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1 **Cluster randomised controlled trial of a nurse-led psychological intervention for type 2**

2 **diabetes: Diabetes-6 study**

3

4 Khalida Ismail, Kirsty Winkley, Nicola de Zoysa, Anita Patel, Margaret Heslin, Helen

5 Graves, Stephen Thomas, Dominic Stringer, Daniel Stahl, Stephanie A Amiel

6 *Corresponding author:*

7 Khalida Ismail

8 Institute of Psychiatry, Psychology and Neuroscience, King's College London

9 Weston Education Centre, 10 Cutcombe Road

10 London SE5 9RJ

11 Email: [khalida.2.ismail@kcl.ac.uk](mailto:khalida.2.ismail@kcl.ac.uk)

12 Telephone: 020 7848 5131

13



15 **Abstract**

16 **Background**

17 Suboptimal glycaemic control in type 2 diabetes (T2D) is common and associated with  
18 psychological barriers.

19 **Aim**

20 We tested whether it was possible to train practice nurses in six psychological skills  
21 (Diabetes 6 (D6)) based on motivational interviewing (MI) and basic cognitive behaviour  
22 therapy (CBT) and whether integrating these with diabetes care was associated with  
23 improved glycaemic control over 18 months compared to standard care.

24 **Design and Setting**

25 A two-arm, single-blind, parallel cluster randomised controlled trial conducted in primary  
26 care practices (n=24) (ISRCTN trial registration: ISRCTN75776892).

27 **Method**

28 Adult participants (n=334) with T2D and HbA1c  $\geq 69.4$  mmol/mol (lowered to  $\geq 64$   
29 mmol/mol midstudy to increase recruitment) at least once in previous 18 months and at  
30 recruitment were randomised to receive 12 sessions of either the D6 intervention or standard  
31 care over 12 months. The practice nurses were trained in the six psychological skills and  
32 their competencies were measured by standardised rating scales. All sessions were  
33 audiotaped. The primary outcome was change in HbA1c at 18 months from randomisation;  
34 secondary outcomes were change in systolic and diastolic blood pressure, body mass index,  
35 waist circumference, depressive symptoms, harmful alcohol intake, diabetes-specific distress,  
36 and cost-effectiveness.

37

38 **Results**

39 Using intention-to-treat analysis, there was no significant difference between D6 intervention  
40 and standard care in HbA1c (absolute mean difference -0.79 mmol/mol, 95% CI -5.75–4.18)  
41 or for any of the secondary outcomes. The competency level of D6 nurses was below the  
42 beginner proficiency level and similar to the standard care nurses.

### 43 **Conclusion**

44 Training nurses in MI and basic CBT to support self-management did not lead to  
45 improvements in glycaemic control or other secondary outcomes in people with T2D at 18  
46 months. It was also unlikely to be cost-effective. Furthermore, the increased contact with  
47 standard care nurses did not improve glycaemic control.

48

49 **Keywords:** Type 2 diabetes, Self-management, Motivational interviewing, Cognitive  
50 behavioural therapy, Glycaemic control

51

### 52 **How this fits in**

53 The evidence that low intensity psychological interventions to support self-management in  
54 people with poorly controlled type 2 diabetes in primary care setting is limited.

55 It is not known whether practice nurses can be trained to deliver low intensity psychological  
56 treatments to support self-management in type 2 diabetes.

57 Training on low intensity psychological interventions based on motivational interviewing and  
58 basic cognitive behaviour therapy led to basic proficiency in these skills but this was not  
59 maintained.

60 Offering more sessions with practice nurses to support self-management in people with  
61 persistent hyperglycaemia does not lead to improvement in glycaemic control in type 2  
62 diabetes.

63

64 **Introduction**

65 Around half of people with type 2 diabetes (T2D) have persistent suboptimal glycaemic  
66 control despite evidence based pathways based on national guidance.<sup>1-3</sup> Psychological  
67 factors, such as depressive symptoms and diabetes-specific fears are common in T2D and  
68 associated with reduced self-management.<sup>4,5</sup> Addressing these psychological barriers could  
69 lead to improvement in glycaemic control.

70 Common psychological interventions include motivational interviewing (MI)<sup>6</sup> and cognitive  
71 behaviour therapy (CBT).<sup>7,8</sup> Recent randomised controlled trials (RCT) suggest that the  
72 effect of low-intensity psychological interventions on glycaemic control is lower than  
73 reported in systematic reviews.<sup>9-11</sup>

74 One of the roles of the practice nurse is to support diabetes self-management. Hospital  
75 diabetes specialist nurses can be trained to competently deliver MI and basic CBT skills with  
76 improvement in glycaemic control in type 1 diabetes<sup>12</sup> and psychological interventions could  
77 be delivered by nurses in research settings.<sup>13</sup> We defined a package of six psychological  
78 skillsets for T2D (Diabetes 6 (D6)) of similar intensity to low-level psychological treatments  
79 for common mental disorders in the NHS.<sup>14</sup> We tested in a cluster RCT whether training  
80 practice nurses in D6 skills was associated with increased competency than nurses not receive  
81 the training, and whether the D6 intervention was more effective than standard care in  
82 improving suboptimal glycaemic control in people with T2D over 18 months and in  
83 improving secondary outcomes (such as lipids, depressive symptoms), and if it was cost-  
84 effective.

85 **Method**

86 **Trial design**

87 D6 was a pragmatic parallel two-arm cluster RCT design for 18 months. GP practices with  
88  $\geq 6000$  patients registered in the Lambeth, Southwark, Lewisham, Wandsworth, and Bexley  
89 Clinical Commissioning Groups (representing a resident population of 1.43 million), were  
90 invited to participate if they had a practice nurse delivering diabetes care. Recruitment of  
91 patients began after each practice consented to randomisation. Randomisation of clusters was  
92 conducted in two phases, as recruitment of practices and patients had slowed down following  
93 the organisational uncertainties preceding the implementation of the Health and Social Care  
94 Act 2012. This Act re-organised the UK's National Health Service (NHS), dismantling  
95 current organisational structures and creating new ones for funding, management,  
96 accountability and regulation.<sup>15</sup>

97 **Patients**

98 Inclusion criteria were: adults aged 18–79 years, duration of T2D for  $\geq 2$  years, persistent  
99 suboptimal glycaemic control defined as International Federation of Clinical Chemistry  
100 (IFCC) HbA1c  $\geq 69.4$  mmol/mol (National Glycohemoglobin Standardization Program  
101 (NGSP) 8.5%) on two occasions (at least once in the preceding 18 months and the second one  
102 at recruitment) while on at least two oral diabetes medication (metformin and one other),  
103 and/or requiring insulin therapy to ensure that efforts to optimise medical care had been  
104 offered to the patient.<sup>15</sup> The IFCC HbA1c was lowered to  $\geq 64$  mmol/mol (NGSP 8%) in  
105 Phase 2 to increase recruitment.

106 Exclusion criteria were: severe mental disorders; terminal illnesses and end-stage diabetes  
107 complications; morbid obesity (body mass index (BMI) >40 kg/m<sup>2</sup> in Phase 1 and >50 kg/m<sup>2</sup>  
108 in Phase 2); non-ambulatory; no phone/internet access; non-English-speaking; and receiving  
109 psychological treatments elsewhere. Patients who had Patient Health Questionnaire-9 (PHQ-  
110 9) depressive scores >20 were excluded if they had psychotic depression or active suicidal  
111 ideation.<sup>16</sup>

## 112 **Baseline measures**

113 Baselines measures before randomisation were: age, gender, self-reported ethnicity,  
114 occupation, employment status, and smoking status. Complication status included:  
115 neuropathic ulcer risk by perception of 10g monofilament; retinopathy coding of the most  
116 recent annual standardised digital retinal photography; nephropathy using the urinary  
117 albumin:creatinine ratio (ACR); and history of macrovascular complications.

## 118 **Randomisation**

119 Randomisation of practices (unit of cluster) was conducted by an independent statistician  
120 using a random number generator to assign equal numbers of practices to each arm at each  
121 phase. For allocation concealment, an independent manager held the randomisation list in  
122 password-locked computer.

## 123 **Intervention**

### 124 **Group 1: Standard care**



125 The nurse delivered diabetes care in both groups as recommended by national guidance,  
126 which included diabetes self-management education, monitoring of biomedical status, and  
127 giving clinical information and advice.<sup>17</sup> To control for attention, standard care nurses offered  
128 the same number of sessions as D6. This consisted of 12 sessions, each 30 minutes in  
129 duration, over 12 months. The sessions were held in routine primary care clinics and  
130 audiotaped.

131

## 132 **Group 2: Standard care plus Diabetes 6**

133 The theory underlying MI is that the patient's state of ambivalence (resistance versus  
134 willingness to make lifestyle changes) is the core psychological construct that needs  
135 addressing.<sup>6</sup> MI is a directive, counselling style which encourages patients to change  
136 behaviours using collaborative, non-judgmental, and affirming communications. The theory  
137 underlying CBT is that barriers to diabetes self-management are maintained by unhelpful  
138 thoughts (e.g., *if I can't cure diabetes, what's the point?*), unhelpful behaviours (e.g., missing  
139 insulin doses), and distressing emotions (e.g., low mood/anxiety when seeing a high blood  
140 glucose reading).<sup>18,19</sup> Identifying and challenging these cognitive barriers are effective in  
141 changing behaviours.<sup>20</sup> The D6 nurses were trained to integrate diabetes care with six skills  
142 drawn from MI and CBT, as follows : 1. Active listening; 2. Managing resistance; 3.  
143 Directing change; 4. Supporting self-efficacy; 5. Addressing health beliefs; and 6. Shaping  
144 behaviours. This consisted of 12 sessions, each 30 minutes in duration, over 12 months. The  
145 sessions were held in routine primary care clinics and were audiotaped.

146 The Motivational Interviewing Treatment Integrity (MITI) Scale (version 3.1.1)<sup>21</sup> and  
147 Behaviour Change Counselling Index (BECCI)<sup>22</sup> were used to compare competencies in both  
148 groups. The middle 20 minutes of sessions were rated by two independent psychologists  
149 trained in MITI and the BECCI was rated by a clinical psychologist, blind to treatment  
150 allocation.

## 151 **Outcomes**

152 The follow-up was reduced from 24 to 18 months secondary to the delays in recruitment. The  
153 primary outcome was change in HbA1c (mmol/mol) from cluster randomisation to 18 months  
154 measured centrally (King's College Hospital NHS Foundation Trust) by affinity  
155 chromatography (Primus Ultra2, Kansas City, USA). If the study HbA1c were missing at 18-  
156 month, we included the 15-month HbA1c as this clinically overlaps with the 3-month  
157 window for 18-month HbA1c. The following secondary outcomes were change in systolic  
158 and diastolic blood pressure using an electronic sphygmomanometer; BMI, and waist  
159 circumference (cm); depressive symptoms using the PHQ-9;<sup>16</sup> the Alcohol Use Disorders  
160 Identification Test (AUDIT);<sup>23</sup> and the Diabetes Distress Scale, which measures diabetes-  
161 specific psychological burden.<sup>24</sup> A fasting blood sample was used for HbA1c, total  
162 cholesterol, and triglycerides.

## 163 **Sample size**

164 An IFCC HbA1c 10.9 mmol/mol (NGSP HbA1c 1%) difference in D6 compared to standard  
165 care was the minimal clinically significant reduction at 18 months, considering that standard  
166 care may produce a 2.2 mmol/mol (NGSP HbA1c 0.2%) reduction in HbA1c (equivalent to a  
167 moderate effect size of  $d=0.55$ ). Assuming 20% dropout, we needed 360 patients to achieve

168 80% power at a two-sided alpha-level of 5%, with 20 practices with 18 patients each per arm.  
169 We assumed two practices per arm would dropout, thus requiring 24 practices with a total  
170 patient sample of  $24 \times 18 = 432$  patients. After adjusting for clustering by practice (clustering  
171 intra-correlation coefficient (ICC)=0.05) and an inflation factor of 1.7, the final required  
172 sample size was  $81 \times 1.7 = 138$  patients per arm.

173 We recruited 334 patients of which 231 had at least one follow-up in 24 clusters. The average  
174 cluster size was therefore 10 patients per cluster, smaller than our assumed size of 15 patients  
175 per cluster with a post-hoc power of 77% at two-sided alpha-level of 5%.<sup>25</sup>

## 176 **Statistical analysis**

177 Data were analysed using STATA 13. The sample characteristics were described as means  
178 (standard deviation (SD)) or as proportions (percentage). A comparison of patient list size  
179 and Index of Multiple Deprivation (IMD) 2010 rank score by practices that participated  
180 versus those that did not was conducted using Student's t-test. The IMD 2010 score is a  
181 composite index of relative deprivation at a small area level, based on seven domains of  
182 deprivation: income, employment, health deprivation and disability, education, skills and  
183 training, barriers to housing and services, crime and disorder, and living environment.<sup>26</sup> A  
184 linear mixed-effects model estimated group differences in HbA1c levels between D6 and  
185 standard care groups at 18 months. Nurse was included as a random effect as the unit of  
186 randomisation. Secondary outcomes were also analysed using linear mixed models to  
187 estimate group differences at 18 months.

188 Twenty-nine participants with HbA1c <64 mmol/mol were mistakenly recruited because of  
189 coding errors by the research team during assessment of eligibility and this mistake was only

190 discovered after randomisation. Therefore, they were retained for the ITT. We performed a  
191 sensitivity analysis by including a binary covariate of this protocol violation using maximum  
192 likelihood under the missing at random assumption. Sensitivity to missingness in HbA1c was  
193 assessed by investigating and including predictors of missingness in the model and by using  
194 multiple imputation for the missing values of HbA1c.

195 For further details of the protocol, including the economic evaluation, see Appendix 1.

## 196 **Results**

197 We invited 116 practices, 26 agreed to participate and two dropped out before randomisation  
198 (Figure 1; Appendix2:Table 1) and 995 potentially eligible participants. Of the 451 who  
199 consented for eligibility, 334 were recruited. Twelve practice clusters were randomly  
200 assigned to standard care (n=164 participants) and 12 to standard care plus D6 (n=170). One  
201 D6 practice dropped out after randomisation, before the nurse received the training, and  
202 before all patients were recruited (those who consented remained in the ITT analysis). Invited  
203 practices that participated (n=24) compared to those that did not (n=89) had higher mean  
204 patient list sizes (12180 (SD=5099) vs. 10091 (SD=3894),  $p=0.03$ ) but no difference in IMD  
205 score (10049 (SD=6910) versus 12441 (SD=7785),  $p=0.17$ ). Table 1 presents the baseline  
206 characteristics of the sample.

207 *Figure 1 here; Table 1 here*

208 The mean number of sessions attended was 7.42 (SD=4.4) and 8.20 (SD=4.4) in the D6 and  
209 standard care groups, respectively.

210 Primary outcome data at 18-month follow-up were collected for 219 (65.6%) participants and  
211 a further 12 had 15-month HbA1c data, providing 231 participants. There was a non-  
212 significant larger proportion with missing HbA1c in the D6 group compared to standard care  
213 (35.9% versus 32.9%, respectively) (Appendix 2:Table 2) and more likely to be  
214 African/Caribbean or Asian/Other ethnicity. In the ITT analysis, there was no significant  
215 difference in mean HbA1c at follow-up in the D6 group compared to the standard care group  
216 (table 2). The ICC for the clustering effect of nurse was 0.02 (95% CI 0.001–0.37). Linear  
217 mixed models showed no significant effects of the intervention on the secondary outcomes  
218 including BMI, blood pressure, fasting triglyceride, or psychological distress (table 2).

219 *Table 2 here*

220 Results were similar for the sensitivity analyses when: using practice as the clustering  
221 variable in place of nurse as cluster; including a binary covariate for the 29 participants with  
222 baseline HbA1c <64 mmol/mol; including ethnicity and history of stroke as predictor of  
223 missingness at follow-up; or using multiple imputation to account for missingness in HbA1c  
224 (Appendix 2:Table 2). There was no evidence of an association between the number of D6  
225 sessions attended and HbA1c at 18 months within the D6 group (-0.44 mmol per additional  
226 session attended, 95% CI -1.28–0.41).

227 Intervention costs were higher in the D6 group (mean difference £276, 95% CI £225–£327)  
228 (Table 3) due to greater training costs but there were no differences in mean total health and  
229 social care costs (adjusted mean difference £150, 95% CI -£34–£333) or QALY gains at 18  
230 months (Appendix 4).

231 *Table 3 here*

232 The inter-rater reliability for the MITI global domains of spirit and empathy was 0.87 and  
233 0.91 respectively so we combined both sets of ratings and derived the mean score for each  
234 domain. We rated 69 sessions (4.0% of all available recordings) for fidelity from 33/170 and  
235 36/164 patients from the D6 and standard care groups respectively (Table 4). The level of  
236 competency in the D6 group was below the beginner proficiency level in all the scales for MI  
237 and BECCI. Except for a slightly higher proportion of open questions in D6, and a slightly  
238 larger reflection/question ratio in standard care, there were no statistically significant  
239 differences in the remaining mean MI domain scores or BECCI scores.

240 *Table 4 here*

241 There were 43 serious adverse events (cardiovascular (n=11), injury (n=5), cancer (n=4),  
242 infection (n=5), diabetes-related (n=3), psychiatric (n=2), and other (n=10)), reported after 18  
243 months for 38 different participants (D6 n=14; standard care n=24) and 2 deaths from cancer,  
244 with no difference between the two groups

## 245 **Discussion**

### 246 **Summary**

247 Training nurses in MI and basic CBT to support self-management did not lead to  
248 improvements in glycaemic control, or any other secondary outcomes, in people with T2D  
249 and persistent hyperglycaemia compared to attention control at 18 months from  
250 randomisation. Further, it was unlikely to be cost-effective.

### 251 **Strengths and limitations**

252 This was a pragmatic design set in real-world, inner-city, primary care representing the ethnic  
253 and social diversity of people with T2D.<sup>27</sup> Only a few other RCTs have achieved similar  
254 ethnicity distributions.<sup>28-34</sup> This was a high risk group for diabetes complications. We  
255 selected a cluster design to reduce contamination of the intervention in the control group.  
256 Contamination is the process whereby an intervention intended for members of the trial  
257 (intervention or treatment) arm of a study is received by members of another (control) arm  
258 leading to a risk of under estimation of the effect.<sup>35</sup> We assessed contamination by comparing  
259 the competencies in the intervention and control group. The hypothesis was that the control  
260 group would have lower competencies than the D6 group. As both groups had similar and  
261 borderline beginner proficiency competencies (which is probably the pre-training level of  
262 competency) we concluded it was unlikely there was contamination. We developed a  
263 theoretically informed intervention and an evidence-based manual. We measured fidelity  
264 (which is the same measure as competency in this study) to the intervention. We controlled  
265 for the non-specific effect of receiving more attention by D6 by offering similar number of  
266 sessions to patients randomised to the control group. We were only slightly underpowered at  
267 77% power compared to the 80% originally proposed. The upper limit of the 95% confidence  
268 interval of the estimated treatment effect for HbA1c (4.8 mmol/mol) was less than estimated  
269 treatment reductions in meta-analyses.<sup>36</sup> The comprehensive within-trial economic evaluation  
270 assessed all relevant health and social care costs.

271 The limitations of D6 included a 20% uptake of practice participation, despite the offer of  
272 generous backfill payments. The main reasons given by the practices when feedback was  
273 informally asked were the pressures to deliver current services with limited resources  
274 exacerbated by co-incidental national restructuring of primary care services creating  
275 organisational uncertainty. Data missingness for the economic analyses was high, however,

276 imputing missing data confirmed the lack of cost-effectiveness of D6. We did not obtain  
277 sufficient repeated measures of HbA1c. We failed to achieve a minimum level of beginner  
278 proficiency in motivational interviewing in the D6 group therefore unable to conclude that  
279 motivational interviewing is not effective in supporting self-management.

## 280 **Comparison with existing literature**

281 Although there have been over 40 RCTs in this field since the last review,<sup>36</sup> only three had  
282 defined poor glycaemic control (HbA1c  $\geq$ 64 mmol/mol) as an inclusion criterion and showed  
283 no benefit from psychological support and only one of these was delivered by nurse care  
284 managers.<sup>37-39</sup> Recent pragmatic RCTs of similar interventions included samples with near  
285 optimal glycaemic control with less room for improvement in the primary outcome.<sup>10,11,40</sup>  
286 Our sample had sustained high HbA1c so we may have selected a more severe group not  
287 suitable for practitioners with lower levels of psychological skill competencies.<sup>28-34</sup>

288 We are one of a handful of RCTs to include fidelity and competency (a complex, laborious,  
289 and expensive process evaluation).<sup>41,42</sup> On average patients attended only 50% of sessions in  
290 either group. This is a common observation in psychological interventions.<sup>43</sup> However, no  
291 dose-response relationship was observed.

## 292 **Implications for research and/or practice**

293 There are several potential nurse, patient and methodological reasons for the non-significant  
294 effect of D6. The nurses did not self-select and may not have had the generic psychotherapist  
295 factors often attributed as the active ingredients in psychological treatments.<sup>44</sup> D6 nurses had  
296 concerns about over-stepping their professional roles, lacking confidence, and/or resented the



297 extra workload.<sup>45</sup> The low competencies in most MI and CBT domains suggest that practice  
298 nurses may need longer periods of training or should self-select for generic psychotherapist  
299 skills in advance. Our findings may also reflect the difficulty of engaging this high risk  
300 clinical group but with low levels of worry. Even offering more nurse support in the form of  
301 more frequent sessions did not lead to improved glycaemic control. In exit interviews,  
302 patients stated they lacked time (although the majority was not employed) and difficulties in  
303 establishing a rapport with the nurses as reasons for dropout (unpublished observations). One  
304 methodological explanation is that we selected HbA1c, strongly associated to the levels of  
305 glycaemia, as a surrogate outcome for diabetes complications. However, a landmark RCT<sup>46</sup>  
306 and a meta-analysis of RCTs<sup>47</sup> aimed at intensive glycaemic control have failed to observe  
307 consistently a positive effect on reduction of complications of diabetes or global mortality  
308 and there may be even a negative effect of increased mortality when tight glycaemic control  
309 is the aim. Perhaps these negative findings represent an opportunity to focus on psychological  
310 interventions to improve other outcomes such as blood pressure, lipids or a composite  
311 outcome. Another methodological implication is whether the duration of the intervention and  
312 the follow up was too short. Brief psychological interventions are designed to be exactly that,  
313 with the added advantage of being cheap and not too demanding on the patient. However, our  
314 patients had a long history of poor self-management and may have needed a longer duration  
315 of therapy. Whether longer therapy would be pragmatic to be funded as a RCT or in the NHS  
316 is to be debated and is showing promise for chronic depression.<sup>48</sup>

317 The implication for clinical practice is that low-intensity psychological interventions  
318 delivered at low level of competencies may not be as effective in supporting self-  
319 management in people with T2D and longstanding suboptimal glycaemic control as  
320 previously thought.

321

322 A conceptual dilemma is that theoretical frameworks for MI and CBT assume that mental  
323 health conditions remit (alcohol problems, smoking, depression) and this assumption does not  
324 apply to T2D which progressively worsen.<sup>49</sup>

325 We urgently need to reconsider what skills, what competencies, which workforce are the  
326 most effective in delivering psychological interventions to improve glycaemic control in  
327 people with T2D<sup>50</sup> before investing sparse funds into low intensity psychological treatments  
328 for improving glycaemic control in T2D.<sup>51</sup>

329

330

331 **Author degrees, positions, and affiliations:**

332 Khalida Ismail, MRCPsych, PhD, professor, Institute of Psychiatry, Psychology and  
333 Neuroscience, King's College London, London, SE5 9RJ, UK

334 Kirsty Winkley, PhD, senior lecturer, Institute of Psychiatry, Psychology and Neuroscience,  
335 King's College London, London, SE5 9RJ, UK

336 Nicole de Zoysa, DClinPsych, clinical psychologist, Diabetes Centre, King's College  
337 Hospital NHS Foundation Trust, London, SE5 9RS, UK

338 Anita Patel, PhD, visiting professor, Institute of Psychiatry, Psychology and Neuroscience,  
339 King's College London, London, SE5 8AF UK & director, Anita Patel Health Economics  
340 Consulting Ltd, London, EC1V 2NX, UK

341 Margaret Heslin, PhD, research fellow, Institute of Psychiatry, Psychology and Neuroscience,  
342 King's College London, London, SE5 8AF, UK

343 Helen Graves, PhD candidate, Institute of Psychiatry, Psychology and Neuroscience, King's  
344 College London, London, SE5 9RJ, UK

345 Stephen Thomas, MRCP, MD, physician, Guys and St Thomas' NHS Foundation Trust SE1  
346 9RT

347 Dominic Stringer, MSc, medical statistician, Institute of Psychiatry, Psychology and  
348 Neuroscience, King's College London, London, SE5 8AF, UK

349 Daniel Stahl, PhD, reader and medical statistician, Institute of Psychiatry, Psychology and  
350 Neuroscience, King's College London, London, SE5 8AF, UK

351 Stephanie A Amiel, FRCP, professor, Division of Diabetes and Nutritional Sciences, King's  
352 College London, London, UK SE1 9NH

### 353 **Author Contributions**

354 KI, SAA, DStahl, AP, SMT developed the hypotheses. SAA and KI led the conduct of the  
355 study; KW project managed and contributed to analysis, training and assessment of nurses;  
356 NDZ developed the Diabetes 6 manual, the protocol for fidelity and did the training and  
357 supervision of the nurses; DStahl was the senior trial statistician and led the statistical plan  
358 and DStringer conducted the statistical analysis; AP designed and led the economic  
359 evaluation and MH conducted the economic analysis. KI drafted the manuscript and all  
360 authors contributed to the drafts and approved final version.

### 361 **Competing Interests**

362 All authors have completed the ICMJE uniform disclosure form at  
363 [www.icmje.org/coi\\_disclosure.pdf](http://www.icmje.org/coi_disclosure.pdf). KI has received honorarium from Eli-Lilly, Sanofi,  
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373 **Ethical Approval**

374 Ethical approval was granted by the King's College Hospital Research Ethics Committee  
375 (reference 09/H0808/97) and Primary Care Trusts (references RDLSLBex 534 and  
376 2010/403/W). Changes to the protocol were approved by the Trial Steering Committee and  
377 the Research Ethics Committee. All participants gave written, informed consent and the trial  
378 was performed in accordance with the ethical standards as laid down in the 1964 Declaration  
379 of Helsinki.

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390 The corresponding author (KI) had full access to all the data in the study and had final  
391 responsibility for the decision to submit for publication. We attest that we have obtained  
392 appropriate permissions and paid any required fees for use of copyright protected materials.

393 **Data Sharing**

394 The protocol and patient-level data are available from the corresponding author upon request.

395

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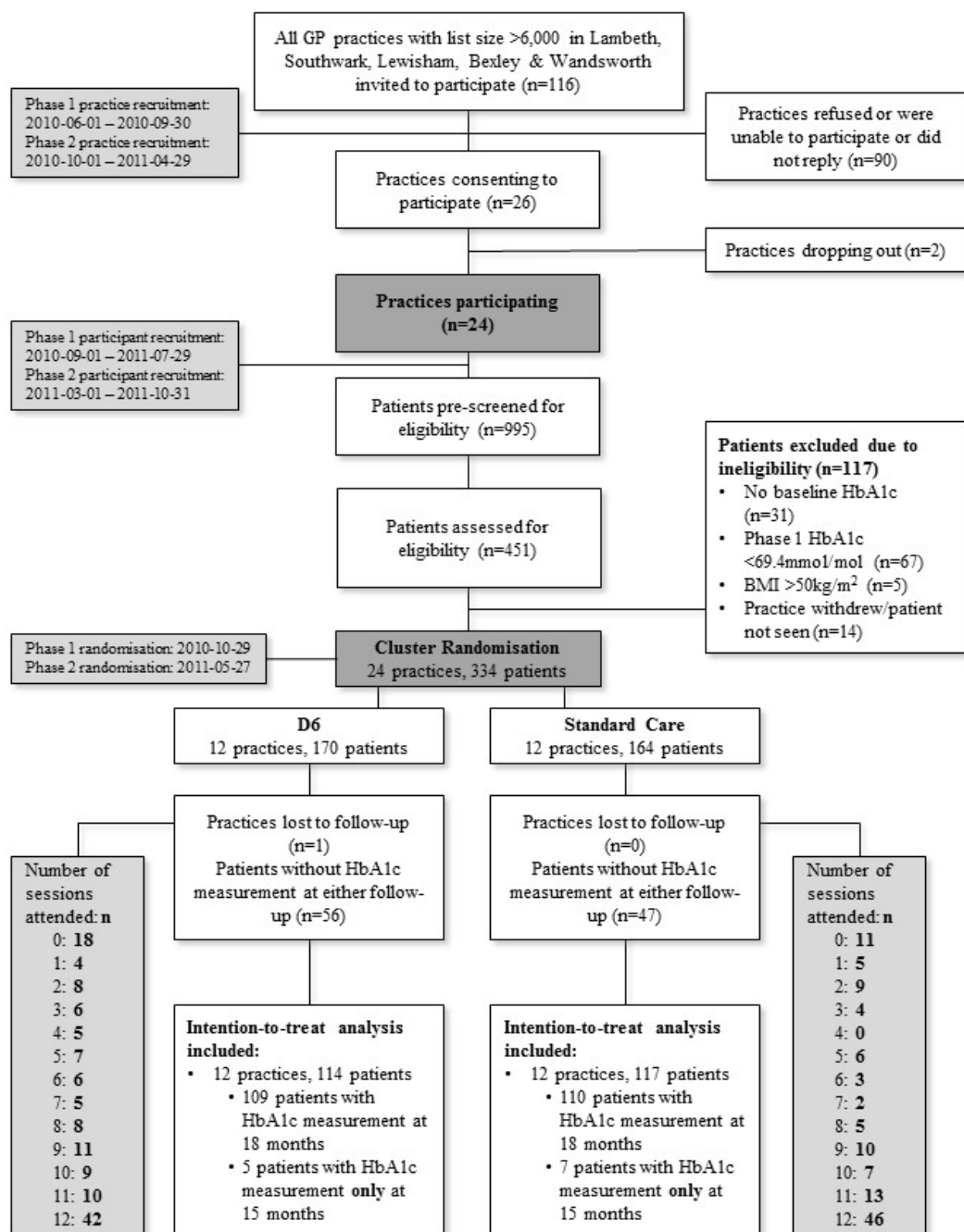
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552 **Figures**

553 **Figure 1. Diabetes 6 (D6) study flow chart**



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<b>Variable*</b>	<b>D6 (n=164)</b>	<b>Standard Care (n=170)</b>	<b>Total</b>
<b>Age (years)</b>	59.0 (11.1)	58.9 (11.4)	58.9 (11.2)
<b>Gender</b>			
<b>Male</b>	82 (50.0%)	81 (47.7%)	163 (48.8%)
<b>Female</b>	82 (50.0%)	89 (52.4%)	171 (51.2%)
<b>Ethnicity</b>			
<b>White</b>	60 (36.8%)	74 (43.8%)	134 (40.4%)
<b>African/Caribbean</b>	81 (49.7%)	62 (36.7%)	143 (43.1%)
<b>Asian/Other</b>	22 (13.5%)	33 (19.5%)	55 (16.6%)
<b>Relationship status</b>			
<b>Married or Cohabiting</b>	82 (50.3%)	89 (52.7%)	171 (51.5%)
<b>Separated/Divorced/Widowed</b>	52 (31.9%)	45 (26.6%)	97 (29.2%)
<b>Single</b>	29 (17.8%)	35 (20.7%)	64 (19.3%)
<b>Education level</b>			
<b>A-level or higher</b>	47 (29.2%)	43 (25.8%)	90 (27.4%)
<b>O-level or GCSE equivalent</b>	68 (42.2%)	48 (28.7%)	116 (35.4%)
<b>No formal qualifications</b>	46 (28.6%)	76 (45.5%)	122 (37.2%)
<b>Employment</b>			
<b>Yes<sup>1</sup></b>	69 (42.1%)	70 (41.2%)	139 (41.6%)
<b>No<sup>2</sup></b>	95 (57.9%)	100 (58.8%)	195 (58.4%)
<b>Borough</b>			
<b>Lambeth</b>	83 (50.6%)	42 (24.7%)	125 (37.4%)
<b>Southwark</b>	25 (15.2%)	40 (23.5%)	65 (19.5%)
<b>Lewisham</b>	19 (11.6%)	52 (30.6%)	71 (21.3%)
<b>Wandsworth</b>	37 (22.6%)	24 (14.1%)	61 (18.3%)
<b>Bexley</b>	0 (0.0%)	12 (7.1%)	12 (3.6%)
<b>Diabetes duration (years)</b>	10 (7–13)	9 (5–12)	9 (6–12)
<b>HbA1c (mmol/mol)</b>	81.0 (17.1)	80.1 (19.1)	80.5 (18.1)
<b>Body mass index (kg/m<sup>2</sup>)</b>	32.0 (5.6)	31.9 (6.6)	31.9 (6.1)
<b>Systolic blood pressure (mm/Hg)</b>	135.2 (16.9)	133.2 (17.3)	134.2 (17.1)
<b>Diastolic blood pressure (mm/Hg)</b>	79.5 (9.8)	79.0 (10.3)	79.2 (10.1)
<b>Total cholesterol (mmol/L)</b>	4.3 (1.1)	4.2 (1.2)	4.2 (1.2)
<b>Fasting triglycerides (mmol/L)</b>	1.7 (1.2)	1.7 (1.3)	1.7 (1.3)
<b>Taking insulin</b>			
<b>Yes</b>	75 (46.3%)	66 (39.8%)	141 (43.0%)
<b>No</b>	87 (53.7%)	100 (60.3%)	187 (57.0%)
<b>Any retinopathy</b>			
<b>Yes</b>	59 (35.9%)	65 (38.2%)	124 (37.1%)
<b>No</b>	105 (64.0%)	105 (61.8%)	210 (62.9%)
<b>Albumin:Creatinine ratio</b>			

<b>Negative</b>	65 (59.1%)	83 (69.8%)	148 (64.6%)
<b>Positive</b>	45 (40.9%)	36 (30.3%)	81 (35.4%)
<b>Protein:Creatinine ratio</b>			
<b>Negative</b>	33 (76.7%)	17 (77.3%)	50 (76.9%)
<b>Positive</b>	10 (23.3%)	5 (22.7%)	15 (23.1%)
<b>Foot ulcers</b>			
<b>Yes</b>	9 (5.6%)	12 (7.1%)	21 (6.4%)
<b>No</b>	152 (94.4%)	157 (92.9%)	309 (93.6%)
<b>Macrovascular disease</b>			
<b>Yes</b>	61 (37.2%)	55 (32.4%)	116 (34.7%)
<b>No</b>	103 (62.8%)	115 (67.7%)	218 (65.3%)
<b>Patient Health Questionnaire-9 score</b>			
<b>≥10</b>	31 (20.4%)	35 (22.4%)	66 (21.4%)
<b>&lt;10</b>	121 (79.6%)	121 (77.6%)	242 (78.6%)
<b>Diabetes Distress Scale (mean item score)</b>	2.1 (1.7–2.7)	2.0 (1.6–2.7)	2.1 (1.6–2.7)
<b>Data are n (%), median (IQR), or mean (SD), as appropriate.</b>			
<b><sup>1</sup>Yes = full-time, part-time, student or self-employed; <sup>2</sup>No = retired/unemployed/not seeking employment</b>			
<b>*Values missing for age (n=1), ethnicity (n=2), relationship status (n=2), education level (n=6), diabetes duration (n=20), body mass index (n=5), systolic blood pressure (n=25), diastolic blood pressure (n=26), HbA1c (n=1), total cholesterol (n=53), fasting triglycerides (n=58), insulin (n=6), albumin:creatinine ratio (n=105), protein:creatinine ratio (n=269), foot ulcers (n=2), Patient Health Questionnaire-9 (n=26), diabetes distress scale (n=27).</b>			

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<b>Table 2. Results from primary and secondary outcomes.</b>			
<b>Outcome at 18 months</b>	<b>Participants with baseline measurements</b>	<b>Participants with measurements at 18 months</b>	<b>Estimated Mean Difference: D6 vs standard care (95% CI)</b>
<b>Primary</b>			
<b>HbA1c (mol/mmol)*</b>	332	231	-0.79 (-5.75–4.18)
<b>Secondary</b>			
<b>Body mass index (kg/m<sup>2</sup>)*</b>	329	152	-0.08 (-1.12–0.97)
<b>Total cholesterol*</b>	281	140	-0.08 (-0.42–0.27)
<b>Systolic blood pressure (mm/Hg)*</b>	309	198	-1.35 (-6.85–4.14)
<b>Diastolic blood pressure (mm/Hg)*</b>	308	198	1.22 (-1.87–4.32)
<b>Fasting triglycerides**</b>	276	135	0.02 (-0.22–0.26)
<b>Patient Health Questionnaire-9 Score***</b>	308	114	-0.18 (-1.30–0.94)
<p>*Estimates based on linear combination from linear mixed-effects model with fixed effects of time (15 or 18 months), an interaction between time and randomisation group, randomisation phase, borough and baseline values of the outcome, a random effect for GP practice nurse clustering and with unstructured covariance matrix to account for dependency of repeated observations.</p> <p>**Estimates based on linear combination from linear mixed-effects model with fixed effects of time (15 months or 18 months), an interaction between time and randomisation group, randomisation phase, borough and baseline values of the outcome, a random effect for GP practice nurse clustering and with independent covariance structure due to convergence issues when estimating non-zero covariances.</p> <p>***Collected at 18 months only. Estimates based on linear combination from linear mixed model with fixed effects of randomisation phase, borough, baseline value and random within-cluster effect of nurse with unstructured covariance matrix to account for dependency of repeated observations.</p> <p>D6=Diabetes 6</p>			

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**Table 3. Mean costs (for the previous 6 months, £ sterling, 2011/12 prices), SF-12-based utility scores and QALY gains at baseline and/or 18 months.**

Costs at baseline	D6			Standard care			UMD*	95% CI	AMD**	95% CI*
	valid n	Mea n £	SD	valid n	Mea n £	SD				
Health and social care costs	157	847	847	161	976	760	-129	-301–44	-96	-293–101
<b>Costs at 18 months</b>										
Health and social care costs, excluding intervention, without discounting	133	707	579	137	793	558	-85	-252–81	-71	-242–100
Health and social costs, excluding intervention, with discounting	133	684	560	137	766	540	-82	-243–78	-69	-234–96
Intervention costs	121	451	99	139	167	100	285	240–329	276	225–327
Health and social care costs, including intervention costs, with discounting for non-intervention costs	92	1184	572	107	1025	573	159	-39–357	150	-34–333
<b>SF-12-based utility scores at baseline</b>										
Utility	157	0.75	0.16	159	0.74	0.16	0.01	-0.03–0.04	0.01	-0.03–0.00
<b>SF-12-based utility scores and QALY gains at 18 months</b>										
Utility	60	0.79	0.13	53	0.75	0.13	0.04	-0.01–0.08	0.01	-0.03–0.06
QALY gain since baseline, without discounting	58	1.15	0.20	48	1.11	0.18	0.03	-0.04–0.10	0.01	-0.03–0.05
QALY gain since baseline, with discounting and interpolation to match 6-month period for cost data	58	0.37	0.06	48	0.36	0.06	0.01	-0.01–0.03	0.00	-0.01–0.02
SF-12 = Short Form 12; QALY = quality-adjusted life year; D6 = Diabetes 6; UMD=Unadjusted mean difference; AMD=adjusted mean difference. *Intervention minus control. Comparisons include clustering for nurse. **Intervention minus control. Cost comparisons account for clustering for nurse plus covariates for baseline cost, age, gender, marital status, ethnicity, duration of diabetes and baseline utility. QALY comparisons account for clustering for nurse plus covariates for age, gender, marital status, ethnicity, duration of diabetes and baseline utility.										

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<b>Table 4. Group comparison for fidelity to MI and CBT.</b>			
<b>MI domain<sup>a</sup></b>	<b>D6</b>	<b>Standard care</b>	<b>p-value*</b>
<b>Global Spirit</b>	3.23 (1.13)	2.87 (0.87)	0.14
<b>Global Empathy</b>	3.00 (2.00–4.00)	2.50 (2.00–3.00)	0.19
<b>Proportion Complex Reflections</b>	0.35 (0.20)	0.40 (0.17)	0.25
<b>Proportion Open Questions</b>	0.36 (0.17)	0.25 (0.10)	<b>&lt;0.01</b>
<b>Reflection/Question Ratio</b>	0.57 (0.47–0.72)	0.74 (0.53–1.19)	<b>0.03</b>
<b>Proportion Motivational Interviewing Adherent</b>	0.58 (0.32)	0.54 (0.28)	0.51
<b>CBT skills</b>			
<b>BECCI score</b>	1.33 (0.56)	1.12 (0.55)	0.12
Data are mean (standard deviation), or median (interquartile range), as appropriate. MI=Motivational interviewing; CBT=Cognitive behaviour therapy; D6=Diabetes 6; BECCI=Behaviour Change Counselling Index. *Based on result of either a t-test or Mann-Whitney U-test. <sup>a</sup> The MITI guidance indicates that to reach proficiency, a practitioner must achieve an average global spirit rating of 3.5, a reflection to question ratio of $\geq 1$ , $\geq 0.5$ open questions relative to all questions, $\geq 0.4$ complex reflections relative to all reflections, and $\geq 0.9$ MI adherent.			

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573 **Appendices**

574 Appendices to: Cluster randomised controlled trial of a psychological intervention for type 2

575 diabetes.

576 **Table of Contents**

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## 590 **1 Full description of the study's methods**

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### 592 **Trial design**

593 D6 was a pragmatic parallel two-arm cluster RCT design for 18 months. Ethical approval was  
594 granted by the King's College Hospital Research Ethics Committee (reference 09/H0808/97)  
595 and by the respective Primary Care Trusts (reference RDLSLBex 534 and 2010/403/W).

596 Changes to the protocol were approved by the Trial Steering Committee and the Research  
597 Ethics Committee. All participants gave informed consent, including access to their medical  
598 records.

599 All moderate-to-large GP practices ( $\geq 6000$  patients registered) in the Lambeth, Southwark,  
600 Lewisham, Wandsworth, and Bexley Clinical Commissioning Groups, representing a resident  
601 population of 1.43 million in south London, UK, were invited to participate if they had a  
602 practice nurse delivering diabetes care. Practices were reimbursed £10k for seconding their  
603 nurse for one day/week for 15 months. We began recruiting patients after each practice  
604 consented to randomisation. The study was conducted in two phases as recruitment had  
605 slowed down significantly secondary to organisational uncertainties caused by the Health and  
606 Social Care Act 2012. This Act reorganised the UK's National Health Service (NHS),  
607 dismantling current organisational structures and creating new ones for funding,  
608 management, accountability, and regulation.<sup>15</sup>

### 609 **Patients**

610 The target population was adults with T2D who had persistent suboptimal glycaemic control  
611 despite care pathways based on national guidance,<sup>17</sup> therefore a group likely to have barriers  
612 to achieving optimal self-management. The study population was patients on diabetes  
613 registers of consenting practices. Using standardised search strategies, a list of potentially  
614 eligible patients based on the HbA1c (current and preceding 18 months) was generated by  
615 each practice and invited to participate. Three practices were eligible and willing to  
616 participate but did not have a nurse to second. A protocol change was made in Phase 2, which  
617 allowed a consenting practice without a nurse to amalgamate with an adjacent consenting  
618 practice which had a nurse, and each pair formed one cluster. The rationale was that the

619 patient catchment area was likely to be similar and that both practices used the same clinical  
620 guidance for diabetes care.

621 Inclusion criteria were adults aged 18–79 years, duration of T2D for  $\geq 2$  years, persistent  
622 suboptimal glycaemic control defined as HbA1c  $\geq 69.4$  mmol/mol on two occasions (at least  
623 once in the preceding 18 months and at recruitment) while on at least two oral diabetes  
624 medications (metformin and one other), and/or requiring insulin therapy. The HbA1c was  
625 lowered to  $\geq 64$  mmol/mol in Phase 2 to increase recruitment. These lower cut-offs for HbA1c  
626 was selected to maximise the proportion of patients who could potentially benefit. The  
627 minimum requirement of being prescribed at least two classes of oral diabetes medications  
628 was to ensure that efforts to optimise and intensify medical care according to national  
629 guidance had been offered to the patient before randomisation. Exclusion criteria were:  
630 severe mental disorders; terminal illnesses and end-stage diabetes complications; morbid  
631 obesity with a BMI  $>40$  kg/m<sup>2</sup> in Phase 1, which was raised to  $>50$  kg/m<sup>2</sup> in Phase 2 to  
632 enhance recruitment; non-ambulatory as patients had to be able to attend the clinic; no  
633 phone/internet access; non-English-speaking as therapy was delivered in English; and  
634 currently receiving psychological treatments from elsewhere. Patients who had Patient Health  
635 Questionnaire-9 (PHQ-9) depressive scores  $>20$  were excluded if they had psychotic  
636 depression or active suicidal ideation.<sup>16</sup>

### 637 **Randomisation**

638 Randomisation of practices (unit of cluster) was conducted after baseline data were collected  
639 by an independent statistician using a random number generator to assign equal numbers of  
640 practices to each arm at each phase. Allocation concealment was conducted by holding the  
641 randomisation list by an independent manager in password-locked computer. The trial  
642 manager was only able to reveal to themselves, and then to one D6 researcher, the allocation  
643 after entering the details of the practice.

644 Randomisation of clusters was intended to take place after all the patients had been recruited  
645 but this was leading to unacceptable delays in training the nurses. Therefore, some patients  
646 were recruited after randomisation of clusters but remained blind to allocation until the  
647 interventions were offered in both groups.

### 648 **Procedures**

649 **Baseline measures**

650 Baseline measures were: age, gender, self-reported ethnicity, occupation, employment  
651 status, and smoking status. HbA1c was measured centrally (King's College Hospital NHS  
652 Foundation Trust) by affinity chromatography (Primus Ultra2, Kansas City, USA) and  
653 reported in mmol/mol. Complication status was assessed before randomisation by the research  
654 assistant as follows: neuropathic ulcer risk was assessed by perception of 10g monofilament;  
655 retinopathy coding was taken from the most recent of annual standardised digital retinal  
656 photography documented in the community-based Diabetic Eye Complications Screening  
657 Service (DECS), with a new appointment arranged if one had been missed; urine was  
658 collected to assess nephropathy using the urinary albumin:creatinine ratio (ACR); and history  
659 of macrovascular complications collected from the medical records.

660 In addition, the following secondary outcomes were measured: systolic and diastolic blood  
661 pressure using an electronic sphygmomanometer; body mass index (BMI) (kg/m<sup>2</sup>) and waist  
662 circumference (cm); depressive symptoms using the Patient Health Questionnaire-9  
663 questionnaire;<sup>16</sup> the Alcohol Use Disorders Identification Test (AUDIT);<sup>23</sup> and the Diabetes  
664 Distress Scale, which measures diabetes specific psychological burden (in the protocol we  
665 had proposed a similar but longer scale).<sup>24</sup> A fasting blood sample was sent for measurement  
666 of HbA1c, total cholesterol, and triglycerides.

667 **Intervention**

668 **Group 1: Standard care**

669 The nurse delivered diabetes care in both groups as recommended by national guidance.<sup>17</sup> To  
670 control for attention, standard care nurses offered the same number of sessions as in D6. The  
671 sessions were audio-taped for assessment of contamination bias.

672 **Group 2: Standard care plus D6**

673 D6 aimed to provide the nurses with skills based on MI and CBT to address psychological  
674 barriers maintaining poor self-management. The theory underlying MI is that the patient's  
675 state of ambivalence (resistance versus willingness to make lifestyle changes) is the core  
676 psychological construct that needs addressing.<sup>6</sup> MI is a directive, person-centered counselling  
677 style which encourages patients to change behaviours using collaborative, non-judgmental,  
678 and affirming communications. The theory underlying CBT is that barriers to diabetes self-

679 management are maintained by unhelpful thoughts (e.g., *if I can't cure diabetes, what's the*  
680 *point?*), unhelpful behaviours (e.g., missing insulin doses), and distressing emotions (e.g.,  
681 low mood/anxiety when seeing a high blood glucose reading).<sup>18,19</sup> Identifying and  
682 challenging these cognitive barriers are effective in changing behaviours.<sup>20</sup>

683 The D6 nurses were trained in six skills drawn from MI and CBT: 1. Active listening; 2.  
684 Managing resistance; 3. Directing change; 4. Supporting self-efficacy; 5. Addressing health  
685 beliefs; and, 6. Shaping behaviours. These skills were applied to common barriers around  
686 diabetes such as medication adherence, self-testing, physical activity and dietary changes.  
687 The training was conducted by a senior diabetes-experienced clinical psychologist and lasted  
688 three months. It comprised three hours per week, interactive classroom activities, a training  
689 caseload (average 3-5 non-study patients), and weekly supervision of audiotaped sessions.  
690 We produced a manual containing the rationale for D6, the six psychological skills, case  
691 examples, strategies to manage clinician's own resistance, and for 'troubleshooting' common  
692 clinical obstacles. D6 nurses were expected to apply the skills flexibly to different situations  
693 (e.g., weight loss, medication adherence) using visual aids and worksheets. The format was  
694 12 face-to-face individual sessions (sessions 1-4 fortnightly during months 1-2, sessions 5-6  
695 monthly during months 3-6, and sessions 7-12 during months 7-12). Monthly group  
696 supervision by a senior clinical psychologist was provided. The sessions were audio-taped for  
697 assessment of fidelity.

698 The Motivational Interviewing Treatment Integrity (MITI) Scale (version 3.1.1)<sup>21</sup> and  
699 Behaviour Change Counselling Index (BECCI)<sup>22</sup> were used to assess treatment fidelity of D6,  
700 and to compare competencies in both groups. The MITI assesses: global spirit and global  
701 empathy with scores  $\geq 3.5$  (range 1-5); percentage of complex reflections, open questions,  
702 and MI adherent behaviours with scores of  $\geq 40\%$ ,  $50\%$ , and  $90\%$  respectively; and ratio of  
703 reflections to closed questions scores with  $\geq 1$  as proficient. The middle 20 minutes of  
704 sessions were rated by two independent psychologists trained in MITI and blind to treatment  
705 allocation. The BECCI consists of 11 items with 5-point Likert scales to rate the frequency or  
706 the strength of the nurse skill, ranging from 0 (not at all) to 4 (a great extent). A clinical  
707 psychologist, blind to treatment allocation, rated the BECCI. We stratified sessions by nurse  
708 and patient and then randomly selected tapes (that lasted  $\geq 20$  minutes) for 3 different patients  
709 for each nurse from either session 2, 3 and 4. Three nurses did not have three tapes lasting 20  
710 minutes or more and, for these, the three longest tapes were chosen.

711 **Outcomes**

712 As the recruitment and follow-up was delayed by the NHS restructuring and patient attrition,  
713 the protocol was changed from 24 months follow-up to 18 months. The primary outcome was  
714 change in HbA1c from cluster randomisation to 18 months. If the study HbA1c data were  
715 missing at 18-month, we used routinely collected HbA1c data if it was collected within the  
716 15-month follow-up window. Secondary outcomes were change in lipids, blood pressure,  
717 BMI and depressive symptoms at 18 months. Research assistants were blind to allocation  
718 when collecting follow-up data.

719 **Sample size**

720 A 10.9 mmol/mol difference in HbA1c in D6 compared to standard care was the minimal  
721 clinically acceptable reduction at 18 months, considering: (a) baseline HbA1c and (b) that  
722 standard care may produce a 2.2 mmol/mol (equivalent to 0.2%) reduction in HbA1c for the  
723 placebo effect of participating in a RCT (actual difference between groups 8.8 mmol/mol  
724 (equivalent to 0.8%), equivalent to a moderate effect size of  $d=0.55$ ). Assuming 20%  
725 dropout, we needed 360 patients to achieve 80% power at a two-sided alpha-level of 5%,  
726 with 20 practices with 18 patients each per arm. We then took account of clustering by  
727 practice and we assumed two practices per arm dropped out. Therefore, we needed 24  
728 practices with a total patient size of  $24 \times 18 = 432$  patients. The required sample size adjusted  
729 for a clustering intra-correlation coefficient (ICC) effect of 0.05 was  $81 \times 1.7 = 138$  patients per  
730 arm (inflation factor 1.7).

731 We recruited 334 patients of which 231 had at least one follow-up in 24 clusters. The average  
732 cluster size was therefore 10 patients per cluster, smaller than our assumed size of 15 patients  
733 per cluster with a post-hoc power of 77% (STATA 13 *clsamps* function) at two-sided alpha-  
734 level of 5%.<sup>25</sup>

735 **Statistical analysis**

736 Data were analysed using STATA 13. The sample characteristics were described as means  
737 (standard deviation (SD)) or as proportions (percentage). A comparison of patient list size  
738 and Index of Multiple Deprivation rank score by practices that participated versus those that  
739 did not was conducted using Student's t-test.<sup>26</sup> A linear mixed-effects model estimated group  
740 differences in HbA1c levels between D6 and standard care groups at 18 months. We included



741 the 15-month HbA1c as this clinically just overlaps with the 3-month window for 18-month  
742 HbA1c and to include more patients with at least one follow-up measure. Data were analysed  
743 as intention-to-treat (ITT). Time (with two levels: 15 and 18 months), treatment group, an  
744 interaction between treatment group and time, Primary Care Trust (as a possible prognostic  
745 factor), recruitment phase, and baseline HbA1c were included as fixed covariates. The  
746 dependency of the repeated observations of the same subjects was modeled on the covariance  
747 between the residuals using an unstructured covariance pattern model. Nurse was included as  
748 a random effect as the unit of randomisation.

749 Observations from the same nurse cluster were likely to be more similar than observations  
750 from two different clusters. However, in three cases, a practice was twinned with an adjacent  
751 practice and one nurse covered both practices. Therefore, two types of clustering could occur:  
752 within practice and within nurse. We assumed that nurse clustering would have a stronger  
753 effect than practice clustering. We therefore treated the twinned practices as one unit which is  
754 equivalent to treating nurse as the primary clustering unit. However, we repeated the model  
755 using 'practice' as the main clustering unit in a sensitivity analysis.

756 Secondary outcomes were analysed in the same way using linear mixed models to estimate  
757 group differences at 18 months (including 15 months). An independent covariance structure  
758 pattern was used for the triglycerides as the model did not converge using unstructured  
759 covariance.

760 Twenty-nine participants with HbA1c <64 mmol/mol contrary to the study criteria were  
761 included and this was a protocol violation. We performed a sensitivity analysis by including a  
762 binary covariate of this protocol violation (yes/no) in the model.

763 The analyses were conducted using maximum likelihood under the missing at random  
764 assumption. Sensitivity analyses were carried out to assess sensitivity to missingness in  
765 HbA1c using several approaches: by investigating and including predictors of missingness in  
766 the model and by using multiple imputation for the missing values of HbA1c (50 imputations  
767 using *mi* impute command in STATA 13 with all variables from the mixed-effects model  
768 included in the imputation model, as well as age, ethnicity, gender, baseline BMI, total  
769 cholesterol, triglycerides, blood pressure, and PHQ-9 score).

770 The Data Monitoring Committee oversaw the study.

771 **Fidelity**

772 To assess IRR for each fidelity measure, absolute agreement was measured by estimating the  
773 ICC from a two-way mixed model or using Spearman's rank correlation coefficient if  
774 residuals from the mixed model were not normally distributed. A t-test or Mann-Whitney U-  
775 test was used to compare the skills of D6 versus standard care nurses, using STATA 14.

776 **Role of funding source**

777 The funder of the study had no role in study design, data collection, data analysis, data  
778 interpretation, or reporting. The authors had full access to all data and final responsibility for  
779 submission for publication and acted independently from the funding source.

780 **Patient Involvement**

781 We included a person with type 1 diabetes from our local community who also was an active  
782 member of the local and national Diabetes UK. This person was instrumental in guiding us  
783 to use NHS practice nurses rather than research diabetes nurses to deliver the intervention.  
784 This person inputted into the importance of quality of life and psychological well-being as  
785 outcome measures alongside glycaemic control. For the process evaluation, we invited  
786 participants to give us feedback of the intervention in terms of the perception of burden as  
787 patients. We included a person with type 1 diabetes on the Trial Steering Committee.

788 **Transparency Declaration**

789 The lead author affirms that the manuscript is an honest, accurate, and transparent account of  
790 the study being reported; that no important aspects of the study have been omitted; there were  
791 discrepancies from the study as planned and these have been explained.

792

## 2 Additional Tables

793

<b>Table 1. Breakdown of patients attending each practice and primary outcome follow-up rates by group.</b>			
<b>D6</b>		<b>Standard care</b>	
<b>Practice*</b>	<b>Proportion with HbA1c data at 18 months (%)</b>	<b>Practice*</b>	<b>Proportion with HbA1c data at 18 months (%)</b>
1	14/18 (77.8)	2	11/12 (91.7)
3	13/19 (72.2)	4	14/19 (73.7)
5	7/16(64.3)	6	11/18 (61.1)
7	6/9 (66.7)	8	12/17 (70.6)
9	15/16 (93.8)	10	6/12 (50.0)
11	6/12 (50.0)	12	13/13 (100.0)
13	6/9 (66.7)	14	13/17 (76.5)
15**	9/18 (50.0)	16	13/17 (76.5)
17	9/13 (69.2)	18	5/8 (62.5)
19**	12/14 (85.7)	20***	1/4 (25.0)
21	8/14 (57.1)	22	5/11 (45.5)
23**	4/12 (33.3)	24	6/16 (37.5)
<b>Total</b>	<b>109/170 (64.1%)</b>	<b>Total</b>	<b>110/164 (67.1%)</b>

\* Practices 1-6 are from Phase 1 (HbA1c  $\geq$  69.4 mmol/mol and BMI  $\leq$  40kg/m<sup>2</sup>). Practices 7-24 are from Phase 2 (HbA1c  $\geq$  64 mmol/mol, BMI  $\leq$  50kg/m<sup>2</sup>, and twinned practices).  
 \*\* Two practices twinned and covered by 1 nurse.  
 \*\*\* Practice dropped out post-randomisation.  
 D6=Diabetes 6

794

795

<b>Table 2. Comparison of missingness in HbA1c at 18 months.</b>			
<b>Variable</b>	<b>HbA1c measured at 18 months (n=219)</b>	<b>Missing HbA1c at 18 months (n=115)</b>	<b>Test of independence (t-test or Pearson <math>\chi^2</math>-test)</b>
Age (years)	58.9 (11.4)	59.0 (11.0)	$t=0.045, p=0.964$
Ethnicity			
White	72 (33.0)	62 (54.4)	$\chi^2(3)=14.854, p=0.001$
African/Caribbean	103 (47.3)	40 (35.1)	
Asian/Other	43 (19.7)	12 (10.5)	
Gender			
Male	104 (47.5)	59 (51.3)	$\chi^2(1)=0.439, p=0.507$
Female	115 (52.5)	56 (48.7)	
Education level			
A levels or higher	60 (27.9)	30 (26.6)	$\chi^2(2)=0.091, p=0.956$
O level or GCSE equivalent	75 (34.9)	41 (36.3)	
No formal qualifications	80 (37.2)	42 (37.2)	
Relationship status			
Married or Cohabiting	112 (51.3)	59 (51.3)	$\chi^2(2)=1.221, p=0.543$
Separated/Divorced/Widowed	60 (27.7)	37 (32.2)	
Single	45 (20.7)	19 (16.5)	
Employment			
Yes	92 (42.0)	47 (40.9)	$\chi^2(1)=0.040, p=0.841$
No	127 (58.0)	68 (59.1)	
BMI (kg/m <sup>2</sup> )	32.1 (6.0)	31.5 (6.4)	$t=-0.839, p=0.402$
Systolic BP (mm/Hg)	133.6 (17.2)	135.3 (16.9)	$t=-0.823, p=0.411$
Diastolic BP (mm/Hg)	79.2 (10.0)	79.2 (10.3)	$t=-0.052, p=0.958$
HbA1c (mmol/mol)	79.1 (17.4)	83.2 (19.3)	$t=-1.96, p=0.051$
Total Cholesterol (mmol/L)	4.2 (1.1)	4.3 (1.3)	$t=-0.501, p=0.617$
Fasting triglycerides (mmol/L)	1.6 (1.2)	1.9 (1.4)	$t=-1.631, p=0.104$
Diabetes duration (years)	10.5 (6.1)	10.0 (6.7)	$t=-0.694, p=0.488$
DDS (mean item score)	2.2 (0.8)	2.3 (0.8)	$t=0.959, p=0.338$
Data are n (%) or mean (SD), as appropriate.			
<sup>1</sup> Yes = full time, part-time, student or self-employed			
<sup>2</sup> No = retired/unemployed/not seeking employment			
BMI = Body mass index; BP = blood pressure; DDS = Diabetes Distress Scale			

<b>Table 3. Inter-rater reliability for each MI domain.</b>	
<b>MI Domain</b>	<b>Inter-rater reliability*</b>
Global Spirit (ICC)	0.87
Global Empathy (Spearman's rho)	0.91
% Complex Reflections (ICC)	0.86
% Open Questions (ICC)	0.92
Reflection/Question Ratio (Spearman's rho)	0.88
% MI Adherent (ICC)	0.90
MI=Motivational interviewing; ICC=Intra-class correlation coefficient *Reliability was calculated as an ICC if the distribution was normal and a Spearman's rho if non-normal.	

799

800 We rated 69 sessions (4.0% of all available recordings) for fidelity from 33/170 and 36/164  
801 patients from the D6 and standard care groups, respectively. The level of competency in the  
802 D6 group was below the beginner proficiency level in all the scales for MI and BECCI.  
803 Except for a slightly higher proportion of open questions in D6, and a slightly larger  
804 reflection/question ratio in standard care, there were no statistically significant differences in  
805 the remaining mean MI domain scores or BECCI scores.



809

810 **3 CONSORT 2010 checklist of information for reporting a cluster randomised**  
 811 **trial**

Section/Topic	Item No	Standard Checklist item	Extension for cluster designs	Page No *
<b>Title and abstract</b>				
	1a	Identification as a randomised trial in the title	Identification as a cluster randomised trial in the title	<b>1</b>
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts) <sup>i,ii</sup>	See table 2	<b>2</b>
<b>Introduction</b>				
<b>Background and objectives</b>	2a	Scientific background and explanation of rationale	Rationale for using a cluster design	<b>4-5</b>
	2b	Specific objectives or hypotheses	Whether objectives pertain to the the cluster level, the individual participant level or both	<b>4</b>
<b>Methods</b>				
<b>Trial design</b>	3a	Description of trial design (such as parallel, factorial) including allocation ratio	Definition of cluster and description of how the design features apply to the clusters	<b>5-6</b>
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons		<b>Appendix</b>
<b>Participants</b>	4a	Eligibility criteria for participants	Eligibility criteria for clusters	<b>5</b>
	4b	Settings and locations where the data were collected		<b>5</b>
<b>Interventions</b>	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	Whether interventions pertain to the cluster level, the individual participant level or both	<b>6-7</b>
<b>Outcomes</b>	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	Whether outcome measures pertain to the cluster level, the individual participant level or both	<b>7-8</b>
	6b	Any changes to trial outcomes after the trial commenced, with reasons		<b>7-8, Appendix</b>
<b>Sample size</b>	7a	How sample size was determined	Method of calculation, number of clusters(s) (and whether equal or unequal cluster sizes are assumed), cluster size, a coefficient of intracluster correlation (ICC or <i>k</i> ), and an indication of its uncertainty	<b>8, Appendix</b>
	7b	When applicable,		<b>NA</b>

		explanation of any interim analyses and stopping guidelines		
<b>Randomisation:</b>				
<b>Sequence generation</b>	8a	Method used to generate the random allocation sequence		<b>6, Appendix</b>
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	Details of stratification or matching if used	<b>6, Appendix</b>
<b>Allocation concealment mechanism</b>	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	Specification that allocation was based on clusters rather than individuals and whether allocation concealment (if any) was at the cluster level, the individual participant level or both	<b>6, Appendix</b>
<b>Implementation</b>	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	Replace by 10a, 10b and 10c	
	10a		Who generated the random allocation sequence, who enrolled clusters, and who assigned clusters to interventions	<b>6, Appendix</b>
	10b		Mechanism by which individual participants were included in clusters for the purposes of the trial (such as complete enumeration, random sampling)	<b>6, Appendix</b>
	10c		From whom consent was sought (representatives of the cluster, or individual cluster members, or both), and whether consent was sought before or after randomisation	<b>5-6,18, Appendix</b>
<b>Blinding</b>	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how		<b>8</b>
	11b	If relevant, description of the similarity of interventions		<b>6-7</b>
<b>Statistical methods</b>	12a	Statistical methods used to compare groups for primary and secondary outcomes	How clustering was taken into account	<b>8-9, Appendix</b>
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses		<b>8-9, Appendix</b>



<b>Results</b>				
<b>Participant flow (a diagram is strongly recommended)</b>	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	For each group, the numbers of clusters that were randomly assigned, received intended treatment, and were analysed for the primary outcome	<b>9-10, Figure 1, Appendix 3 Table 1</b>
	13b	For each group, losses and exclusions after randomisation, together with reasons	For each group, losses and exclusions for both clusters and individual cluster members	<b>9-10, Figure 1, Appendix 3 Table 1</b>
<b>Recruitment</b>	14a	Dates defining the periods of recruitment and follow-up		<b>Figure 1, Appendix</b>
	14b	Why the trial ended or was stopped		<b>NA</b>
<b>Baseline data</b>	15	A table showing baseline demographic and clinical characteristics for each group	Baseline characteristics for the individual and cluster levels as applicable for each group	<b>Table 1</b>
<b>Numbers analysed</b>	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	For each group, number of clusters included in each analysis	<b>10, Figure 1</b>
<b>Outcomes and estimation</b>	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	Results at the individual or cluster level as applicable and a coefficient of intracluster correlation (ICC or $k$ ) for each primary outcome	<b>10-11</b>
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended		<b>NA</b>
<b>Ancillary analyses</b>	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory		<b>10-11, Appendix</b>
<b>Harms</b>	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms <sup>iii</sup> )		<b>12</b>
<b>Discussion</b>				
<b>Limitations</b>	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses		<b>12-15</b>
<b>Generalisability</b>	21	Generalisability (external validity, applicability) of the trial findings	Generalisability to clusters and/or individual participants (as relevant)	<b>12-15</b>
<b>Interpretation</b>	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant		<b>12-15</b>

		evidence	
<b>Other information</b>			
<b>Registration</b>	23	Registration number and name of trial registry	<b>2</b>
<b>Protocol</b>	24	Where the full trial protocol can be accessed, if available	<b>NA</b>
<b>Funding</b>	25	Sources of funding and other support (such as supply of drugs), role of funders	<b>17</b>

812  
813

*\* Note: page numbers optional depending on journal requirements*

814

## 815 **4 Supplementary Data from the Economic Evaluation**

816 Correspondence to: Professor Anita Patel anitapatelconsulting@gmail.com

### 817 **4.1 Summary of methods**

818

819 A within-trial economic evaluation assessed the cost-effectiveness of D6 from a health and  
820 social care perspective at 18 months. This linked individual-level costs with HbA1c and  
821 quality-adjusted life year (QALY) gains estimated from the Short Form 12 (SF-12) version  
822 2.<sup>52,53</sup> We calculated individual-level total costs (English pounds sterling, £, 2011–12 prices)  
823 by attaching unit costs from national sources to individual-level (all-cause) resource use  
824 quantities covering a retrospective 6-month period at baseline and 18 months. Use of hospital  
825 services was assessed by retrospective review of hospital records. Use of out-of-area hospital  
826 services, community-based services, and medications were measured by self-report using a  
827 specifically developed proforma. Cost estimates for D6 included the full costs of staff  
828 training/supervision/assessment and time spent on delivery to patients. Outcomes and costs at  
829 18 months were discounted by 3.5%.

830 Costs and QALY gains at 18 months were compared using non-parametric bootstrap  
831 regressions (10000 repetitions) with baseline covariates and adjustment for nurse. We only  
832 calculated incremental cost-effectiveness ratios where either group showed statistically  
833 greater costs and outcomes. The probability of cost-effectiveness for D6 was assessed by  
834 constructing cost-effectiveness acceptability curves (10000 bootstrap repetitions) for  
835 threshold ranges of £0–£50,000 per QALY gain/point improvement in HbA1c. Sensitivity  
836 analyses explored the impact on cost and/or outcome differences when: (a) missing data due  
837 to loss of follow-up were imputed (using multiple imputation in STATA 11.2) rather than  
838 excluded, (b) the unit cost of the D6 intervention was lowered by assuming 50% more people  
839 received D6, (c) accounting for the inadvertent inclusion of 29 individuals with HbA1c <64  
840 mmol/mol by including a binary covariate for this, and (d) accounting for clustering at  
841 practice rather than nurse level.

842 **4.2 Intervention Costs**

843

844 **Table S1: D6 intervention costs (English pounds sterling, £, 2011–12 prices; total costs rounded to nearest £)**

Intervention Component	Description	Resources	Resource and cost details	Total cost	Unit cost per participant (n164)
<b>Training</b>	One training session (three hours) per week for 12 weeks, for 11 trainees. Delivered by one clinical psychologist over two training courses.	Trainer's time	1 band 8a clinical psychologist for 4 hours (3 hour training plus 1 hour preparation) for 12 weeks for 2 courses (1 * 4 * 12 * 2 * £60 <sup>1</sup> ) £5,760	£20,074	£122
		Trainees' time	11 trainees (primary care nurses) for 3 hours for 12 weeks (11 * 3 * 12 * £35 <sup>2</sup> ) £13,860.		
		Capital/materials	Room to train in: 3 hours training for 12 weeks for 2 courses (3 * 12 * 2 * £3.10 per hour <sup>3</sup> ) £223.20. Printing of 11 D6 psychology skills handbook: (11 * £11.94 <sup>4</sup> ) £131.34. Printing of 10 A4 PowerPoint presentations for 12 session for 11 trainees (10 * 12 * 11 * £0.06 <sup>5</sup> ) £79.20. Use of 1 video camera: £19.99 <sup>6</sup>		
<b>Supervision</b>	Supervision for trainees provided in two hour group sessions by a clinical psychologist.	Trainer's time	1 band 8a clinical psychologist for 3 hours (2 hour supervision plus 1 hour preparation) for a total of 35 group supervision sessions (1 * 3 * 35 * £60 <sup>1</sup> ) £6,300. 1 band 8a clinical psychologist for 30 minutes for transcription of 131 taped trainee sessions (0.5 * 131 * £60 <sup>1</sup> ) £3,930.	£23,449	£143
		Trainees' time	1 trainee (primary care nurse) for 2 hours for 140 trainee attendances at group sessions (1 * 2 * 140 * £35 <sup>2</sup> ) £9,800.		
		Transcription	Transcription of 131 30-minute sessions: (131 * 30 * 0.80) £3,144 <sup>7</sup> .		
		Materials	1 audio recorder per trainee: (11 * £24.99 <sup>8</sup> ) £274.89.		
<b>Assessment</b>	One 30-minute assessment by band 8a nurse per trainee	Assessor's time	1 band 8a nurse for 30-minutes, for 11 assessments (1 * 0.5 * 11 * £60 <sup>9</sup> ) £330	£330	£2

<b>Total for training</b>				£43,853	£267
<b>Intervention</b>	Participants offered 12 sessions over twelve months.	Trainees' time	Individually calculated for each case based on number of sessions attended (assume 30 minute session): (30 minutes * £0.75 per minute <sup>10</sup> ) £22.50 per session.	Cost per patient	Mean £301
<b>Sources and details (all pounds sterling (£), 2011/12 prices):</b>					
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3. Hurley MV, Walsh NE, Mitchell HL, Pimm J, Williamson E, Jones RH, Reeves BC, Dieppe PA, Patel A. Economic evaluation of a rehabilitation program integrating exercise, self-management, and active coping strategies for chronic knee pain. <i>Arthritis &amp; Rheumatism (Arthritis Care &amp; Research)</i> 2007; 57 (7): 1220-1222. Obtained further details via correspondence with the authors. Based on capital costs of a gym (£5.10 per hour, 2003/4 prices), halved to give more appropriate sized room (£2.55), inflated to 2011/12 prices (£3.10), (inflation source: Curtis L. 2012. Unit Costs of Health and Social Care 2012. Personal Social Services Research Unit: University of Kent, The Hospital & Community Health Services (HCHS) index – annual percentage prices increase).					
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10. Curtis L. 2012. Unit Costs of Health and Social Care 2012. Personal Social Services Research Unit: University of Kent. Based on £45 per hour of face-to-face contact excluding qualifications.					

847 Table S2: Unit costs

Item	Unit	Unit cost (£) 2011-12 prices	Source	Notes
<b>Inpatient services</b>				
Nervous System	bed day	368	1	NHS reference cost - Code A
Eyes & Periorbital	bed day	606	1	NHS reference cost - Code B
Mouth, head, neck & ears	bed day	519	1	NHS reference cost - Code C
Respiratory system	bed day	326	1	NHS reference cost - Code D
Cardiac Surgery & Primary Cardiac Conditions	bed day	452	1	NHS reference cost - Code E
Digestive System	bed day	428	1	NHS reference cost - Code F
Hepato-biliary and Pancreatic Systems	bed day	398	1	NHS reference cost - Code G
Musculoskeletal System	bed day	486	1	NHS reference cost - Code H
Skin, Breast & Burns	bed day	404	1	NHS reference cost - Code J
Endocrine & Metabolic System	bed day	327	1	NHS reference cost - Code K
Urinary Tract & Male Reproductive Systems	bed day	350	1	NHS reference cost - Code L
Female Reproductive System & Assisted Reproduction	bed day	599	1	NHS reference cost - Code M
Obstetrics	bed day	818	1	NHS reference cost - Code N
Diseases of Childhood & Neonates	bed day	577	1	NHS reference cost - Code P
Vascular System	bed day	472	1	NHS reference cost - Code Q
Radiology and Nuclear Medicine	bed day	513	1	NHS reference cost - Code R
Haematology, Chemotherapy, Radiotherapy & Specialist Palliative Care	bed day	448	1	NHS reference cost - Code S
Multiple Trauma, Emergency Medicine and Rehabilitation	bed day	458	1	NHS reference cost - Code T
Immunology, Infectious Diseases & other contacts	bed day	360	1	NHS reference cost - Code W
General inpatient	bed day	439	1	NHS reference cost - Overall inpatient
A&E	bed day	112	1	TAandEMSNA - Accident and Emergency Services: Not Leading to Admitted
<b>Outpatient services</b>				
Diabetes clinic	visit	134	1	307 - diabetic medicine on Total-OPATT tab
Diabetes foot clinic	visit	134	1	cost as diabetes clinic
Diabetes eye clinic	visit	134	1	cost as diabetes clinic
Ophthalmology	visit	86	1	130 - ophthalmology on Total-OPATT tab
Blood tests / phlebotomy	visit	3	1	DAP839 - Phlebotomy: on TDAPS tab (Pathology services)
Dietetics	visit	57	1	Total - OPATT Tab: Service code 654A - Adult dietetics
General medical outpatient	visit	158	1	300 - general medicine on Total-OPATT tab
Day surgery centre	visit	123	1	Total OPATT (Outpatient Attendances Data) tab - code 100 - general surgery
A&E	visit	110	1	180 - A&E on Total-OPATT tab
X-ray (x-ray only)	visit	30	1	Total - OPATT Tab: Direct Access Plain Film - DAPF
<b>Community based professionals</b>				
GP at surgery	contact	36	2	P183 - PSSRU - per patient contact lasting 11.7 minutes - Excludes qualification costs, including direct care staff costs.
GP at home	contact	92	2	P183 - PSSRU - per patient out of surgery visit lasting 23.4 minutes - Excludes qualification costs, including direct care staff costs.
GP telephone	contact	22	2	P183 - PSSRU - per telephone contact lasting 7.2 minutes - Excludes qualification costs, including direct care staff costs.
Diabetes specialist nurse at surgery	contact	11.11	2	p178 - PSSRU - Nurse specialist - £43 per hour excluding qualifications, assuming 15.5 (specified on p180 for practice nurse) min appointment
Diabetes specialist nurse at home	contact	16.11	2	p178 - PSSRU - Nurse specialist - £43 per hour excluding qualifications, - using per hour of home visiting from community nurse (p175) - £61:£42 = 1.45 SO - 11.11*1.45=16.11
Diabetes specialist nurse telephone	contact	6.78	2	p178 - PSSRU - Nurse specialist - £43 per hour

					excluding qualifications, assume same proportion of costs as a GP telephone call (61% (*0.61)) - $11.11 * .61 = 6.78$
Practice nurse at surgery	contact	11.63	2		P180 - PSSRU - £45 per hour of face-to-face contact excluding qualifications assuming 15.5 (specified on p180) min appointment
Practice nurse at home	contact	16.166	2		based on practice nurse surgery visit cost above but use the proportion of district nurse home visit hour / clinic hour proportion from PSSRU 2010 ( $68/49=139\%$ )
Practice nurse telephone	contact	7.0943	2		assume same proportion of costs as a GP telephone call (61% (*0.61))
Chiropodist/podiatrist at surgery	contact	48.529	1		TOCS tab - N910 Podiatry services - £47 per activity
Chiropodist/podiatrist at home	contact	70.367	1		TOCS tab - N910 Podiatry services - £47 per activity - with proportions of home visit from community nurse (p175, PSSRU) - $£61 : £42 = 1.45$ SO - $47 * 1.45 = 68.15$
Chiropodist/podiatrist telephone	contact	29.603	1		assume same proportion of costs as a GP telephone call (61% (*0.61))
Optician at surgery	contact	20.7	3		"The fee paid to an optical contractor for carrying out an NHS sight test by the governments of England, Wales, and Northern Ireland remains at £20.70 for the year 1 April 2011 to 31 March 2012"
Optician at home	contact	28.773	2		based on surgery visit cost above but use the proportion of district nurse home visit hour / clinic hour proportion from PSSRU 2010 ( $68/49=139\%$ )
Optician telephone	contact	12.627	2		assume same proportion of costs as a GP telephone call (61% (*0.61))
District nurse at surgery	contact	11.347	2		based on district nurse home visit cost above but use the proportion of clinic hour / home visit hour proportion from PSSRU 2010 ( $49/68=72\%$ )
District nurse at home	contact	15.76	2		P175 - PSSRU - Community nurse including district - £61 per hour of home visiting including travel, excluding quals, assume 15.5 (see page 180) min appointment
District nurse telephone	contact	9.6136	2		assume same proportion of costs as a GP telephone call (61% (*0.61))
Dietician at surgery	contact	72.277	1		TOCS tab - N800 Dietetics services - £70 per activity
Dietician at home	contact	104.8	1		Cost combines price from 2011/12 (above) but with proportions of home visit from community nurse (p175, PSSRU) - $£61 : £42 = 1.45$ SO - $70 * 1.45 = 101.5$
Dietician telephone	contact	44.089	1		assume same proportion of costs as a GP telephone call (61% (*0.61))
Physiotherapist at surgery	contact	48.529	1		TCSCT tab (community based therapy services) - N5A1 - Community Physiotherapy Services : Adult - One-to-One Services - £47
Physiotherapist at home	contact	70.367	1		TCSCT tab (community based therapy services) - N5A1 - Community Physiotherapy Services : Adult - One-to-One Services - £47 - but with proportions of home visit from community nurse (p175, PSSRU) - $£61 : £42 = 1.45$ SO - $47 * 1.45 = 68.15$
Physiotherapist telephone	contact	29.603	1		assume same proportion of costs as a GP telephone call (61% (*0.61))
Occupational therapist at surgery	contact	30	2		p168 - pssru - NHS community OT - £30 per hour - assume 1 hour meeting, Excludes qualification costs.
Occupational therapist at home	contact	54.78	2		Cost combines price from 2011/12 (above) but with proportions of client time set down in 2009-10 (p152) book (£42 per home visit / £23 per hour = 182.61%). £30 per hour (excluding qualifications) multiplied by 182.61%
Occupational therapist telephone	contact	18.3	2		assume same proportion of costs as a GP telephone call (61% (*0.61))
Psychiatrist at surgery	contact	171.4	1		TMHC SOPFUAF tab (Mental Health Consultant Services (Outpatient Setting) - Follow-up Attendance Face to Face) - MHOPFUA2 (Adult other services)
Psychiatrist at home	contact	248.53	1		based on psychiatrist visit cost above but use the proportion of home visiting from community nurse (p175, PSSRU) - $£61 : £42 = 1.45$ SO - $166 * 1.45 = 240.70$
Psychiatrist telephone	contact	51.626	1		TMHC SOPFUANF tab (Mental Health Consultant

					Services (Outpatient Setting) - Follow-up Attendance Non Face to Face) - MHOPFUA2 (Adult other services)
Psychologist at surgery	contact	136	2		p171 PSSRU - £136 per hour of client contact - assume 1 hour appointment, Excludes qualification costs.
Psychologist at home	contact	189.04	2		based on psychologist visit cost above but use the proportion of district nurse home visit hour / clinic hour proportion from PSSRU 2010 (68/49=139%)
Psychologist telephone	contact	40.8	2		assume same proportion of costs as a psychiatrist face to face v non face to face (30% (*0.30))
Psychotherapist at surgery	contact	136	2		Assume same as a psychologist. "A psychotherapist may be a psychiatrist, social worker, psychologist, mental health nurse or other mental health professional who has had further specialist training in psychotherapy. Increasingly, there are a number of psychotherapists who do not have backgrounds in these fields but who have undertaken in-depth training in this area.
					" - from <a href="http://www.nhscareers.nhs.uk/explore-by-career/psychological-therapies/careers-in-psychological-therapies/psychotherapist/">http://www.nhscareers.nhs.uk/explore-by-career/psychological-therapies/careers-in-psychological-therapies/psychotherapist/</a> - accessed 16April2013
Psychotherapist at home	contact	189.04	2		based on psychotherapist visit cost above but use the proportion of district nurse home visit hour / clinic hour proportion from PSSRU 2010 (68/49=139%)
Psychotherapist telephone	contact	40.8	2		assume same proportion of costs as a psychiatrist face to face v non face to face (30% (*0.30))
Counsellor at surgery	contact	59	2		P53 Pssru - £59 per consultation
Counsellor at home	contact	82.01	2		based on surgery visit cost above but use the proportion of district nurse home visit hour / clinic hour proportion from PSSRU 2010 (68/49=139%)
Counsellor telephone	contact	35.99	2		assume same proportion of costs as a GP telephone call (61% (*0.61))
Social worker at surgery	contact	78	2		P190 - PSSRU - social worker adult services - £156 per hour of face to face contact - assume 30 min appointment - excludes qualifications.
Social worker at home	contact	108.42	2		based on social worker visit cost above but use the proportion of district nurse home visit hour / clinic hour proportion from PSSRU 2010 (68/49=139%)
Social worker telephone	contact	23.4	2		assume same proportion of costs as a psychiatrist face to face v non face to face (30% (*0.30))
Home help/ care worker at surgery	contact	11.58	2		same as surgery
Home help/ care worker at home	contact	11.58	2		P193 PSSRU - Home care worker per hour of face to face contact, Weighted average accounting for different rates for day/evening/weekday/weekends. Plus, info that over 50% of visits are for 30 minutes so accounting for this (23.16/2= £11.58)
Home help/ care worker telephone	contact	7.0638	2		assume same proportion of costs as a GP telephone call (61% (*0.61))
Meals on Wheels at surgery	contact	5	2		same as home visit
Meals on Wheels at home	contact	5	2		P125 PSSRU - £6 local authority meal v £4 independent sector cost per day
Meals on Wheels telephone	contact	3.05	2		assume same proportion of costs as a GP telephone call (61% (*0.61))
Pharmacist for advice at surgery	contact	4.17	2		p172 PSSRU - £50 - assume 5 min consultation - Excludes qualification costs.
Pharmacist for advice at home	contact	4.17	2		same as home visit
Pharmacist for advice telephone	contact	4.17	2		Assume same as a pharmacist surgery consult
NHS direct at surgery	contact	22.358	4		cost as telephone
NHS direct at home	contact	22.358	4		cost as telephone
NHS direct telephone	contact	22.358	4		21.02 in 2009/10 so inflate up to 2011/12
<b>Insulin equipment</b>					
Blood glucose monitor / metre	item	12	5		
Blood glucose testing strips	100-pack	30.1	6		per 100: p459 - accu-chek mobile - n100
Insulin pen	item	15.7	6		per 1 pen: p446 - autopen 24
Insulin pump	item	2375	7		
Needle	100-pack	2.79	1		per 100: p447 - hypodermic needle - n100
Syringe	10-pack	1.35	6		per 10; p447 - U100 syringe with needle - 10 needles - 1.35
Finger prick device	200-pack	2.94	6		p446 - unilet eco - 200



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855 **4.4 Sensitivity Analyses**

856 **Table S11: Total costs at baseline and 18 months including intervention costs based on sensitivity analyses (2011/12 prices; all 18 month costs except intervention**  
 857 **costs discounted)**

	Control			Intervention			Unadjusted mean difference <sup>s</sup>	95% C.I.	Adjusted mean difference <sup>ss</sup>	95% C.I. <sup>s</sup>
	valid n	Mean £	SD	valid n	Mean £	SD				
<b>Costs at 18 months</b>										
<i>Per protocol</i>										
Health & social care costs including intervention costs	107	1025	573	92	1184	572	159	-39 to 357	151	-32 to 334
<i>GP Clustering</i>										
Health & social care costs including intervention costs	107	1025	573	92	1184	572	159	-39 to 357	150	-30 to 329
<i>Alternative intervention cost</i>										
Health & social care costs including intervention costs	107	1025	573	92	1095	572	70	-128 to 268	61	-123 to 244
<i>Intention to treat</i>										
Health & social care costs including intervention costs – intention to treat	170	1052	497	164	1126	473	74	-42 to 190	107	7 to 207*

858 <sup>s</sup>Comparisons include clustering for nurse. <sup>ss</sup>Comparisons include clustering for nurse plus covariates for baseline cost, age, gender, marital status, ethnicity, duration of  
 859 diabetes and baseline utility. \* Statistically significant

860  
 861 **Table S12: Outcomes at baseline and 18 months interpolated to a six month period to match the cost data based on sensitivity analyses**

	Control			Intervention			Unadjusted mean difference <sup>s</sup>	95% C.I.	Adjusted mean difference <sup>ss</sup>	95% C.I. <sup>s</sup>
	valid n	Mean £	SD	valid n	Mean £	SD				
<b>Outcomes at 18 months</b>										
<i>Per protocol</i>										
HbA1c (discounted)	109	71.31	19.22	110	71.60	18.11	0.29	-5.40 to 5.98	0.00	-6.08 to 6.09
SF12 based QALY (discounted and interpolated)	48	0.36	0.06	58	0.37	0.06	0.01	-0.01 to 0.03	0.00	-0.01 to 0.02
<i>GP cluster</i>										
HbA1c (discounted)	109	71.31	19.22	110	71.60	18.11	0.29	-5.38 to 5.97	0.66	-5.43 to 6.75
SF12 based QALY (discounted and interpolated)	48	0.36	0.06	58	0.37	0.06	0.01	-0.01 to 0.03	0.00	-0.01 to 0.00
<i>Intention to treat</i>										
HbA1c (discounted)	170	72.16	16.74	164	72.19	15.61	0.02	-4.34 to 4.39	0.47	-4.75 to 3.82
SF12 based QALY (discounted)	170	0.36	0.06	164	0.37	0.06	0.00	-0.01 to 0.02	0.00	-0.00 to 0.01

and interpolated)

862 <sup>s</sup>Comparisons include clustering for nurse. <sup>ss</sup>Comparisons include clustering for nurse plus covariates for age, gender, marital status, ethnicity, duration of diabetes and

863 baseline utility. \* Statistically significant

864 **4.5 Cost-effectiveness**

865 For the economic analysis, 139 (42%) and 85 (25%) participants had the two necessary combinations of cost/HbA1c/covariate and cost/SF-  
866 12/covariate data, respectively; characteristics of those with and without data were comparable.

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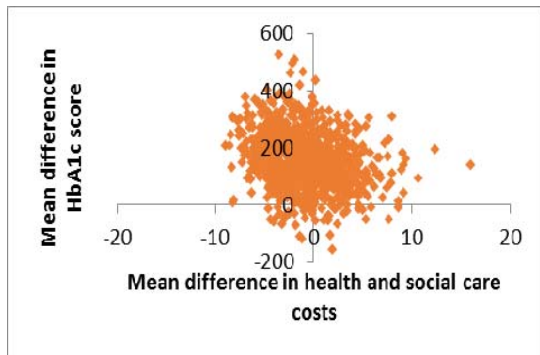
868 Based on QALYs, probabilities of cost-effectiveness for the D6 group at 18 months did not exceed 35% at the examined willingness to pay  
869 thresholds. However, based on HbA1c, probabilities of cost-effectiveness were around 5% at a willingness to pay threshold of £0, rising to (and  
870 remaining at) around 65% at thresholds of £5000–£50000. However, willingness to pay for a point improvement in HbA1c is unknown, and such  
871 a small improvement is unlikely to be clinically meaningful. Based on QALYs, probabilities of cost-effectiveness for the D6 group at 18 months  
872 did not exceed 35% at the examined willingness to pay thresholds. However, based on HbA1c, probabilities of cost-effectiveness were around  
873 5% at a willingness to pay threshold of £0, rising to (and remaining at) around 65% at thresholds of £5000–£50000. However, willingness to pay  
874 for a point improvement in HbA1c is unknown, and such a small improvement is unlikely to be clinically meaningful.

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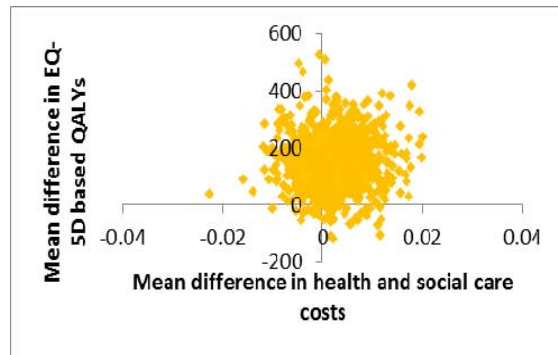
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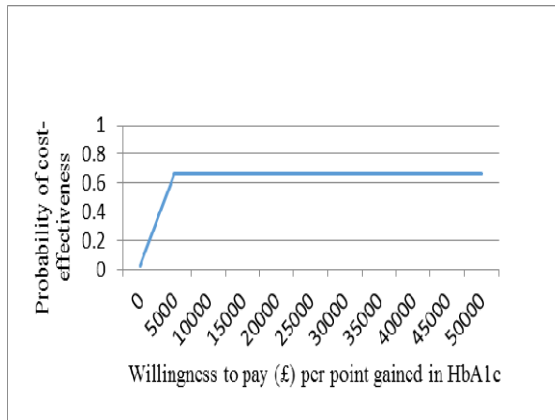
**Figure S1: Cost-effectiveness plane for HbA1c changes at 18 months from a health & social care perspective**



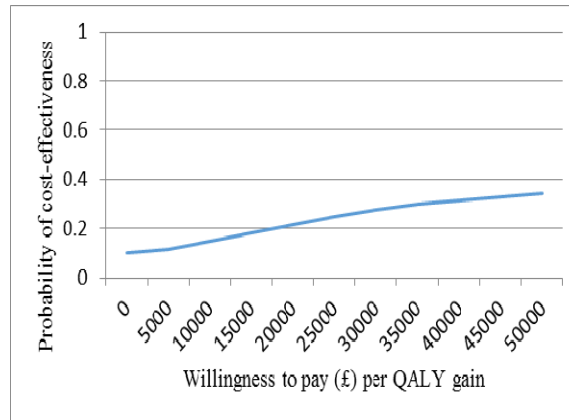
**Figure S2: Cost-effectiveness plane for QALY gains at 18 months from a health & social care perspective**



**Figure S3: Cost-effectiveness acceptability curve for HbA1c point improvements at 18 months from a health & social care perspective**



**Figure S4: Cost-effectiveness acceptability curve QALY gains at 18 months from a health & social care perspective**



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