



A mobile phone telemedicine system for the self-management of Type 1 diabetes: results of randomized controlled trial and measures of glycemc control

Oliver Gibson¹, Patrick McSharry¹, Paul Hayton¹, Andrew Farmer², Andrew Neil² and Lionel Tarassenko¹

¹ Department of Engineering Science, University of Oxford, UK

² Division of Public Health and Primary Health Care, University of Oxford, UK

Telemedicine system

A telemedicine system for diabetes self-management has been developed using a Motorola T720i mobile phone interfaced to a LifeScan One Touch Ultra blood glucose meter. Blood glucose measurements and patient diary information are transmitted in real time to a secure server, and graphical feedback is shown both on the phone screen and via a web site. The system has been tested in a randomized controlled trial in which the effect of remote nurse support was also studied.



Figure 1. The mobile phone, blood glucose meter and interface cable



Figure 2. Examples of screens shown by the phone software: a diary question and a colour-coded histogram

The telemedicine system functions as follows:

- The patient takes a blood glucose reading and connects the meter to the phone.
- Software on the phone downloads the reading, and asks the patient a short series of diary questions (insulin dose, diet, exercise, and any other events the patient wishes to record).
- The phone transmits the reading and diary information wirelessly to a secure server, using GPRS ("always-on Internet").
- Based on feedback from the server, the phone displays graphs and colour-coded histograms of blood glucose to assist the patient in interpreting their data.
- Clinicians and patients can view the data on a secure web site. Several different visualisations of the data are available, including time series plots with colour coding to highlight the relationships between insulin doses and subsequent blood glucose levels.
- The server prioritises patients for intervention, to optimize use of the clinicians' time. The clinicians can contact the patients using phone calls or text messages, as necessary.

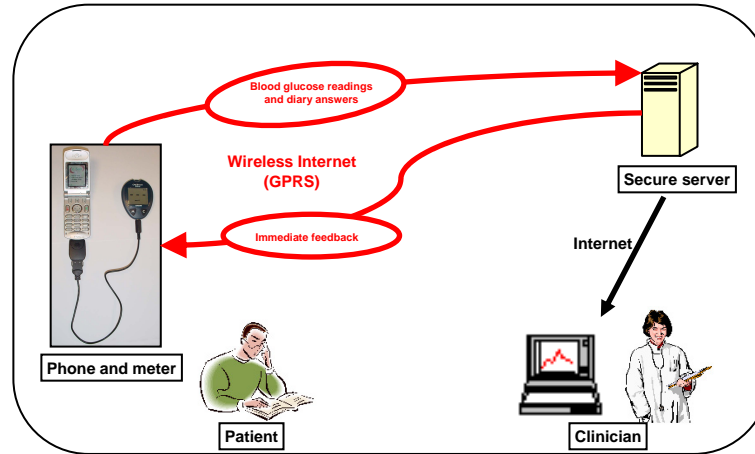


Figure 3. Overview of the telemedicine system

Randomized controlled trial design

- 93 patients with Type 1 diabetes (aged 18-30 years)
- All patients had sub-optimal glycemc control at recruitment (HbA1c 8% - 11%)
- Intervention and control groups used the telemedicine system for 9 months, but the intervention group additionally received proactive nurse support

Results

- 51,000 blood glucose test results transmitted.
- Intervention group HbA1c decreased from 9.2% to 8.5% (p=0.001)
- Control group HbA1c decreased from 9.3% to 8.9% (p=0.04).
- Difference in reductions between groups was not significant (p=0.3)
- Median of blood glucose measurements during trial was significantly different between groups (p<0.001)
- Compliance declined during the trial in the control group, but was maintained in the intervention group.
- The nurse time required was not excessive: 1.5 phone calls per patient per month, each lasting on average 7 minutes 9 seconds.

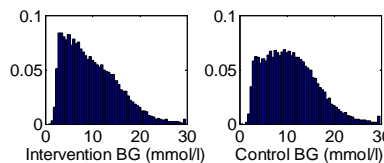


Figure 4. Histograms of blood glucose readings received during the trial from each group of patients, with areas normalized.

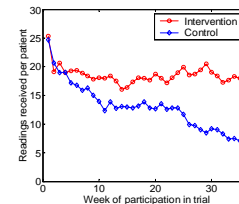


Figure 5. Mean number of readings received from patients in the intervention and control groups, during each week of participation in the trial.

Discussion

In comparison with previous telemedicine systems described in the literature, this system is portable, with immediate transmission of data and graphical feedback. It is largely based on standard components (the mobile phone and blood glucose meter are readily-available) and can easily be integrated into a patient's daily routine.

The randomized controlled trial showed that this technology can be used in a clinical setting to achieve improvements in glycemc control. Nurse support is essential if patients are to gain the most benefit from the system and maintain compliance, but the time demands on the nurses are not excessive (11 minutes per month per patient, on average).

Since the trial, the system has been developed further. A wide variety of modern mobile phones can now be used, and the interface cable has been replaced with a Bluetooth link to the meter.

Measures of glycemc control

The large data set of readings collected during the trial are being used to develop novel measures of glycemc control based on the prediction errors of a prediction model fitted to consecutive blood glucose measurements. A measure of glycemc control would allow a patient to be prioritised for clinician intervention when a loss of control is detected. Other, more specific measures will be studied with the aim of detecting particular patterns such as nocturnal hypoglycemia.

Acknowledgements

This trial was supported by an unrestricted grant from the Vodafone Group Foundation, and supported by e-San Ltd. The blood glucose meters were supplied by Lifescan.

References

- Tarassenko, L. et al. (2004). "Mobile phone technology to support the self-management of diabetes", Proc. Diabetes UK Annual Professional Conference, Birmingham, UK
- Farmer, A., Gibson, O. J., Tarassenko, L., and Neil, A. (2005). "A systematic review of telemedicine interventions to support blood glucose self-monitoring in diabetes", Diabetic Medicine 22(10), 1372-1378.
- Farmer, A., Gibson, O. J., Dudley, C., Bryden, K., Hayton, P., Tarassenko, L., and Neil, A. (2005). "A randomized controlled trial of the effect of real-time telemedicine support on glycaemic control in young adults with type 1 diabetes", Diabetes Care 28: 2697-2702.

For further information, please contact Oliver Gibson (oliver@robots.ox.ac.uk). See also <http://www.thinkdiabetes.com>