Implementation of telehealth support for patients with type 2 diabetes using insulin treatment: an exploratory study

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ABSTRACT

Background Initiating and adjusting insulin treatment for people with type 2 diabetes (T2D) requires frequent clinician contacts both face-to-face and by telephone. We explored the use of a telehealth system to offer additional support to these patients.

Methods Twenty-three patients with uncontrolled T2D were recruited from nine general practices to assess the feasibility and acceptability of telehealth monitoring and support for insulin initiation and adjustment. The intervention included a standard algorithm for self-titration of insulin dose, a Bluetooth enabled glucose meter linked to a mobile phone, an integrated diary to record insulin dose, feedback of charted blood glucose data and telehealth nurse review with telephone follow-up. Additional contact with patients was initiated when no readings were transmitted for >3 days or when persistent hyper- or hypoglycaemia was identified. Responses of patients and clinicians to the system were assessed informally.

Results The mean (SD) patient age was 58 years (12) with 78% male. The mean (SD) diabetes duration was 6.4 years (4.5), HbA1c at baseline was 9.5% (2.2), and the decrease in HbA1c at three months was 0.52% (0.91) with an insulin dose increase of 9 units (26). A mean (SD) of 160 (93) blood glucose readings was transmitted per patient in these three months. Practice nurses and general practitioners (GPs) viewed the technology as having the potential to improve patient care. Most patients were able to use the equipment with training and welcomed review of their blood glucose readings by a telehealth nurse.

Conclusions Although the concept of telehealth monitoring is unfamiliar to most patients and practice nurses, the technology improved the support available for T2D patients commencing insulin treatment.

Keywords: primary care, telehealth, type 2 diabetes
### Introduction

Supporting people in self-management of their long-term conditions is a key healthcare objective. Evidence for the benefit of programmes to fulfil this requirement is strong, but there is a need to extend current interventions to provide support for the increasing number of patients in ways that are better integrated with their day-to-day lives. Appropriate use of technology can make a major contribution towards enabling patients to monitor their health and make informed decisions about treatment. The term ‘telehealth’ is used to denote the use of a technology capable of providing the elements required for remote exchange of physiological data by electronic means, enabling self-management. Patients can use this technology at convenient times of day, at relevant stages in the progression of their condition, and with integration of clinician support. This type of technology has potential for wide reach at an affordable cost.

Self-management has potential to play a major role in improving outcomes for people with diabetes. Treatments of proven efficacy are available, yet these treatments are not always used appropriately. Insulin treatment for patients with T2D can bring about reductions in glycaemia, but patients may be reluctant to start using or to increase their insulin dose. Studies have suggested lack of acceptance of insulin therapy relates to anxiety about pain of injection, concerns that the disease has progressed, association of insulin therapy with catastrophic events, fear of hypoglycaemia, social embarrassment, perceived restrictions in lifestyle, and concern about weight gain. Support and reassurance are therefore needed to help acceptance of treatment, but the scale of the problem demands innovative approaches. Current clinical pathways for supporting patients involve either frequent clinic visits or routine visits supplemented by frequent telephone calls. Both options involve exchanging information about blood glucose results and providing advice on adjusting treatment, but they are also very time consuming. Support using telehealth technology may be a potential solution to this problem.

Telehealth is a term encompassing healthcare practices, particularly those benefiting patients with long-term conditions, which are supported by innovative telecommunication strategies. Our current telehealth project was preceded by a trial using a telehealth system to support patients with type 1 diabetes. Building on knowledge already gained we extended this work to examine the system’s potential to support patients with T2D to adjust their insulin dose to improve glycaemic control. We report here the way in which the telehealth system was set up and used, and the initial experiences and level of engagement of clinicians and patients.

### Methods

We undertook an informal review of the experience of patients and clinicians participating in a cohort study to evaluate the impact of telehealth support for people with T2D treated with insulin. Data for this review were obtained from notes made at the time of contacts with patients, clinicians and practice teams, informal observations by members of the telehealth nurse and research team, and from comments made by patients in completing study questionnaires.

The study was set in larger (list size >6500) Oxfordshire general practices. Patients with HbA1c >7.5% commencing treatment with a basal insulin regimen during the past 12 months were invited to take part. Patients unable to use a mobile phone for visual or sensory reasons or who were unable to self-test their blood glucose were excluded from the study. All patients and practices provided material for this review.

Patients entering the study were given a mobile phone with a preloaded software application, and a blood glucose meter linked to the phone via a Bluetooth cradle. The telehealth software used in the study was based on a commercially available system t+ Diabetes (supplied by t+ Medical, Abingdon, UK). It provides real-time data transmission and feedback to patients on their mobile phone through: (i) transmission of blood glucose test results and real-time feedback of trends to the mobile phone; (ii) an electronic patient diary with the facility to record insulin doses; and (iii) a facility to transmit blood pressure results and weight. Patients were provided with immediate feedback including summaries and charts of entered data allowing them to monitor and make decisions about future self-management (Figure 1). The telehealth nurse and other clinicians were provided with access to password protected web-based summary and feedback screens and the capacity for automated messaging to patients’ mobile phones for alerts and reminders. Patient’s telehealth data could be viewed securely by the telehealth nurse and the patient’s clinician, without the necessity of a face-to-face visit.

### Procedures

The process of using the telehealth system in the study was designed to match, as far as possible, current clinical practice for managing insulin treatment for patients with T2D with the addition of a clinically feasible protocol for telehealth support. Recruitment to and participation in the study followed standard procedures, with patients identified through review of practice lists and invitations issued to eligible patients. Following informed consent, blood samples were...
Implementation of telehealth support for patients with T2D using insulin treatment

Patients were offered a standard educational package with information about the need for insulin treatment, requirements for blood glucose self-monitoring, training with respect to injection technique and information about what to do in the event of hypoglycaemia. Clinical staff at each general practice asked patients to adjust their own insulin dose by two units every three days based on self-monitored glucose levels. Patients were encouraged to monitor their blood glucose levels a minimum of once a day according to the advice of their general practitioner or practice nurse. Once target blood glucose levels were achieved, self-monitoring continued less frequently to identify any further requirement for insulin dose adjustment.

Training in use of the telehealth system was provided by the telehealth nurse at the first study visit. These visits took place at the patient’s general practice and the training took between 30 and 60 minutes to complete. A short training and support manual containing information about use of the system and viewing data was given to each patient. Following the initial training session patients were provided with a mobile telephone number for the telehealth nurse and were asked to contact her if they had any questions or problems.

The telehealth nurse reviewed transmitted patient data every two to three days with the following criteria for making additional telephone contact with the patient in advance of routine two to four weekly contacts:

- failure to receive blood glucose readings >3 days
- a seven-day trend of higher than usual blood glucose readings (fasting blood glucose levels >7.5 mmol/l)
- a single record of blood glucose <4 mmol/l or a diary entry of hypoglycaemia
- patient-specific excursions from usual trend (see Box 1 for examples).

Box 1 Patient case histories illustrating impact of telehealth intervention

Patient T029 was contacted by his practice nurse after five days of blood glucose readings >11 mmol/l. His insulin regimen was reviewed and he was requested to make weekly visits until a significant reduction in blood glucose levels was achieved. At follow-up visits it became clear that he had been missing out insulin doses to facilitate weight loss. He was referred to a dietician.

Patient T030 had a blood glucose reading of 30.5 mmol/l and was contacted by the telehealth nurse who discovered that the patient had drunk three cans of coca-cola a few hours before performing the test. He was advised about the high sugar content of fizzy drinks and the association of sugar and carbohydrate intake and increased blood glucose levels.

Printouts of these readings were also sent to practice clinical staff every two weeks. The telehealth nurse encouraged patients to follow the recommendations...
for insulin titration, but clinical care remained with
the practice nurse and general practitioner who were
advised by email or telephone of abnormally high
results or abnormal trends so that they could make
additional recommendations to the patient.

Results

Recruitment

Twenty-three patients were recruited from nine gen-
eral practices across the Thames Valley. Patient char-
acteristics are recorded in Table 1.

Practice views on the technology and
the research

Clinicians reported that they valued three aspects of
the telehealth system: (i) the ability to access up-to-
date information about patients’ blood glucose read-
ings and insulin doses; (ii) the potential to support
patients in making their own adjustments to insulin
regimens; (iii) the opportunity given by the telehealth
system to help patients with diabetes enhance their
personal control over the day-to-day management
of their diabetes. Overall the telehealth system was
perceived by clinical staff to be a valuable support tool
for helping patients and for making them more confident
in their self-management. They also reported that the
ability to access the mobile phone technology was
valued, and it helped them to provide a more timely
response to patients who were having problems
managing their diabetes. Finally, the telehealth system
was seen as a way of enhancing patients’ understanding
of their condition and improving their compliance
with treatment. These findings are in keeping with
those reported in other studies of telehealth systems
for people with diabetes, which have shown that they
are effective in improving patients’ knowledge, self-
efficacy, and treatment adherence.

Six out of the 15 practices approached declined the
opportunity to participate in the study. Reasons given
included: (i) their practice nurses were overstretched
and unable to take on further commitments; (ii) the
general practice was moving premises and would not
take on further work at that time; and (iii) as a policy
decision, the practice did not participate in any
research studies.

During initial meetings between the telehealth nurse
and general practice staff, the following issues were
raised about the use of the mobile phone technology,
most of which required explanation of the concept of
telehealth and healthcare policy:
• the meaning of the term telehealth, both generally
  and in relation to the study
• how telehealth relates to the implementation of
  national guidelines and policies for information
  communications technology
• relevance of telehealth to national and local stan-
dards and guidelines for the support of patients with
  diabetes in their day-to-day lives
• current evidence for standards of practice relating to
  insulin regimens
• telehealth technology and its appropriateness for
data gathering, data review and interpretation
• confidentiality and anonymity with respect to data
  transfer and messaging
• benefits of accessing information via the ‘world
  wide web’
• patient data monitoring by a telehealth nurse
• future opportunities and possible developments in
  the field of telehealth
• scope of interaction between a telehealth nurse and
  the practice-based clinicians.

Table 1 Baseline patient characteristics: n=23

<table>
<thead>
<tr>
<th></th>
<th>%</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age in years</td>
<td>57.6</td>
<td>12.0</td>
</tr>
<tr>
<td>Duration of diabetes (months)</td>
<td>77.2</td>
<td>53.6</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>101.3</td>
<td>26.6</td>
</tr>
<tr>
<td>BMI</td>
<td>33.2</td>
<td>6.3</td>
</tr>
<tr>
<td>Systolic BP (mmHg)</td>
<td>144</td>
<td>18</td>
</tr>
<tr>
<td>Diastolic BP (mmHg)</td>
<td>84</td>
<td>8</td>
</tr>
<tr>
<td>HbA1c (%)</td>
<td>9.5</td>
<td>2.2</td>
</tr>
<tr>
<td>Insulin dose (units)</td>
<td>51.5</td>
<td>39.5</td>
</tr>
</tbody>
</table>
None of the nine practice nurses involved in the study exploited the opportunity to review patients’ transmitted data via web pages. Printouts of data were sent to practices at two-weekly intervals for information, but the contact from the telehealth nurse for alerts where necessary was seen as more valuable.

Patients’ views on the technology

Patients quickly and enthusiastically engaged with the study and were keen to take part both for their own benefit and because of the perception that others might also benefit. They reported feeling more ‘in control’ of their diabetes and having increased confidence to self-manage insulin titration.

During their first study visit patients were asked how frequently they monitored their blood glucose levels. In all cases patients were in the habit of performing a daily fasting blood glucose reading and in several cases an additional one or two tests per day following guidance from their clinician. Individual monitoring schedules remained as previously specified and were not varied due to study participation. All patients had previously been trained to carry out self-monitoring of blood glucose although technique in carrying out the procedure was checked.

Patients were instructed to follow the self-managed dose adjustment algorithm. The telehealth nurse reviewed transmitted glucose results data, either by computer-prompted or routine two-to-four weekly telephone follow-ups, and encouraged patients to follow the self-managed titration schedule. Some patients reported discontinuing the regimen after a few weeks because of a concern that they were taking too much insulin despite daily fasting blood glucose readings frequently above 7.5 mmol/l. Following liaison between the telehealth nurse and practice-based clinicians, patients were reassured that they could continue to follow the titration algorithm with the aim of achieving an HbA1c <7.5%.

The majority of patients called the telehealth nurse with questions at least once during the initial two weeks. Patients who had never used a mobile phone before required additional support to assist them in navigating the phone’s menu systems.

Some patients expressed concern that they might be ‘judged’ on their blood glucose control. Reassurance was offered, explaining that results would be monitored for trends over time and to ascertain the correct insulin treatment regimen. Patients were also surprised and reassured to learn that most people had their ‘bad days’ where their glucose levels were raised beyond the normal range. This reduced any concerns patients might have regarding distant monitoring and motivated them to continue transmitting information during the course of the study.

Feasibility of the technology

A number of issues relating to use of the technology were identified in the early part of the study as a result of phone calls made by study participants to the telehealth nurse. These system usage problems were classified by call type and actions taken or recommendations given (Table 2).

Interim clinical and technical outcomes

Mean (SD) HbA1c at baseline was 9.5% (2.2), and the decrease in HbA1c at three months after the start of the intervention was 0.52% (0.91) with a mean (SD) insulin dose increase of nine units (26). A mean (SD) of 160 (93) blood glucose readings were transmitted per patient.

Discussion

We found that the concept of telehealth monitoring was unfamiliar to most patients and practice nurses. While clinicians valued the additional patient monitoring and support that resulted from patients using the telehealth system, the telehealth nurse carried out the majority of data review and patient communication. Patients were enthusiastic about the additional level of support facilitated by the telehealth system and felt that the service complemented their primary care services. Previous experience with a mobile phone enabled more rapid adoption of the telehealth system. Early findings indicate that the transmission of results is maintained throughout the study.

Clinicians expressed concerns about the extent to which use of a telehealth approach might lead to patients becoming increasingly dependent on external guidance for day-to-day disease management. The way in which the technology is implemented has potential to undermine the extent to which patients are confident in their own disease self-management. One of the principles used in designing the system was that it should not make additional demands on clinical staff at the practice. Clear agreements would be needed on the respective roles of the telehealth nurse and the practice-based clinicians in future implementation of the system. Despite the design of the system, some concerns about the potential for increased demands on practice-based clinicians remained, although the benefits of reduced patient travel and ease of obtaining and reviewing patient data were recognised.
Following the initial use of technical language to describe the system, some clinicians expressed concerns that this might mean the requirements of the study were complex and would require extensive training. Further discussions using familiar concepts helped some clinicians engage with the study. Patients could also find the use of jargon off-putting, while more technically minded patients requested more detail. Therefore, training and support documentation need to address the range of participants’ individual knowledge, interests and expertise. People with visual impairment or disturbed touch sensitivity may be unable to use the current mobile phone technology. However, it is possible with most mobile phones to increase the resolution of the screen display. Research would be required to verify that the larger displays would be acceptable to people with visual impairment.

A telehealth system, such as the one adopted for this study, provides the means for a telehealth nurse, liaising with the practice, to better understand a patient’s insulin usage on a daily basis and to enable appropriate medication titration. Patients taking part in this study were able to view their blood glucose readings in several different formats and were aware that a clinician was also actively monitoring them. Engaging people with diabetes in their own care is a core part of the National Service Framework delivery strategy and the high levels of transmission of blood glucose results and enthusiasm for use of the technology by patients suggest that it has clinical utility.

**ACKNOWLEDGEMENTS**

The Telehealth Programme is supported by the NIHR Biomedical Research Centre, Oxford (also funding JT and ML) and the NIHR School of Primary Care Research. Technical support was provided by t+ Medical (Abingdon, UK).

### Table 2 Technical problems experienced in using the telehealth system

<table>
<thead>
<tr>
<th>Call type</th>
<th>Action/recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifiable technical problems, such as phone transmission or application errors</td>
<td>Normally resolved by the telehealth nurse or escalated to the application supplier’s front-line support team</td>
</tr>
<tr>
<td>Ongoing training relating to certain aspects of the application or monitoring system</td>
<td>The telehealth nurse provided telephone training or visited the patient at their home. Additional training materials were also provided including a step-by-step user guide and more detailed training manual</td>
</tr>
<tr>
<td>Mobile phone service provider problems, insufficient signal or lack of phone credit</td>
<td>Service provider issues normally due to temporary network faults and resolved without action. If signal insufficient patient advised to transmit in area with stronger signal strength. Phone credit topped up remotely by telehealth nurse</td>
</tr>
<tr>
<td>Bluetooth cradle fault or battery failure</td>
<td>Cradle replaced by post or by telehealth nurse visit. New battery provided</td>
</tr>
<tr>
<td>General enquiries, such as ‘I’m going on holiday, will my phone still work and what do you want me to do while I’m away?’</td>
<td>Advice and guidance provided by the telehealth nurse. If patients travelled abroad they were requested not to use their phones but to continue monitoring their blood glucose and to download the results on their return</td>
</tr>
</tbody>
</table>

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Providing support for patients with T2D during the early stages of insulin treatment is demanding. Future direction of development of the telehealth system will depend on the findings from this and similar studies. For example, there is the possibility of providing text-message alerts to the telehealth nurse if patients experience blood glucose excursions outside a pre-defined range. Equally, decision support could be directly targeted at patients and encourage adherence to the titration regimens. However, there is no current view on the extent to which advice determined through an algorithm requires clinician review. New ways of working are likely to develop that will cut across traditional boundaries between primary, secondary and social care.

A telehealth system, such as the one adopted for this study, provides the means for a telehealth nurse, liaising with the practice, to better understand a patient’s insulin usage on a daily basis and to enable appropriate medication titration. Patients taking part in this study were able to view their blood glucose readings in several different formats and were aware that a clinician was also actively monitoring them. Engaging people with diabetes in their own care is a core part of the National Service Framework delivery strategy and the high levels of transmission of blood glucose results and enthusiasm for use of the technology by patients suggest that it has clinical utility.
REFERENCES


CONFLICTS OF INTEREST

None.

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