

TOWARDS BETTER MANAGEMENT OF DIABETES USING HEPTEx

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ABSTRACT. Diabetes remains a major challenge in Medicine in the 21st century. Managing diabetes involves not just lifestyle modification but also regular testing to detect any abnormalities that could lead to serious complications. With the presence of automated system, many clinical or pathology laboratories can now process a large number of test orders and generate clinical reports within a short time. Yet, most of these reports do not contain patient-specific interpretative comment that could assist physicians in decision making process for a better management of diabetes. This paper presents the development of an interpretative expert system module named HePTEx that interprets the health profile test report and adds patient-specific comments to the existing clinical reports. It enhanced the information richness of the existing clinical reports.

Keywords: diabetic management, interpretative expert system, clinical expert system, laboratory information system

INTRODUCTION

Diabetes is a controllable disease and is much easier to treat at the early stages; yet it is also a deadly disease if patients do not receive appropriate treatment. Diabetic management is therefore important to prevent or delay diabetes complications such as cardiovascular disease and kidney problems. Diabetes management includes lifestyle modification and regular check-up at the hospitals or clinics. Patient specimens taken during hospital visit are sent to clinical laboratory whereby various tests will be conducted. The advances in clinical laboratories to date have enabled automated handling and analysis of the specimens. Modern laboratories nowadays have been equipped with the Laboratory Information System (LIS) to support the processing at all stages in clinical laboratory workflow (Figure 1).

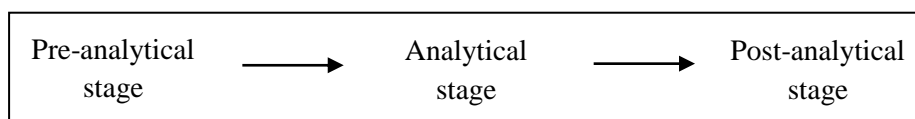


Figure 1. Stages of Clinical Laboratory Workflow

At pre-analytical stage, LIS handles patient check-in, order entry as well as the ordering physicians and patients' demographics. The processing of specimen takes place at the analytical stage and report is generated at post-analytical stage. Thus, LIS provides all the basic functionality needed for a clinical laboratory. Data from this area is very significant to the physicians as 60 to 70 percent of the most important decisions on hospital admissions, discharges and medications are based on laboratory test results (Forsman, 1996).

Despite the importance of the results, many LIS are still providing reports that contain generic, very test-focused result and without meaningful comment or interpretation (Williamson, 2001). This paper discusses the development of Health Profile Test Expert (HePTE_x) to demonstrate how better management of diabetes could be achieved by enhancing the LIS report with expert's interpretation.

HEPTEX FOR DIABETES MANAGEMENT

HePTE_x was developed to enhance the health profile test report produced by the Medical Diagnostic University Utara Malaysia (MDUUM). Figure 2 shows the current health profile test report that contains statistics of various tests including full blood count (FBC), lipid profile, renal profile, liver function, thyroid function, blood sugar level as well as traces of some types of cancer. To date, these results are presented as numeric values, and no interpretation of these values is provided. The report also contains list of reference range and indicators, in chart form, that show the position of each result whether it is within or outside the normal range.

MDUUM		MEDICAL DIAGNOSTIC UNIVERSITY UTARA MALAYSIA (MDUUM) UNIVERSITI UTARA MALAYSIA 06010 SINTOK, KEDAH DARILAMAN Tel: 04 - 9285951, 9285905, 9285917 (LABORATORY), 9285914 (X-RAY) Fax: 04 - 9241302	
CLINICAL LABORATORY REPORT			
Name :		Register Date :	26 - Apr - 2012 9:08
No. IC :		Matric No. / Staff :	
SID :	13097	Room :	
Gender :	FEMALE	Department / College :	UUM CAS
Age :	44 yr	First Report :	03/05/2012 06:55:12
Patient Type :	STAF	Reprint :	-
Patient History :		Printed By :	MAKMAL
		Page No :	2 / 2
		Record By :	MAKMAL
	RESULT	UNIT	REFERENCE RANGE
Granulocytes %	47.3	%	(40.0 - 75.0)
LIPID PROFILE			
Cholesterol	4.7	mmol/L	(3.6 - 5.2)
Triglycerides	1.1	mmol/L	(0.0 - 1.9)
HDL Cholesterol	1.2	mmol/L	(0.8 - 2.2)
LDL	3.0	mmol/L	(2.3 - 4.5)
Cholesterol/HDL	3.9	Ratio	(3.1 - 5.9)
RENAL PROFILE			
Blood Urea Nitrogen	4.2	mmol/L	(2.0 - 7.5)
Creatinine	64	mmol/L	(40 - 130)
Uric Acid	H 456	umol/L	(130 - 420)
LIVER FUNCTION TEST			
Total Protein	70	g/L	(60 - 83)
Albumin	43	g/L	(35 - 50)

Figure 2. Current MDUUM's Health Profile Test Report

The absence of interpretative comment is a major drawback of the current MDUUM's health profile test report. The chart indicators do provide minimal help, yet this does not accurately indicate the real health condition of patients. The same reference range is used for all patients; thus, the chart ignores patient's specific health condition such as diabetes, hypertension, high blood pressure and other diseases. For example, a diabetic patient whose LDL level is 3.0 mmol/L is shown as far below the maximum range. Doctor's interpretation, however, suggest that such reading is considered as high for a diabetic patient. The LDL level of a diabetic patient to be considered as far below the maximum range should less than 2.8 mmol/L; some experts suggest it should less than 2.0 mmol/L.

Methodology

HePTE_x development follows the normal expert system development approach in conjunction with Rapid Application Development (Figure 3). The first development phase emphasized on knowledge engineering (KE) activities. Due to the time constraint and restricted access to clinical pathologists, we only managed to involve two doctors at Hospital Bahagia Ulu Kinta (HBUK) and Hospital Kuala Lumpur (HKL) to participate in this project as our primary source of knowledge. Besides, knowledge was also acquired from the

secondary source, i.e. the Clinical Practice Guideline for Management of Type 2 Diabetes Mellitus (Ministry of Health, 2009).

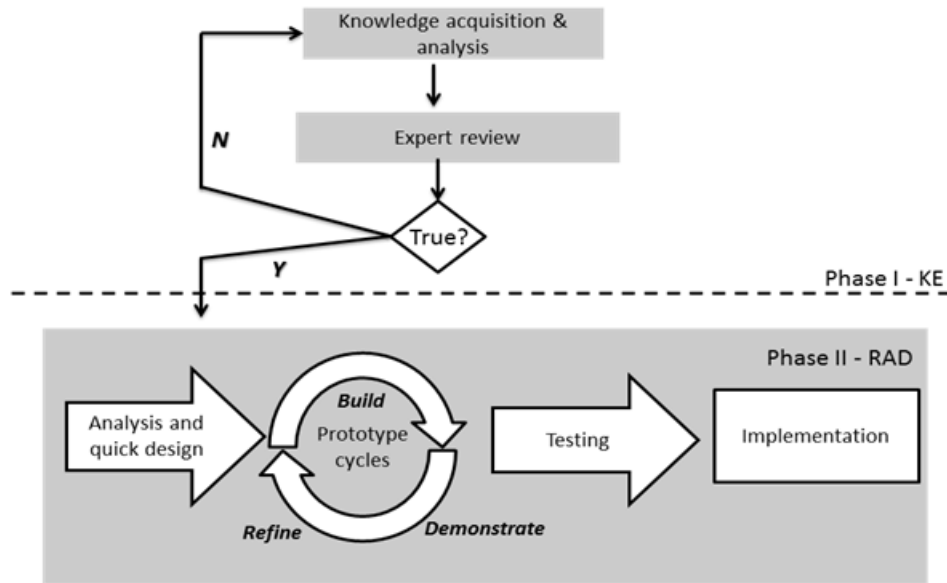


Figure 3. The Methodology

The form used during the acquisition process was based on the samples of health profile test reports of 20 patients. Each doctor was asked to interpret the results of every individual patient and comment according to their specific condition. The acquired knowledge was generalized into 18 production rules and presented to the doctors for verification. For each test there were rules for both normal and abnormal states. During prototyping at Phase II, these rules were converted into PHP codes, as shown in Figure 4 below, and stored in a single knowledge base.

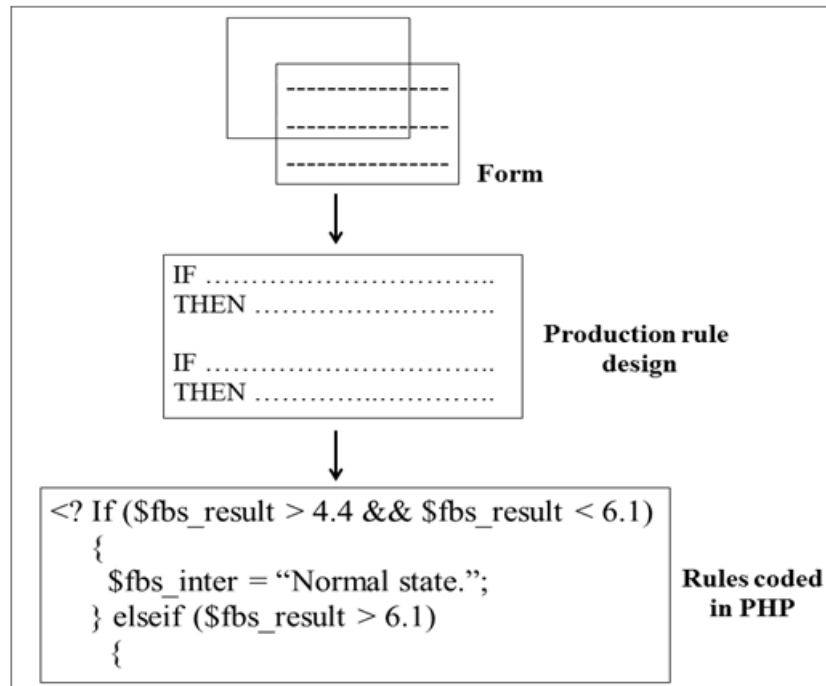


Figure 4. Stages of HePTEx Knowledge Base Development

RESULT AND DISCUSSION

Figure 5 shows the new report generated by HePTEx. Compared to the report produced by the existing LIS (Figure 2), the one produced by HePTEx contains richer content with experts' interpretation for every individual test conducted during the health profile test. Interpretation adds values to clinical reports as it contains expert-written, evidence-based and patient-specific comments, as suggested in Vasikaran et al. (2004), Laposata et al. (2004), Smythe & Drew (1997) and Williamson (2001).

CLINICAL LABORATORY REPORT WITH INTERPRETATION				
Date Today : 2012-12-31				
NAME	IC NUMBER	AGE	GENDER	PATIENT HISTORY
		42	Male	Diabetes
	RESULT	UNIT	REFERENCE RANGE	RESULT INTERPRETATION
LIPID PROFILE				
Cholesterol	6	mmol/L	< 4.9	Hypercholesterolemia state. Consider low sugar diet and regularly exercise. Assess for compliance. Consider to change drug regime if patient is compliant.
Triglycerides	6	mmol/L	< 1.7	Hypertriglyceridemia state. Consider diet control. If patient in diet control, consider to start statin. Assess for compliance. Consider to change drug regime if patient is compliant.
HDL Cholesterol	6	mmol/L	> 1.1	Normal state.
LDL Cholesterol	6	mmol/L	< 2.6	LDL Cholesterol is raised. Consider low sugar diet control and regularly exercise.
GLYCAEMIC CONTROL				
Fasting Blood Sugar	6	mmol/L	(3.89 - 5.89)	Normal state.
HbA1c	6	%	< 6.5	Normal state.
RENAL PROFILE				
Blood Urea Nitrogen	6	mmol/L	(2.0 - 7.5)	Normal state.
Creatinine	60	mmol/L	(40 - 130)	Normal state.
Uric Acid	6	umol/L	(130 - 420)	Assess in food intake and medication aspect.

Figure 5. HePTEx Report

Testing and evaluation of HePTEx were conducted with 2 doctors of Sultanah Bahiyah Hospital and a nurse of Jitra Health Centre. We used expert review approach whereby we asked the respondents to test the functionality of the prototype including the Login, Search Patient, Patient Registration, Insert Value and Result functions. In addition, questionnaires with 5 Likert-scale ranging from Strongly Disagree to Strongly Agree were also used. The 10 questions questionnaire was developed based on the guideline from IBM Computer Usability Satisfaction Questionnaire. The summary of the result is as shown in Table 1 below.

Table 1. Summary of Evaluation Result

Total Respondent: 3		1	2	3	4	5
1.	Overall, I am satisfied with how easy it is to use this system.					3
2.	I feel comfortable using this system.				3	
3.	I can effectively complete the tasks using this system.				3	
4.	I am able to complete my work quickly using this system.				3	
5.	This system is easy to understand and easy to use.				3	
6.	It was easy to learn to use this system.				3	
7.	Whenever I make a mistake in the system, system will let me know how to handle it.				3	
8.	The organization of information on the system screens is clear.				3	
9.	The interface of this system is pleasant.				2	1
10.	I like using the interface of this system.				2	1

The summary above indicates that all respondents were strongly agreed on easy to use aspect. All also agreed on aspects such as easy to understand and learn, comfortable, ability to complete task effectively and quickly, error assistance and clear organization of information. 1 out of 3 strongly agreed on pleasant interface aspect while the other 2 agreed.

Positive feedback was also received during expert review evaluation whereby the respondents recommended to broadening the scope of the prototype to high blood pressure and cardiovascular diseases.

The work presented in this paper is still significant despite the many similar attempts in the past (Cruise, 2006; Cursy, 2002; Edward, 2008; Kara, 2008; Mavio, 2003; Michael, 2001; Smitha, 2010). The use of expert system approach has its own significance in clinical area, in particular when there is a need to automate an interpretative task. Ivandic, Hofmann & Guder (2000) describe the task as complex, difficult and require high level expertise of clinical pathologists. Since as early as 1979, interpretation has been proven as one of the best candidate for expert system technology (Aikins et al., 1983). Recently, there have been a growing number of specimens that need to be processed every day by each laboratory and it is therefore unrealistic and impossible for the clinical pathologists to examine and provide specialist feedback to each one of them. The adoption of interpretative expert system within clinical laboratories nowadays is also favored by the aim to improve the quality of patient care and to achieve cost effectiveness (Metaxiotis et al., 2006). The growth is also associated to the progress in medical informatics (Heathfield, 1999). These systems work in the background to provide highly specific interpretive comments for laboratory results; they normally do not interfere with the existing clinical laboratory workflow, as long as careful integration plan was taken into consideration prior to their development.

Furthermore, it has been mentioned earlier about the importance of the data from clinical area to support physician's decision making. In the case of diabetic patients, for example, information about past medical history and pregnancy will provide more insights to the actual health condition of the patients. Having an automated interpretation system to utilize these data in-line with laboratory test result will enhance the quality of the data. The ordering physicians receiving the data can then tailor their management plan to specific needs of their individual patient.

The current version of HePTE_x still has limitation in a number of aspects, as describes next. At the moment, HePTE_x is not integrated with the existing LIS as well as the electronic patient record (EPR). We are aware of the need for integration as this will allow HePTE_x to automatically extract patient- specific data from EPR and laboratory test result from LIS. However, time does not permit us to carry out such integration during the undertaking of this small scale project. The temporary patient database we created to be used by HePTE_x contains only basic patient information. This, in some way can be considered as another limitation of HePTE_x. In light of this, future works should focus on integration between existing healthcare systems such as EPR, LIS and interpretative expert system.

CONCLUSION

A simple prototype of interpretative expert system, HePTE_x, has been developed to enhance the MDUUM's current health profile test report. The prototype meets its development objective but needs further enhancement if it is to be implemented as a fully functional system at MDUUM.

REFERENCES

- Aikin, J. S., Kunz, J. C., Shortliffe, E. H. & Fallat, R.J. (1983). PUFF: an expert system for interpretation of pulmonary function data. *Computers in Biomedical Research*, 16(199-208), 444-455.
- Cruise, A. (2006). Health evaluation through logical processing. *Decision Support System in Laboratory*. Retrieved from <http://neamh.cns.uni.edu/MedInfo/ldshs>.

- Cursy, J. (2002). Becton Dickinson laboratory systems. *Becton Dickinson Medical Information System*. Retrieved from http://www.computer.privateweb.at/judith/special_field3.htm#
- Edward, G. A. (2008). Expert systems for clinical pathology reporting. *PMC*. Retrieved from <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2556573/>.
- Forsman, R. W. (1996). Why is the laboratory an afterthought for managed care organizations? *Clinical Chemistry*, 42, 813-816.
- Heathfield, H. (1999). The rise and “fall” of expert system in medicine. *Expert Systems*, 6(3), 183-188.
- Kara, A. (2008). *Developing Expert System For Diabetes*. Bahcesehir University.
- Laposata, M.E., Laposata, M., Van Cott, E.M., Buchner, D.S., Kashalo, M.S., & Dighe, A.S. (2004). Physician survey of a laboratory medicine interpretive service and evaluation of the influence of interpretations on laboratory test ordering. *Archives of Pathology and Laboratory Medicine*, 128, 1424-1427.
- Mavio, G. (2003). ES Diabetes. *Expert System For Diabetes* , 100-180.
- Metaxiotis, K.S., Askounis, D.T. & Nikolopoulos, K. (2006). Identifying the characteristics of successful expert systems: an empirical evaluation. *International Journal of Information Technology and Management*, 5(1), 21-36.
- Michael, G. K. (2001). Automated Interpretation of Diabetes Patient. *Expert System for Diabetes Patient* , 101-190.
- Ministry of Health. (2009). *Clinical Practise Guideline*. Kuala Lumpur, Malaysia: KKM MALaysia.
- Smitha, V. (2010). Expert system for medical area. *Diabetes*, 56-70.
- Smythe, G. A. & Drew, C. M. (1997). REPCAT: desktop expert system for interpreting and validating laboratory data for phechromocytoma diagnosis with the database application Omnis 7. *Clinical Chemistry*, 43, 134-140.
- Williamson, S. (2001). *Pathology Information System*. United Kiingdom: LifeScience - Detent System.