Wireless Transfer of Sensor Data into Electronic Health Records

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Abstract

The purpose of this study is to explore how wireless transfer of sensor data can be implemented in existing Electronic Health Record (EHR) systems. Blood glucose data from people with diabetes Type 1 has been selected as the case. As proof of concept, a prototype for sending blood glucose measurements into an EHR system was developed for the DIPS EHR system. For the prototype to be transferable to a general setting, care was taken not to introduce any additional workload for the diabetes nurses or the diabetes Type 1 patients. In the prototype, the transfer of blood glucose data is automatic and invisible to the user, and the data is presented to the nurses within the existing DIPS laboratory module. To determine whether deployment of such a system would present any risks or hazards to patients (medical or financial), a risk analysis was performed. The analysis indicates that storing blood glucose values in the patient’s EHR does not represent any significantly increased risks for the diabetes patient. The study shows that existing EHR systems are well suited to receive sensor data. The three main EHR systems in Norwegian hospitals are all supported with application programming interfaces (APIs), enabling external vendors to add modules. These APIs are sufficient to implement modules for receiving sensor data. However, none of the systems currently have commercially available modules for receiving such data.

Keywords:
Blood glucose sensor, Diabetes, Diabetes nurse, Diabetes management system, EHR, Electronic health record, Risk analysis

1. Introduction

In the case of a chronic disease such as diabetes, much of the responsibility for managing the disease falls on the patient. When diagnosed, the patient is given a certain amount of initial training and information, but throughout the lifelong course of the illness it is primarily up to the patient to maintain the discipline required to keep blood glucose levels within recommended levels.

Monitoring and control of blood glucose levels are critical in the management of diabetes Type 1 to minimize long-term complications, and people with diabetes Type 1 may need to measure their blood glucose level several times a day [1,2]. Blood glucose measurements are performed by applying a single drop of blood to a measurement strip in a blood glucose monitor.
Norwegian health services put together diabetes teams, combining the skills of different professionals, to help and support patients with diabetes. A diabetes team may include doctors, diabetes nurses, secretaries, dieticians and paediatricians. If patients have poorly controlled diabetes they may require extensive, often continuous, follow-up, while well-regulated patients may require as little as one visit every six to twelve months.

The routines and strategies for storing and maintaining patient information vary between different diabetes teams and health services. The information may be stored on paper health records, in Electronic Health Record (EHR) systems or both. Some hospitals even use special software for storing diabetes health record information. The trend, however, is for health-related information to be collected in fewer and larger systems.

**Electronic Health Care Records in Norwegian hospitals**

During the last years there has been a considerable increase in the use of EHR systems in Norwegian hospitals. While only 36% of Norwegian hospitals had implemented EHR systems in 1999, this percentage had reached 84% in 2003 [3].

The Norwegian Centre for Informatics in Health and Social Care (KITH) is responsible for the Norwegian EHR standard. The standard is not mandatory, but the various health sectors may require EHR vendors to comply with certain parts of the standard. The standard is technology independent.

The three main providers of EHR systems for Norwegian hospitals are Siemens (Doculive), DIPS ASA (DIPS) and Tieto Enator (Infomedix). In 2001 the KVALIS project [4] conducted a survey on how Norwegian hospitals use these systems in clinical tasks. This study concludes that “doctors use electronic medical record systems for far fewer tasks than the systems supported” but for the task of “following results of a test or investigation over time” most doctors use the EHR system or other computer software if available.

Hospitals with an EHR system licence often tailor the EHR system to fit the individual hospital’s needs. Since smaller hospitals tend to have fewer or less complex needs, such hospitals are often pioneers in taking full advantage of EHR use [4].

This study investigates the feasibility of wireless input and long-term storage in Norwegian EHR systems of routinely collected diabetes data by the patients themselves.

2. Materials and methods

The three main EHR vendors in Norway were asked about the possibility for their systems to receive and use wireless sensor data, and we visited the software division of two of these vendors. We also had contact with external vendors making add-on modules for the EHR systems. Diabetes nurses at four different hospitals were interviewed to provide information on current diabetes practice and how they would prefer diabetes data presented in the EHR system.

The DIPS EHR system was selected to develop and test a prototype for wireless transfer of blood glucose values from patients.

Through collaboration with NR (the Norwegian Computing Centre), we performed a risk analysis. The purpose of this analysis was to investigate whether wireless transfer of blood glucose data from diabetes Type 1 patients into EHR systems is feasible and whether such a system presents any risks or hazards to the patients (medical or financial).
3. Results

The diabetes nurses who were interviewed said they would prefer to have the blood glucose values presented as a list. They said that it was easier to see the actual values when they were presented this way, and that it was faster for them to read a list than to interpret graphs or pie charts since they were used to traditional paper-based lists. However, data presented as pie charts and graphs were also found to be useful. [5]

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The three main EHR systems in Norwegian hospitals are all supported with application programming interfaces (APIs), enabling external vendors to add modules. This makes it possible for smaller or specialised companies to make software that extends or communicates with the EHR. The APIs are openly available for the Infomedix and the DocuLive EHR systems and licensed for the DIPS EHR system. All three EHR APIs contain sufficient functionality to receive and manage the sensor data applied in our prototype.

Chosen EHR system

To develop a prototype for wireless transfer of blood glucose data from diabetes Type 1 patients into an EHR system, we collaborated with DIPS ASA. The company provided access to a DIPS EHR server, complete with a set of fictitious patients, DIPS client software as well as support and technical help. The program for storing blood glucose measurements in DIPS was developed using the DIPS API, which is a COM+ interface. The DIPS API provides functions for creating and updating patient information, lab results, lab requisitions and documents. The interface also includes various search functions.

The prototype

The prototype for wireless transfer of blood glucose data into the DIPS EHR system is a further development of an NST prototype where an in-house developed Bluetooth unit automatically transfers blood glucose values from a OneTouch Ultra blood glucose monitor to a Nokia 7650 mobile phone using a Bluetooth connection [6], and where these data are sent from the mobile phone as an SMS to a preset phone number.

The only part of this process visible to the user is when the diabetes patient measures his/her blood glucose level using the blood glucose monitor.

When the blood glucose monitor is switched off after the measurement, the NST Bluetooth unit is automatically switched on and stays active for 3 minutes. If the Nokia 7650 mobile phone is within Bluetooth range (10 meter) a connection will automatically be established, and the last blood glucose measurement will be transferred. If the Nokia 7650 is not within range (or turned off), the blood glucose measurements taken will be sent the next time the Bluetooth unit is turned on and the phone is within range.

When the Nokia 7650 receives the blood glucose value from the patient, the phone will automatically send the measurement as a SMS to a preset phone number. In this study we have configured the Nokia 7650 to send the measurement data to a PC equipped with a Nokia D211 phone card. The measurement data received at the D211 server contains the blood glucose values together with the date and time of the measurement.

The D211 server runs a small application that accesses an external DIPS server using the DIPS COM+ API over an Internet connection (the Norwegian Health Network in a real setting). The values are stored as lab results in the DIPS EHR laboratory module. Once a measurement is stored in the DIPS server, any DIPS client connected to the server can
present it.

Figure 1 – Transfer of blood glucose measurements into the DIPS EHR system

The DIPS EHR client laboratory module is used to display lab results, and the blood glucose values can be displayed as a list of data or as a time graph.

Figure 2 – The DIPS lab module displaying blood glucose values

Risk analysis

In Norway, diabetes patients are not highly stigmatised, and in the case of Type 1 diabetes, the disease is typically not something the patient would hide from his/her surroundings. It is even considered as an extra safety if the surroundings know that a person has Type 1 diabetes, due to the characteristics and consequences of potential low blood glucose values. The OneTouch Ultra blood glucose monitor used in the prototype stores the last 150 values (without any security measures), and the other parts of the prototype are not considered to make the data more accessible for the surroundings. The security for the data once they are stored in the EHR is ensured through the security of the EHR system.
In this context our findings suggest that blood glucose values are not highly sensitive. For the data to be of interest to somebody other than the patient and the hospital, the attacker probably needs to collect data for a certain period of time. The probability of such an attack is small, as would be the consequences.

Blood glucose data as described in the prototype are typically used as a tool for communication between diabetes nurses and patients. Today, the patient brings a handwritten diabetes diary or a computer printout of these values to discuss diabetes management with the diabetes nurse. It is also common for many patients to give an approximate of the values based on memory. Storing the measurements automatically will simplify this process, and should not introduce any new security issues. Loss of data or incorrect measurements may still occur (through hardware or software failure or through intentional manipulation by the user). The average blood glucose level of a patient is also measured through the HBA1c, and this serves as a security mechanism. The measurements provided by the prototype are not by themselves sufficient for providing medical advice.

The Norwegian jurisdiction on confidentiality of personal data is very strict. There are several laws and security requirements that must be followed, addressing issues such as documentation requirements, professional secrecy, privacy protection, disclosure requirements and information requirements. Applicable laws include the Personal Data Act, the Health Personnel Act and the Personal Health Data Filing System Act.

It seems likely that no extra safeguards need to be applied for blood glucose data compared with those necessary for other types of personal data, and security should be satisfied with any solution that complies with Norwegian legislation. Security safeguards include:

- The receiver of the information (blood glucose data) should be able to verify the identity of the sender.
- Sensitive personal data that are transferred electronically via a medium that is beyond the physical control of the responsible institution should be encrypted. SMS messages are encrypted over the radio link from the mobile phone to the GSM base station. The messages are transferred in plain text from the GSM base station through the telecommunication network or the Norwegian Health Network, but tracing these messages in the network is very difficult.
- The data received should be handled in a sufficiently secure manner with respect to confidentiality, integrity, availability and quality.
- In order to be able to make demands with regard to security of the equipment used by the patients, the health care institution should consider whether they should own the equipment.
- Communications (transfer of data) to or from the hospital should be fully controlled by the hospital.
- The blood glucose data should be protected against unauthorised access on the patient’s side.

4. Discussion

Norway is approaching complete EHR coverage, and several hospitals are aiming to become totally paperless within the next few years. In order to gain the full benefits of this development, it is important that the EHR systems are not just electronic versions of the old paper-based health records, but take full advantage of the possibilities the new medium presents. EHR systems provide the possibility for automation of data retrieval, data structuring and data presentation. Transfer of sensor data from patients with chronic diseases is one such possibility [7].
In the case of diabetes Type 1, blood glucose data gathered automatically could support health personnel in helping and advising their patients in managing their disease. This function would also spare patients the trouble of keeping handwritten diabetes diaries. For an actual deployment of the system, SMS is probably too expensive. GPRS/3G should therefore be considered as an alternative for data transmission.

The concept can be applied to other settings, such as monitoring patient data at the patient’s home and in some cases shortening hospital stays or eliminating the need for hospitalisation.

5. Conclusion

Our study suggests that transfer of sensor data into EHR systems is feasible with the current Norwegian EHR systems. A prototype has been implemented as proof of concept. The risk analysis suggests that the implemented prototype is sufficient for testing in an empirical trial. This is a possible continuation of the project and would help to further understand the usefulness of the concept in diabetes management.

6. Acknowledgments

We would like to thank DIPS ASA and our partners in the Wireless Health and Care project of which this study is a part: Abelia, IBM Norway, Memscape, Norwegian Computing Center, Rikshospitalet University Hospital, Sintef and Telenor R&D.

7. Reference


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