

Rhodes House meeting  
2 December 2010



UNIVERSITY OF  
OXFORD

# Self-monitoring of Blood Glucose Current and future technology (using mobile phones)

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Prof. Andrew Farmer, Prof. Andrew Neil

Dr Paul Hayton, Dr Oliver Gibson

Prof. Lionel Tarassenko, FREng

Professor of Electrical Engineering

Director, Institute of Biomedical Engineering

University of Oxford

# 25 years ago: The launch of the UK cellular telephony service



# 10 years ago – Mobile phones and health

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August 2<sup>nd</sup>, 2000

## Are companies liable for cell-phone health risks?

CIOs need to ensure that their companies' employees operate cell phones and other wireless devices in a manner that reduces health risks associated with radiation... or face the legal consequences.



All mobile phones banned inside hospitals

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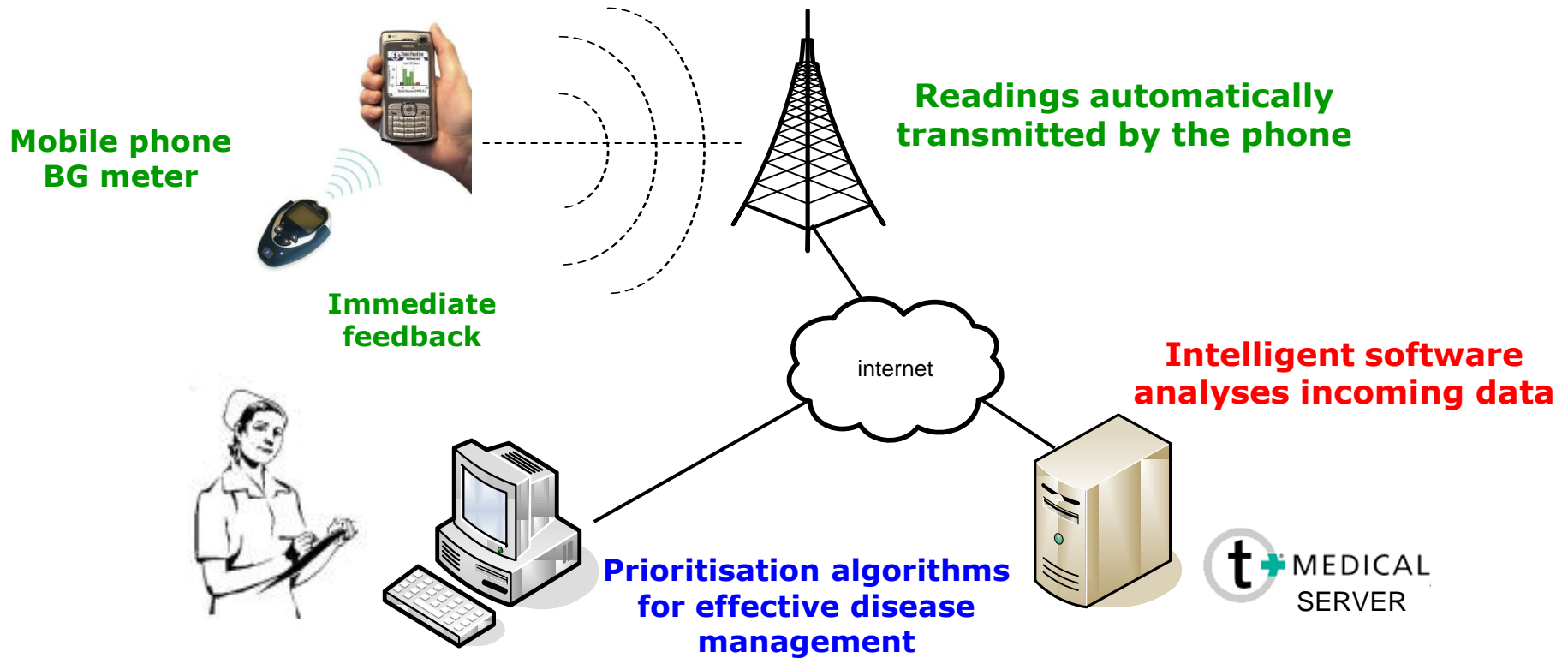
# Mobile phones and health

## What has changed between 2000 and 2010?

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- Studies (e.g. Stewart report, WHO reports, BMJ paper in 2006) have shown minimal health risks associated with mobile phone use.
  - General Packet Radio Service (GPRS) was launched in Europe in 2002:
    - GPRS and now 3G allow for the *real-time transfer of data* (including medical data) to and from a remote server, using the mobile phone for both data entry and/or review.
  - Mobile access to the internet is now a reality.
  - Mobile phones are now seen as sophisticated tools to facilitate delivery of healthcare → mHealth
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# mHealth for diabetes (2003-6)



- Mobile phone technology for diabetes management developed in collaboration with Dept of Primary Care (Andrew Farmer and Andrew Neil)

# mHealth for diabetes

## Patient diary

**Last meal**

How long is it since you last had a meal?

**0-1 hour**

1-2 hours

2-4 hours

4-8 hours

More than 8 hours

Back Next

**Exercise**

How much exercise will you do today?

**Skip**

Less than usual

About average

More than usual

Back Skip

**B.G. Reading**

Enter your Blood Glucose Reading (0.0 - 38.0)

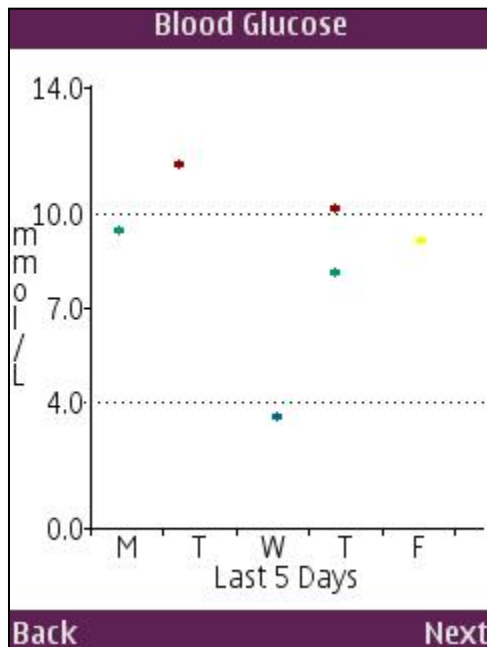
mmol/L

Press BT for Bluetooth link

Back BT Skip

# mHealth for diabetes

## Personalised feedback screens

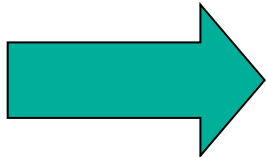


# Regular support from telehealth nurse



Telehealth  
Nurse

Messaging  
service



Contact Us  
0800 389 3205  
info@tplusmedical.com

My Account Patients Support Forum Education Shop Clinic

You are here: Home > Patients > View Patient

Language: English Select

Hello t+!

Log out

John Buchan  
174E Milton Park

Oxfordshire  
OX14 4SE

Mobile: 07825035377

Landline: +441235432050

Date of birth: 16/05/1967

Diabetes Type: Type 1

Clinic: ZZZ t+ Medical UK  
Diabetes Clinic

Healthcare Service ID (e.g.

NHS ID): 456372891123

Hospital ID: 987654321

Health Details

Send Message

Medical Notes

Send Message

[Text input area for medical notes]

Send as t+ message  
 Send as SMS Message

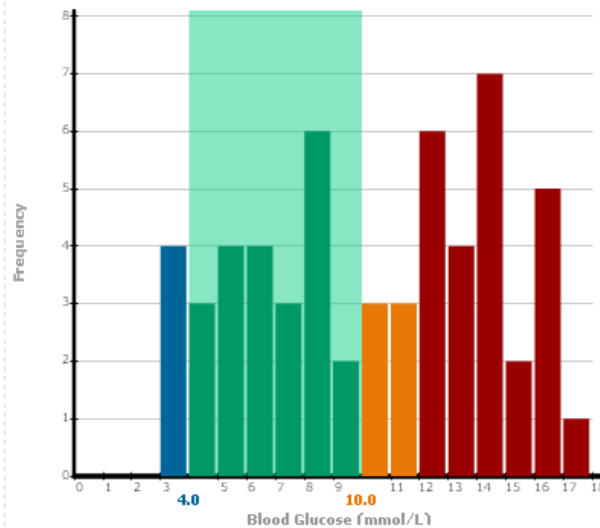
Send Message

Chart for John Buchan Report: Histogram mmol/L  
Date Range: Last 30 days From: 18 Mar 2008 To: 17 Apr 2008 Apply

Histogram

from 57 readings

Chart



- Histogram
- Glucose Trend
- Insulin Track
- Data List
- Standard Day
- Modal Day
- Averages
- Pie Charts
- HbA1c
- Predicted HbA1c
- E.P. Averages
- Blood Pressure
- Weight

Print

# Oxford Diabetes Type 1 clinical trial



Division of Public Health and Primary Care  
University of Oxford



## Principal Investigators:

- Prof. L. Tarassenko
- Prof. A. Neil
- Dr A. Farmer

- 9-month *Randomised Controlled Trial* with patients from Young Adult Clinic
- Inclusion criteria:
  - Type 1 diabetes, aged between 18 and 30
  - Twice daily or basal bolus insulin therapy
  - Poor glycaemic control (HbA<sub>1C</sub> between 8 and 11%)
- Aim to detect a difference of 0.7% in HbA<sub>1C</sub> based on baseline mean value of 9%

# Oxford Type 1 diabetes clinical trial



Division of Public Health and Primary Care  
University of Oxford

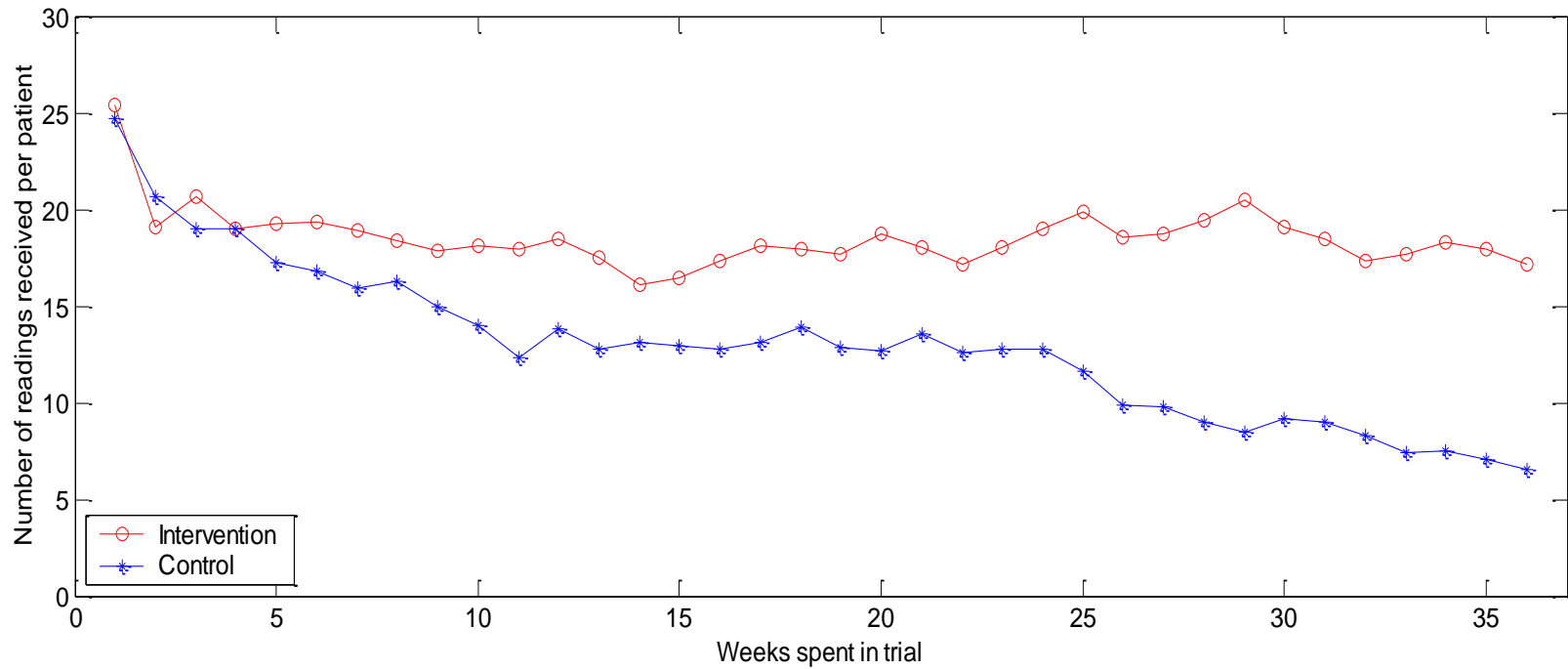


## Principal Investigators:

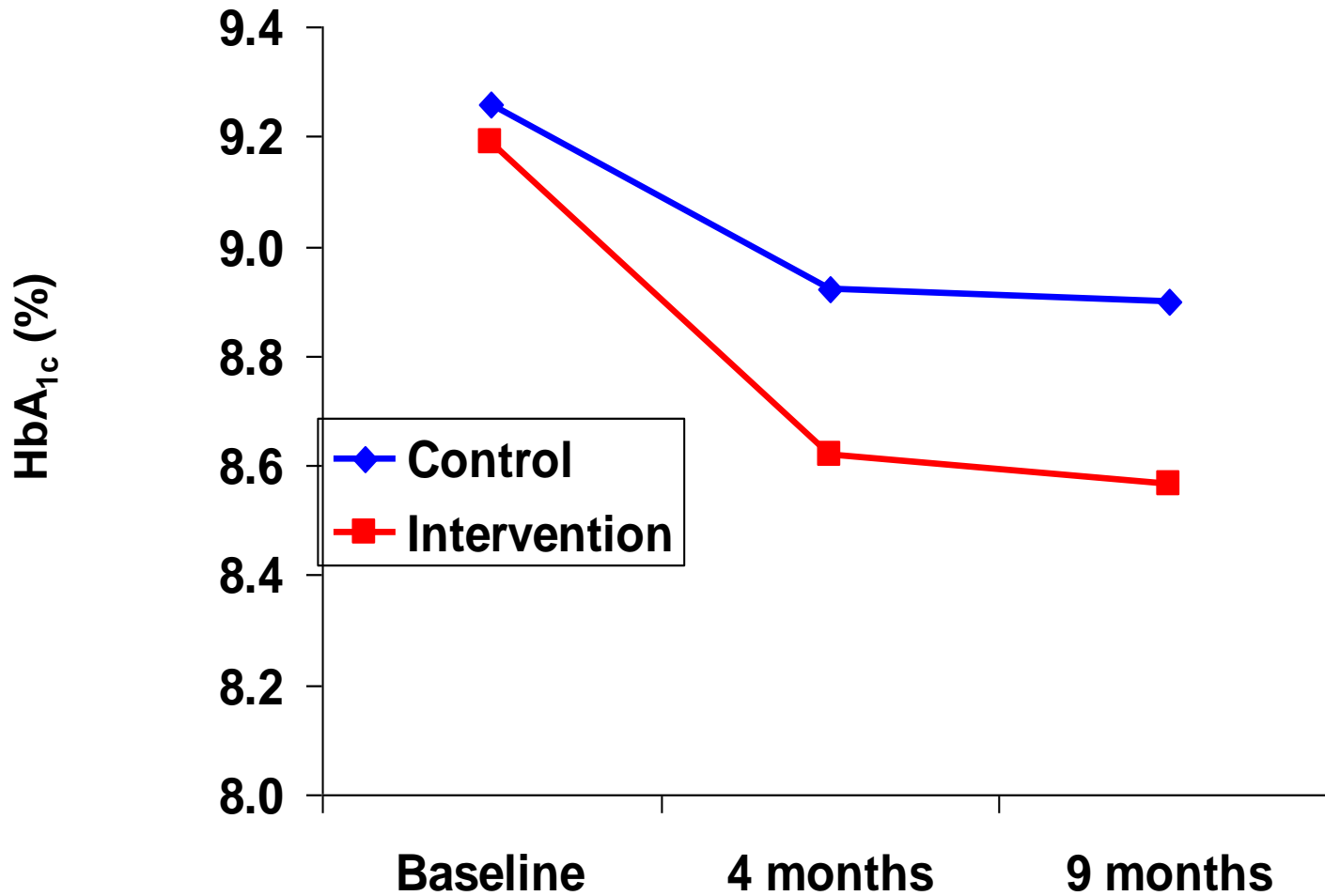
- Prof. L. Tarassenko
- Prof. A. Neil
- Dr A. Farmer

- 9-month *Randomised Controlled Trial* with patients from Young Adult Clinic
- Control group: mobile phone + Bluetooth BG meter + electronic patient diary
- Intervention group: mobile phone + Bluetooth BG meter + electronic patient diary + feedback screens + telehealth nurse support

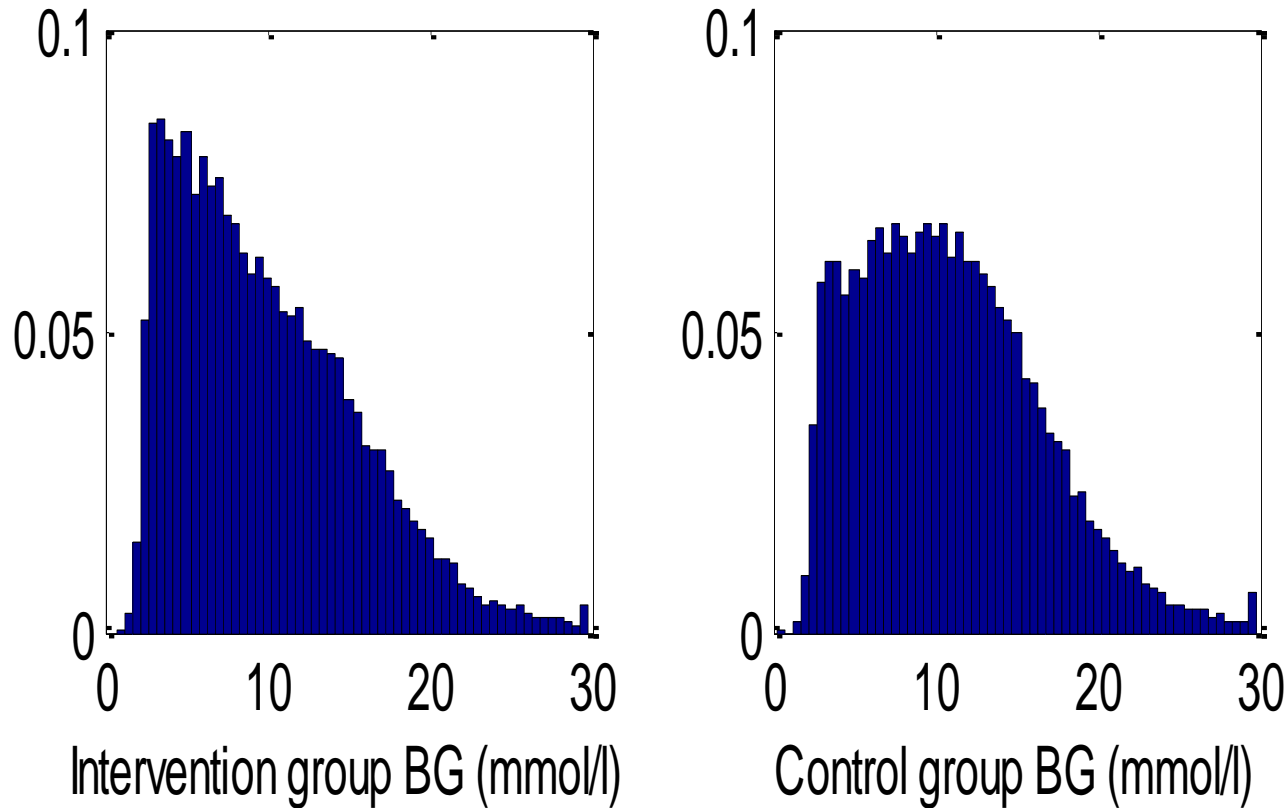
# Results – patient compliance



# Changes in HbA<sub>1c</sub> over 9 months



# Blood Glucose distribution in each group



For intervention group, mean BG = 8.9 mmol/l

For control group, mean BG = 10.3 mmol/l

# The Oxford Type 1 diabetes clinical trial

## Summary of results

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- Statistically significant reduction in HbA<sub>1c</sub> in intervention group after 9 months from 9.2% to 8.6% (difference 0.62%, P = 0.001)
- Statistically significant difference between the two groups in the number of well-controlled patients (HbA<sub>1c</sub> ≤ 8.0%) at 9 months compared to baseline: from 11% to 49% in the intervention group and from 18% to 25% in the control group (P < 0.0002)
- Cost-effective way to improve outcome without substantially increasing resources: telehealth nurse only spent, on average, 11 minutes per month per patient in the intervention group.

# mHealth for Type 2 diabetes (2007-2010)

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- Focus on *targeted interventions for short periods of time* during which mHealth can deliver maximum benefit in terms of both improved patient outcomes and NHS efficiency:
    - Insulin titration in Type 2 diabetes
    - Self-titration of oral medication in Type 2 diabetes
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# Insulin titration in Type 2 diabetes

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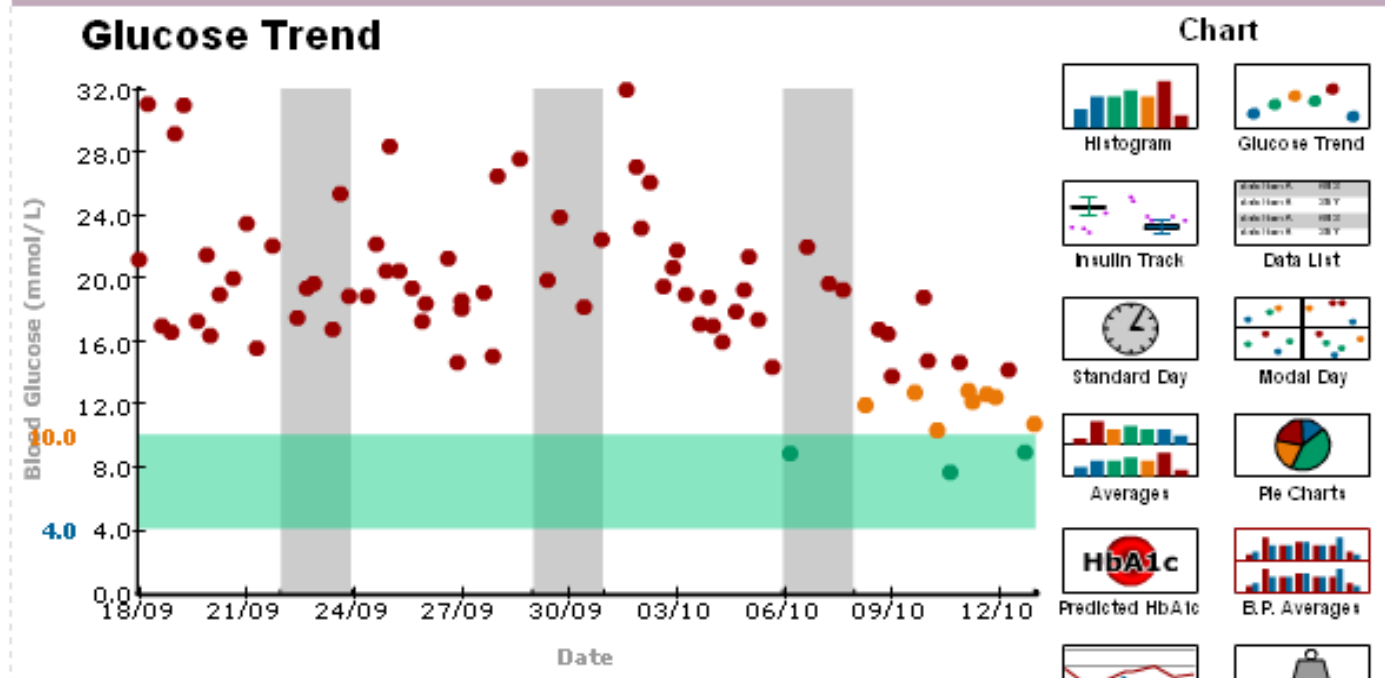
- 28 patients with type 2 diabetes recruited from 15 General Practices in Oxfordshire (23 male, 5 female)
  - Mean age = 58 years, with an average diabetes duration of 6 years
  - Mean body weight = 97 kgs (mean BMI of 32)
  - Mean HbA<sub>1c</sub> at the start = 9.5% (Target is 7.5% or below)
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**Hello Jane!**  
[Log out](#)

**User Nine**  
Broadshires Health Centre  
Broadshires Way  
Oxfordshire  
OX18 1JA  
**Mobile:** 07964214850  
**Landline:** 01865289261  
**Date of birth:** 01/01/2000  
**Diabetes Type:** Type 1  
**Clinic:** Broadshires Health Centre (Gini Trial)  
**Healthcare Service ID (e.g. NHS ID):**  
**Hospital ID:**

**Health Details**  
[Send Message](#)  
[Medical Notes](#)  
**Health Details**  
**Takes insulin:** Yes  
**Smoker:** Yes  
**Weight:**  
**Monitors BP:** Yes

Chart for User Nine Report: **Glucose Trend** mmol/L  
Date Range: Custom From: 19 Sep 2007 To: 13 Oct 2007 Apply



Print

# Insulin titration in Type 2 diabetes

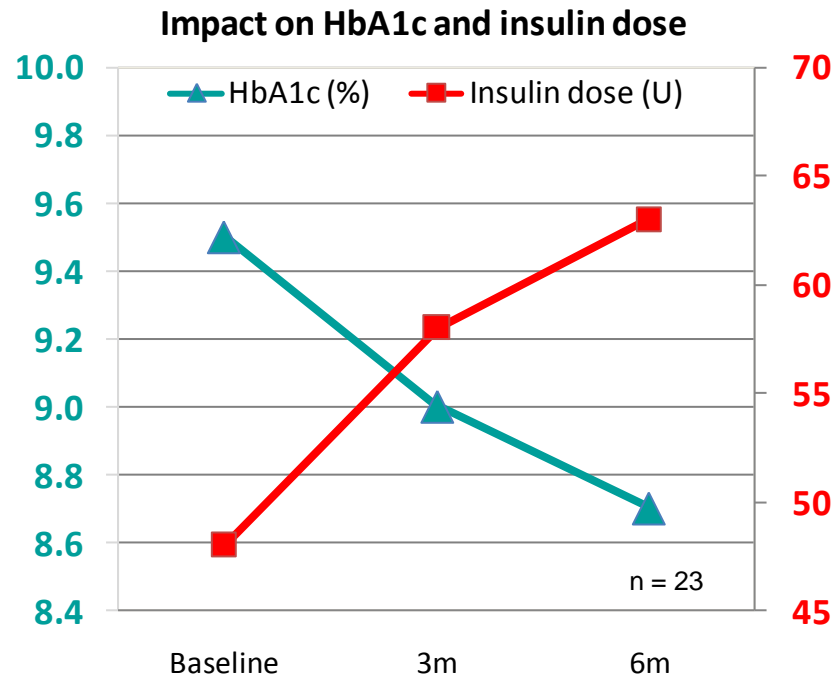
## Weekly fasting BG averaged across all patients



Week 1: 11.0 5.0 mmol/l  
Week 26: 7.7 2.0 mmol/l

Linear trend improvement of  
3.3 mmol/l over six months

# Insulin titration in Type 2 diabetes



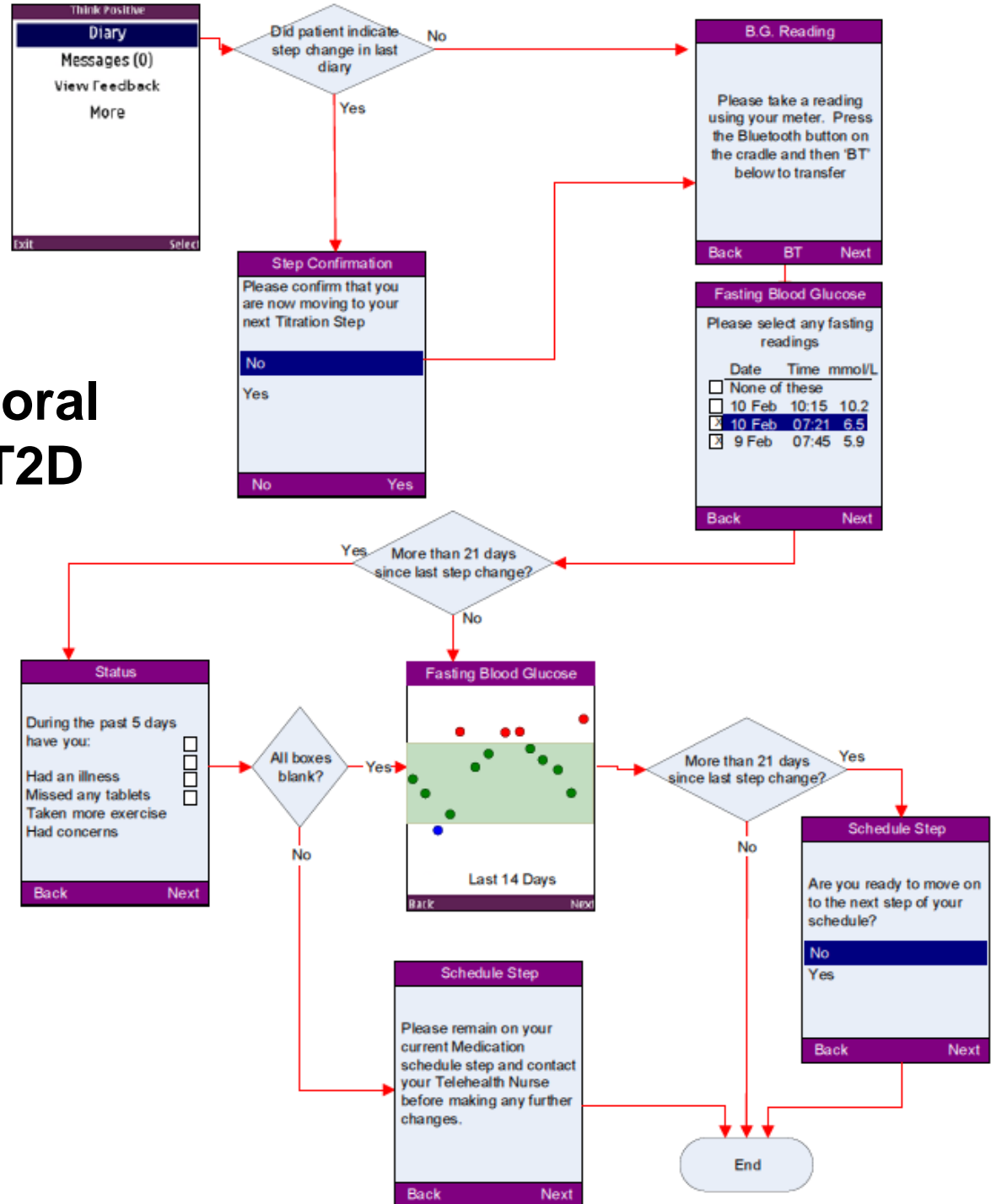
- Clinicians viewed the technology as having the potential to improve patient care
- Practice nurses saw a reduction in time to support insulin titration
- Most patients could use the equipment and were enthusiastic about the extra support

# Self-titration of oral medication in Type 2 diabetes (2010-11)

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- Patients with  $8\% < \text{HbA}_{1c} < 11\%$ , who are on sub-maximal doses of oral glucose lowering medication (OGLM).
  - A sequence of colour-coded displays on the mobile phone will indicate to the patients when three or more fasting plasma glucose (FPG) readings are above the threshold for hyperglycaemia.
  - The OGLM dose will then be titrated aiming at a target of  $\text{FPG} \leq 6.1$  mmol/L or the highest tolerable dose up to a maximum in accordance with NICE guidance.
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# Self-titration of oral medication in T2D



# Self-titration of oral medication in Type 2 diabetes (2010-11)

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- Patients with  $8\% < \text{HbA}_{1c} < 11\%$ , who are on sub-maximal doses of oral glucose lowering medication (OGLM).
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  - The OGLM dose will then be titrated aiming at a target of  $\text{FPG} \leq 6.1$  mmol/L or the highest tolerable dose up to a maximum in accordance with NICE guidance.
  - Once target blood glucose has been achieved, intervention participants will be asked to stop testing.
  - Prior to each 3-monthly  $\text{HbA}_{1c}$  measurement, an SMS text message will be sent requesting a period of two weeks during which self-monitoring of blood glucose will be resumed.
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# From 2002 to 2010 - the beginning of mHealth

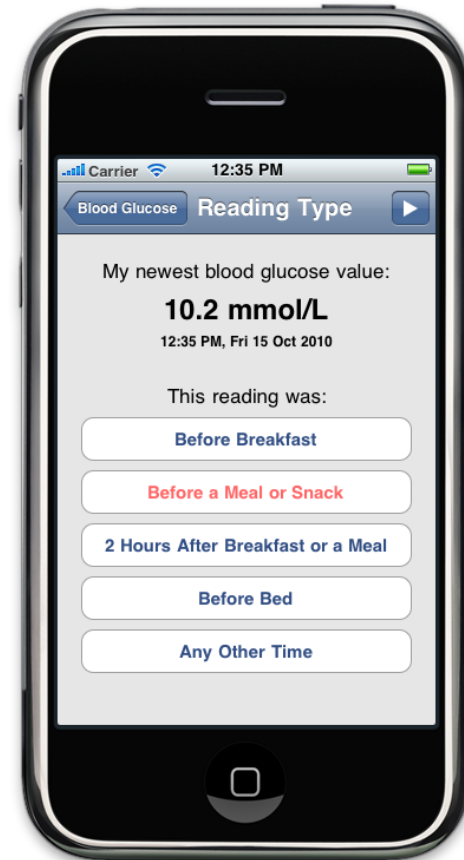
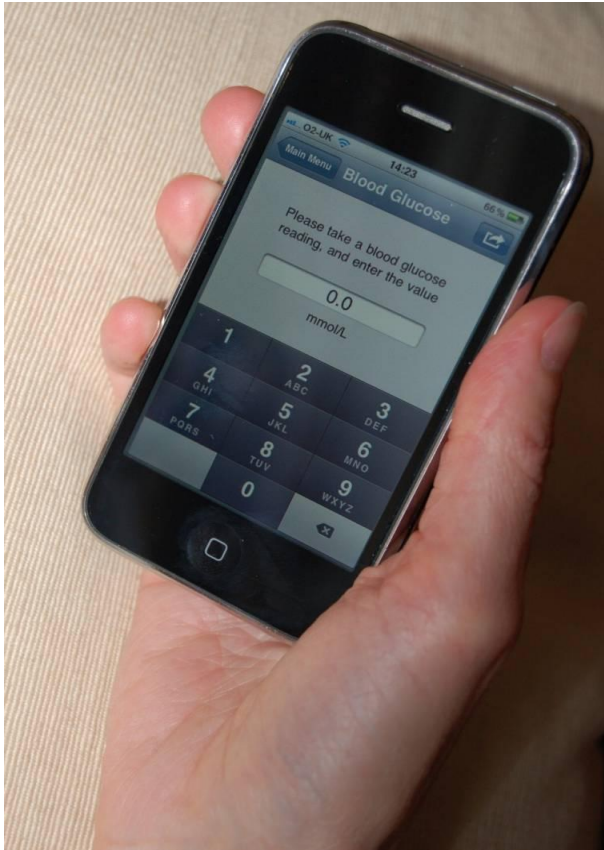
Phase 1: Proof of concept and building up the clinical evidence (hundreds of patients on pilot studies/ clinical trials)



Phase 2: Delivering mHealth applications using new generation of smart phones (iPhone, Android phones) and iPads.



# iPhone diabetes application



# Forward look

## Use of new technology

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Validate new iPhone application for diabetes in RCT of educational intervention (2011 – 2012)

Replace diabetes educational courses with e-learning using mobile phone (“e-DAFNE” and “e-DESMOND”)

For wide adoption of telehealth in the NHS, the costs of the technology need to decrease by at least a factor of ten

We are developing an open-architecture, open-source system using Android phones and iPads for *sustainable use* of telehealth (partners: Vodafone, ARM, Sharp, PA Consulting, South Central SHA, t+ Medical & Adherence Science)

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