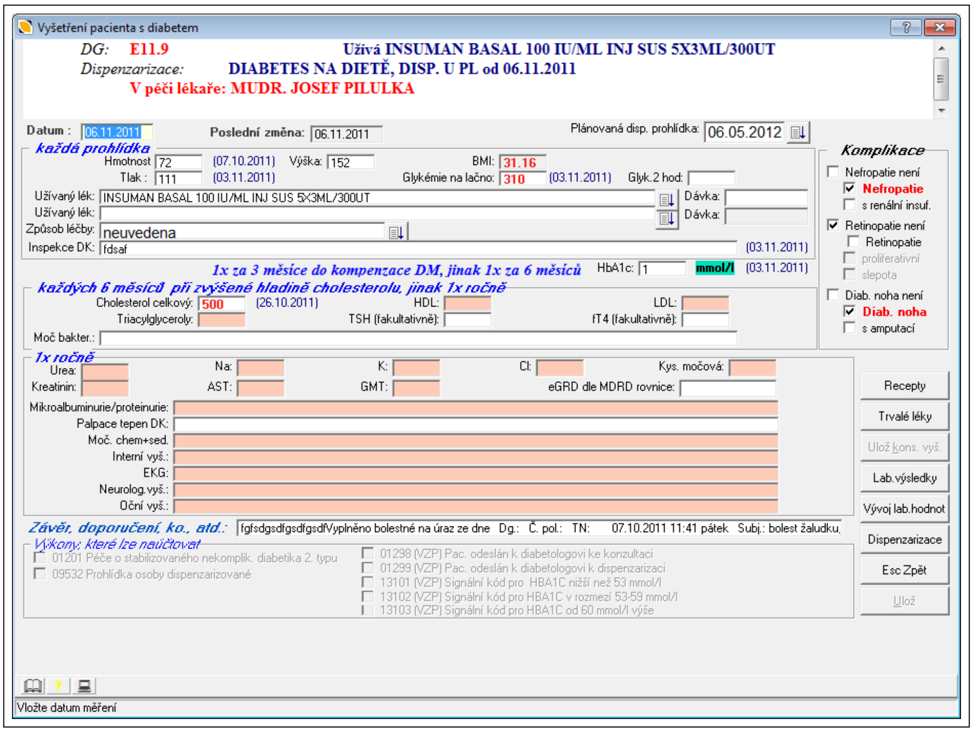

Figure 1: Screen for investigation of diabetic patient in the system PC DOKTOR [3].

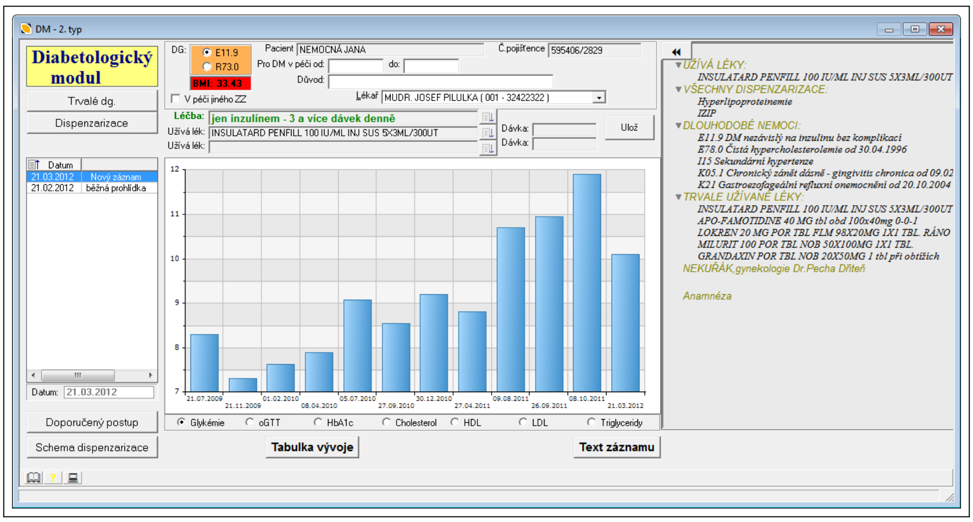

Figure 2: Review of laboratory data (blood glucose level) from one patient record [3].

- investigations to be done once a year,
- summary of insurance coding.

Fig 2 shows the summary of laboratory data from the record of one patient. The data can be filtered by investigation type – blood glucose level in this example.

To support the training of GPs two standards for "Diabetes" and "Prediabetes", concerning both diagnosis and treatment and evaluation of diabetic complications, have been defined, published, and also regularly updated on the Internet. The rules for sending the patients to the specialists are also included.

Several dry chemistry laboratory devices for laboratory measurements are used and directly connected to the system. The laboratory device has to be used directly in the GP's office.

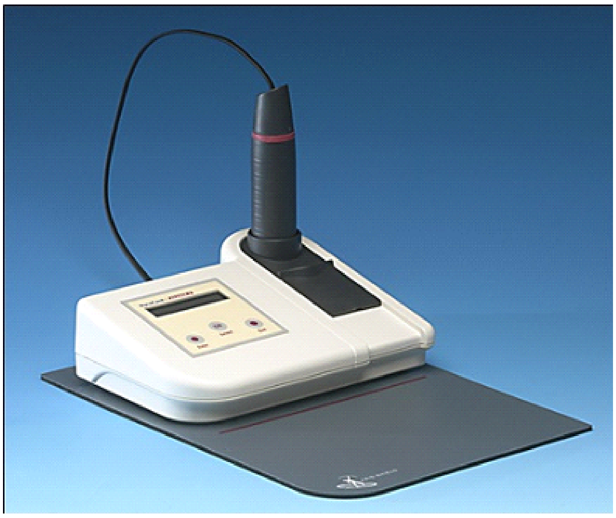

Figure 3: NycoCard Leader for HbA1c measurement.

The Quick Seal system enables to measure several parameters:

1. CRP – laboratory evaluation of the inflammation presence,
2. INR – coagulation test,
3. FOB – test for blood in stool,
4. HbA1c – long-term parameter of diabetes compensation,
5. Micro albuminuria – early detection of diabetes complications.

Figure 4: Quick Seal system Smart 700/340.

Both devices are used and directly connected to the information system in the office. Many systems for home blood glucose measurements done by the patients (glucometers) are also used. Data can be recorded to the information system from the patient's device.

4 Conclusion

The technical support for diabetes care has enabled a complex care for diabetic patient even in the critical situation when the number of diabetic patients is extremely increasing. Using the information system support, the general practitioners have been able to perform high quality care for diabetic patients.

References

[1] Svačina S, Malík M, Pacovský V, Hovorka R.: Computers in internal medicine [Article in Czech]. Vnitr Lek. 1987 May; 33(5):480-4.

[2] Svačina S., Hovorka R.(eds) Proc. of Computers in diabetes European Meeting, Czech Medical society, Karlovy Vary 1992.

[3] CompuGroup Medical Česká republika s.r.o. PC DOKTOR: Physician Information System [online]. 2014 [cit. 2014-03-23]. Dostupné z: http://www.pcdoktor.cz/

[4] CompuGroup Medical Česká republika s.r.o. MEDICUS: IS for Physician, Dentist, Hospital, Spa [online]. 2014 [cit. 2014-03-23]. Dostupné z: http://www.medicus.cz/