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What are the combined effects of negative emotions and illness cognitions on self-care in people with type 2 diabetes? A longitudinal structural equation model

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Abstract

Objective To explore whether negative emotions mediate the effect of diabetes cognitions on diabetes self-care and conversely whether diabetes cognitions mediate the effect of negative emotions on diabetes self-care.

Design Longitudinal observational study in adults with Type 2 diabetes.

Main outcome measures Self-reported depression and anxiety (Diabetes Wellbeing Questionnaire), cognitions (Illness Perceptions Questionnaire-Revised; Beliefs about Medicines Questionnaire), and diabetes self-care (Summary of Diabetes Self-Care Activities Scale) were completed at baseline and six months. Analyses used structural equation modelling.

Results Baseline medication concerns were associated with elevated symptoms of depression and anxiety at follow-up, but emotions did not mediate medication concern's effect on diabetes self-care. Baseline depression and anxiety symptoms were associated with specific diabetes cognitions over time, but these cognition domains did not mediate emotion's effect on diabetes self-care. Personal control remained independent of emotions and was associated with diabetes self-care over time.

Conclusions Negative emotions did not act directly or alongside cognitions to influence diabetes self-care. The reciprocal relationship between diabetes cognitions and emotions suggests cognitive restructuring, in addition to other mood management intervention techniques would likely improve the emotional wellbeing of adults with Type 2 diabetes.

Likewise, personal control beliefs are likely important intervention targets for improving self-care.

Key words:

Depression, anxiety, illness cognitions, diabetes self-care, structural equation modelling, longitudinal

1 **Introduction**

2

3 In adults with diabetes, symptoms of depression and anxiety are prevalent (Anderson,
4 Freedland, Clouse, & Lustman, 2001; Grigsby, Anderson, Freedland, Clouse, & Lustman,
5 2002) and associated with increased glycosylated haemoglobin (HbA1c) (Lustman et al.,
6 2000), morbidity (de Groot, Anderson, Freedland, Clouse, & Lustman, 2001), and mortality
7 (Park, Katon, & Wolf, 2013). Both biological (Rustad, Musselman, & Nemeroff, 2011) and
8 behavioural (Gonzalez et al., 2008) mechanisms influence relationships between symptoms
9 of depression and anxiety and poorer diabetes health outcomes. However, a detailed
10 understanding of the behavioural mechanisms responsible for the relationship between
11 depression and anxiety and poorer diabetes health outcomes is lacking.

12 A behavioural theory used to understand what motivates self-care behaviour in the context
13 of illness is the Common Sense Self-Regulation Model (CS-SRM) (Leventhal, Meyer, &
14 Nerenz, 1980). The CS-SRM argues that when presented with a health threat we initiate
15 parallel cognitive and emotional responses. Indeed the CS-SRM hypothesises that reciprocal
16 causal relationships exist between illness cognitions and emotional responses, which then go
17 on to determine the types of illness self-care and emotional coping behaviours implemented
18 by an individual. Thus it provides an appropriate framework to explore how depression and
19 anxiety operates in the context of chronic illness.

20 The cognitive response of the CS-SRM includes an appraisal of the health threat to
21 generate an illness representation framework. This includes illness cognitions about the
22 perceived cause of the health threat, associated symptoms, and their likely duration and
23 predictability. It also includes cognitions about the degree of personal and treatment
24 resources available for health threat management, its impact on functioning, and the extent to
25 which a person has a coherent understanding of the health threat. A person's illness

26 representation framework determines the types of self-care behaviours a person might
27 implement to manage the health threat.

28 Specifically in the context of diabetes, cross-sectional observational studies have
29 confirmed the importance of the relationship between illness cognitions and diabetes self-
30 care. Having an optimistic diabetes appraisal including perceiving diabetes treatments to be
31 effective and believing that one has personal resources available for managing diabetes
32 demonstrates relatively consistent associations with improved adherence to one or more
33 diabetes self-care behaviours: diet, exercise, and medication taking (Broadbent, Donkin, &
34 Stroh, 2011; Hampson, Glasgow, & Foster, 1995; Hampson, Glasgow, & Toobert, 1990;
35 Searle, Norman, Thompson, & Vedhara, 2007). Conversely, having a pessimistic appraisal of
36 diabetes including perceiving diabetes to cause a high number of physical and social
37 consequences (Barnes, Moss-Morris, & Kaufusi, 2004; Broadbent et al., 2011; Hampson et
38 al., 1990) in addition to perceiving diabetes as an unpredictable condition (Barnes et al.,
39 2004) is associated with lower adherence to diabetes self-care behaviours.

40 The CS-SRM acknowledges with equal emphasis the role of the emotional response
41 to the health threat. This includes an emotional reaction (e.g. depression and anxiety), thus
42 coping behaviours are simultaneously initiated to manage these emotions, for example,
43 avoidance of medical settings. The relationship between diabetes emotional responses and
44 coping behaviours (e.g. avoidance, withdrawal, denial) to our knowledge has not been
45 directly assessed, but indirectly inferred from studies demonstrating lower rates of adherence
46 among people with higher levels of depression (Gonzalez et al., 2008).

47 Empirical studies based on the CS-SRM have largely used cross-sectional designs and
48 focussed on investigating direct pathways leading from illness cognitions to diabetes self-care
49 behaviours. These studies have not taken into account the hypothesised reciprocal

50 relationships that occur between illness cognitions and emotional responses and their
51 subsequent combined effects on diabetes self-management. Thus studies have only tested
52 partial aspects of the CS-SRM. In the context of diabetes, cross-sectional evidence across
53 nine studies indicates that having a pessimistic cognitive appraisal of diabetes heightens a
54 person's experience of negative emotions or vice versa (Hudson, Bundy, Coventry, &
55 Dickens, 2014). However, we are aware of no longitudinal studies which have explored
56 simultaneously the direct and indirect pathways through which illness cognitions and
57 emotional responses operate to have downstream effects on diabetes self-care.

58 Our study thus tested the salience of the CS-SRM. We longitudinally explored using
59 structural equation modelling (SEM) both direct and indirect (mediated) relationships
60 between diabetes cognitions, negative emotions, and diabetes self-care behaviours. We used
61 SEM to explore if: i) cognitions can have a direct effect on diabetes self-care and also an
62 indirect effect mediated through negative emotions; ii) negative emotions can have a direct
63 effect on diabetes self-care and also an indirect effect mediated through cognitions. The
64 hypothesised nature and direction of effects between variables is detailed below. It was not
65 possible to define a priori the specific cognition-emotion pathways that would demonstrate a
66 relationship with diabetes self-care because no prior studies have examined simultaneously
67 these multiple mediator pathways over time in adults with type 2 diabetes.

68 ***Study hypotheses***

- 69 i) Having a pessimistic cognitive appraisal of diabetes will be directly associated
70 with lower adherence to diabetes self-care (cognitions → diabetes self-care).
- 71 ii) Having a pessimistic cognitive appraisal of diabetes will be indirectly associated
72 with lower adherence to diabetes self-care via heightened negative emotions
73 (cognitions → emotions → diabetes self-care)

- 74 iii) Heightened negative emotions will be directly associated with lower adherence to
75 diabetes self-care (emotions → diabetes self-care)
- 76 iv) Heightened negative emotions will be indirectly associated with lower adherence
77 to diabetes self-care via pessimistic cognitive appraisals of diabetes (emotions →
78 cognitions → diabetes self-care)

79 **Materials and Method**

80

81 *Participants*

82 At baseline people with Type 2 diabetes were recruited consecutively (face to face) from a
83 UK diabetes outpatient clinic (central Manchester) from May 2011 to October 2011 (ethical
84 approval reference 11/NW/0069). Participants were followed up at six months to coincide
85 with their next bi-annual review at the outpatient clinic. Outpatients were eligible for
86 inclusion if they had diagnosed Type 2 diabetes and were ≥ 18 years old, but were ineligible
87 if they had an impairment that was deemed inappropriate for participation by the person
88 themselves, a carer or their medical team (e.g. lacked capacity, high risk of suicide).

89 *Measures*

90

91 The following data were collected at baseline and six months follow-up after informed
92 consent:

93 *Demographic and Clinical Characteristics (baseline only)*

94

95 Self-reported demographics: age, gender, and ethnicity. Clinical characteristics were
96 extracted from medical records: diabetes duration, diabetes medication type, number of
97 diabetes complications (retinopathy, neuropathy, nephropathy, cardio-vascular,

98 cerebrovascular, peripheral vascular, and metabolic), and number of other health co-
99 morbidities (according to International Classification of Diseases categories ICD-10) (World
100 Health Organization, 2010).

101 *Depression and Anxiety*

102

103 Depressive and anxious symptoms were measured using the Diabetes Wellbeing
104 Questionnaire (DWBQ) (Bradley, 1994). The DWBQ has four subscales: depression (six
105 items), anxiety (six items), energy (four items), and positive wellbeing (six items). DWBQ
106 items are responded to on a four point Likert scale. Only the depression and anxiety
107 subscales were used. These subscales were adapted from Zung's self-rating depression
108 (Zung, Richards, & Short, 1965) and anxiety (Zung, 1974) scales specifically for use among
109 the diabetes population. The DWBQ depression and anxiety subscales demonstrate high
110 concurrent validity with the Hospital Anxiety and Depression scale (Pincus, Griffiths,
111 Isenberg, & Pearce, 1997). Higher DWBQ scores indicate higher depressive and anxious
112 symptoms.

113 *Diabetes Illness Cognitions*

114

115 Illness cognitions were measured using the revised Illness Perception Questionnaire
116 (IPQ-R) (Moss-Morris et al., 2002) and the Beliefs about Medicines Questionnaire-specific
117 (BMQ-specific) (Horne, Weinman, & Hankins, 1999). The IPQ-R assesses the following
118 illness cognition domains (subjective beliefs; 70 items): identity (symptoms attributed to
119 diabetes), timeline acute/chronic (diabetes duration), timeline cyclical (predictability of
120 diabetes), cause (cause of diabetes), consequences (impact of diabetes), personal control
121 (availability of individual resources for managing diabetes), treatment control (efficacy of
122 treatments for managing diabetes), illness coherence (degree of diabetes understanding), and
123 emotional representations (negative emotions experienced because of diabetes). All IPQ-R

124 items use a five point Likert scale excluding identity, which has a binary yes/no response
125 based on whether symptoms are experienced and attributed to diabetes. All yes responses
126 receive a score of one and are summed. High scores on each subscale indicate stronger
127 endorsements of the construct measured. The BMQ-specific (Horne et al., 1999) has two
128 subscales: medication concerns (perceived negative effects of taking medications; 5 items)
129 and medication necessity (perceived need for taking medication to manage diabetes; 5 items).
130 Both subscales contain five point Likert response items; higher scores indicate a stronger
131 degree of belief in the construct.

132 *Diabetes Self-Care Behaviours*

133

134 The Summary of Diabetes Self-Care Activities Scale (SDSCA) (Toobert, Hampson, &
135 Glasgow, 2000) was used to measure diabetes self-care behaviours. Participants indicated the
136 extent to which they adhered to the following behaviours over the last seven days (eight point
137 Likert scale ranging from zero to seven days): i) general diet (following a healthy eating
138 plan), ii) specific diet (fruit and vegetable and fat intake), iii) exercise, iv) self-monitoring of
139 blood glucose (SMBG), v) foot care, and vi) medication adherence. Higher scores indicate
140 greater adherence. We combined scores across the individual SDSCA items to generate a
141 single overall outcome measure of diabetes self-care. The diabetes self-care outcome
142 represents the mean number of days per week a person adhered to their multi-dimensional
143 diabetes self-care routine, an approach used by others to determine overall levels of diabetes
144 self-care (Walker, Gebregziabher, Martin-Harris, & Egede, 2015).

145 *Statistical Analysis*

146

147 Data were non-normally distributed. Descriptive statistics are reported as means and
148 standard deviations given our relatively large sample size. Mann-Whitney U tests and
149 Pearson chi-square tests were used to compare demographic and clinical characteristics

150 between completers and non-completers at follow-up. Bootstrapping (10,000 resamples) was
151 applied to account for non-normally distributed outcomes (Mooney & Duval, 1993).

152 *Analytical model building*
153

154 We used a two-phase approach to building and testing our analytical models of the
155 relationships between cognitions, emotions, and diabetes self-care. In Phase 1 we used
156 traditional bivariate regression models to statistically test hypothesised direct and indirect
157 pathways from cognitions and emotions to diabetes self-care; in Phase 2 we used SEM
158 procedures, with measured variables only, to simultaneously evaluate the multiple pathways
159 identified as statistically significant in Phase 1, to arrive at the final models. As well as
160 testing the statistical significance of each individual pathway within the model, SEM also
161 provides an overall assessment of how well hypothesised relationships reflect actual observed
162 relationships in the sample dataset, providing an overall test of model validity (Kline, 2005).
163 Goodness of fit indices are used to evaluate the overall model (See Table 1) (Kline, 2005).

164 [INSERT TABLE 1 HERE]

165 *Phase 1 Bivariate Analyses*
166

167 Whilst the CS-SRM explicitly states that cognitions and emotions have the potential to
168 directly and indirectly affect illness management behaviours, the specific pathways that apply
169 longitudinally in the context of an outpatient Type 2 diabetes population are not known. We
170 undertook initial (Phase 1) bivariate regression analyses in order to empirically identify
171 potentially important direct and indirect relationships between cognitions, emotions, and
172 diabetes self-care, for subsequent simultaneous testing using SEM. This step was necessary
173 because simultaneous entry of all plausible directional pathways between the eight illness
174 cognition domains, depression, anxiety, and diabetes self-care would have led to high

175 multicollinearity due to inter-correlated cognition domains and an unacceptably low
 176 participant to parameter ratio, affecting the reliability of the path coefficients. The bivariate
 177 phase was therefore used to filter out non-existent or very weak paths as a first step. We
 178 therefore used a high alpha-level to avoid prematurely excluding potentially important
 179 pathways and a pathway was retained for use in SEM analyses if it was statistically
 180 significant in bivariate regression analyses at an alpha of $\leq 10\%$.

181 Bivariate regression models were constructed to evaluate the direct effects summarised
 182 below:

Baseline explanatory variables (Time 1)	Directional pathway	Outcome variables at follow-up (Time 2)
Cognitions	→	Emotions
Emotions	→	Cognitions
Cognitions	→	Diabetes self-care
Emotions	→	Diabetes self-care

183

184 Bivariate regression analyses also provided a test of indirect effects. Because we were limited
 185 to two time points of data collection, we applied a modified version of the Baron and Kenny
 186 (1986) approach to test for the presence of indirect effects (mediation). We used Cole and
 187 Maxwell's (2003) two step procedure.

- 188 i. Step one: Identify if the baseline explanatory variable (time 1) has a directional effect
 189 on the hypothesised mediator at follow-up (time 2) (i.e. regress the mediator at time 2
 190 on both the explanatory and mediator variable at baseline, time 1)
- 191 ii. Step two: Identify if the baseline mediator variable (time 1) has a directional effect on
 192 the outcome variable at follow-up (time 2) (i.e. regress the outcome variable at time 2
 193 on both the mediator and outcome variable at baseline, time 1).

194 This two-step approach allowed us to use our two waves of data collection so that: i) the
195 effect of the explanatory variable on the mediator variable and ii) the effect of the mediator
196 variable on the outcome variable were both tested using prospective analyses as opposed to
197 limiting one aspect of our mediation pathway to a contemporaneous analysis only.

198 *Phase 2 SEM Model specification*

199

200 We produced separate SEM models for depression and anxiety because of
201 multicollinearity between these variables ($r=0.71$). In each model we initially included all
202 pathways identified as (separately) statistically significant at an alpha of $\leq 10\%$ in the Phase 1
203 bivariate regression analyses. Starting from this initial model, we sequentially trimmed
204 pathways from the model, at each step removing the pathway with the highest p value, until
205 all remaining pathways were significant at an alpha of $\leq 5\%$. This approach allows the
206 generation of parsimonious models and promotes translation into clinical interventions
207 (Kline, 2005).

208 In a subsequent step we assessed the impact of potential confounders on the relationships
209 in the final models. The impact of each potential confounder was explored separately to
210 retain statistical power and reliability of the estimates (see phase 1 bivariate analyses for
211 rationale). The confounders examined were: age, gender, ethnicity (white vs non-white),
212 diabetes duration, number of diabetes complications, number of co-morbidities, and
213 medication type (oral medication insulin/injection therapy). SEM was conducted using IBM
214 SPSS version 19 (IBM SPSS Statistics, 2010) and Analysis of Moment Structures (AMOS)
215 (Arbuckle, 2007) statistical software and used complete cases analyses.

216 **Results**

217

218 Figure 1 shows the flow of participants through the study. Of the 441 participants
219 approached at baseline, 261 completed baseline questionnaires (59% response rate). Of these,
220 194 participants completed six month follow-up questionnaires (74% retention rate). A
221 greater proportion of completers were of white ethnicity than non-completers (72.2% vs
222 43.1%, $p \leq 0.001$). No other differences were found. Table 2 summarises socio-demographic
223 and clinical characteristics of the 194 participants who returned follow-up questionnaires.
224 Table 3 summarises mean scores on self-report measures at six months follow-up.

225 INSERT FIG 1 AND TABLES 2 AND 3 HERE]

226 *Bivariate regression analyses*

227 Statistical appendix 1 (online supplement) presents regression coefficients and p values for all
228 bivariate regression pathways tested. Pathways that showed a relationship with the outcome
229 variable at $\alpha \leq 10\%$ are highlighted and were included for robust simultaneous testing
230 using SEM. Figures 2 and 3 summarises the final depression and anxiety models. They
231 include only those pathways that remained statistically significant using an alpha of 0.05
232 when evaluated simultaneously alongside other explanatory and outcome variables using
233 SEM.

234

235 *Structural Model of Relationships between Diabetes Cognitions, Negative Emotions, and* 236 *Diabetes Self-Care*

237

238 *SEM model: Diabetes Cognitions, Depression and Diabetes Self-Care*

239

240 The solid directional arrows in Figure 2 summarises the final SEM of the longitudinal
241 relationships between cognitions, depression, and diabetes self-care. Only three pathways

242 remained statistically significant when evaluated simultaneously. Participants who were
243 more concerned about their diabetes at baseline were more likely to demonstrate higher
244 depressive symptoms at six months; thus demonstrating a direct effect from cognitions
245 (explanatory variable) to emotions (mediator). As such these findings met Cole and
246 Maxwell's (2003) step one criterion for the initial part of the cognition → emotion →
247 diabetes self-care pathway. However, as indicated by an absent directional pathway from
248 baseline depression to diabetes self-care at six months, the effect of the mediator (depression)
249 on the outcome (diabetes self-care) was not supported. Conversely, participants with higher
250 depression scores at baseline were more likely to believe that their diabetes was unpredictable
251 (timeline cyclical) at six months follow-up. Thus demonstrating a direct effect from emotions
252 (explanatory variable) to cognitions (mediator variable). This finding met Cole and
253 Maxwell's (2003) step one criteria for the emotion → cognition → diabetes self-care
254 pathway. However, the pathway leading from baseline timeline cyclical (mediator variable)
255 to diabetes self-care (outcome variable) at six months follow-up is absent from Figure 2. The
256 effect of the mediator on the outcome was not supported according to Cole and Maxwell's
257 (2003) step two criteria. Baseline personal control beliefs acted autonomously from
258 depression and had a direct effect on adherence to diabetes self-care at six months follow-up.
259 Individuals who felt more confident in their ability to manage their diabetes at baseline
260 showed reduced adherence to their diabetes treatment regimens over time.

261 We evaluated the statistical fit of the model using the goodness of fit indices and criteria
262 summarised in Table 1. The model shown in Figure 2 had evidence of good statistical fit on
263 all model fit indices ($\chi^2=36.47$, $df_m=27$, $p=0.11$; $RMSEA=.05$, $CFI=.98$, $SRMR=.05$, $N=154$).

264 [INSERT FIGURE 2 HERE]

265 *SEM model: Diabetes cognitions, Anxiety, and Diabetes Self-Care*

266

267 The solid arrows in Figure 3 depicts the final SEM for the directional relationships between
268 cognitions, anxiety, and diabetes self-care. Five pathways were statistically significant using
269 an alpha of 0.05. Figure 3 shows that individuals who were more concerned about their
270 diabetes at baseline had greater symptoms of anxiety at six months. Thus indicating a direct
271 effect of cognitions (explanatory variable) on anxiety (mediator variable). However because a
272 pathway leading from baseline anxiety (mediator variable) to diabetes self-care (outcome
273 variable) at six months follow-up is absent, Cole and Maxwell's (2003) step two criteria for
274 establishing longitudinal mediation for the cognition → emotion → diabetes self-care
275 pathway was not supported. Conversely, individuals who were more anxious at baseline had
276 higher beliefs in the unpredictable nature of diabetes (timeline cyclical), attributed greater
277 importance to their diabetes medications for managing their condition (medication necessity),
278 and had greater concerns about the potential consequences of their diabetes medications
279 (medication concerns). Thus demonstrating the direct effect of anxiety (explanatory variable)
280 on cognitions (mediator variables) and met Cole and Maxwell's (2003) step one criteria for
281 the initial part of the emotion → cognition → diabetes self-care pathway. However because
282 Figure 3 does not include any directional pathways leading from baseline timeline cyclical,
283 medication necessity, and medication concerns to diabetes self-care the effect of the mediator
284 (cognitions) on the outcome (diabetes self-care) was not supported. Consistent with the
285 depression model, baseline personal control beliefs acted independently of emotions to
286 influence the degree of adherence to diabetes self-care at six months follow-up.

287 We evaluated the overall model fit of all of the directional pathways included in our
288 anxiety model, using model fit indices and criteria described in Table 1. The model shown in
289 Figure 3, had evidence of good statistical fit on all fit indices, excluding the model chi-square
290 statistic ($\chi^2=57.45$, $df_m=40$, $p=.04$; RMSEA=.04, CFI=.97, SRMR=.05, N=153).

291 [INSERT FIGURE 3 HERE]

292 *Potential confounders*

293

294 In both models the statistical significance of directional pathways remained
295 unchanged after controlling for potential confounders, with three exceptions. In both models
296 the directional pathway leading from baseline personal control to diabetes self-care became
297 statistically non-significant when number of diabetes complications was added as a covariate.
298 Specifically for the depression model, baseline depression scores did not explain variance in
299 the timeline cyclical cognition at six months, after controlling for diabetes treatment regimen.
300 Similarly, for anxiety, the directional pathway from baseline medication concerns to anxiety
301 at six months follow-up was not significant when diabetes duration was controlled for.

302 **Discussion**

303

304 This is the first study to simultaneously examine directional relationships between
305 cognitions, emotions, and diabetes self-care in an outpatient type 2 diabetes population. Our
306 findings support our theoretically driven hypothesis that cognitions have direct effects on
307 diabetes self-care. Indeed, we found that personal control beliefs operated independently of
308 emotions to influence adherence to diabetes self-care over time. However contrary to our
309 hypothesis about the nature of this relationship, we found that individuals who felt more
310 confident in their ability to self-manage their diabetes actually adhered less to their diabetes
311 self-care treatments over time. Furthermore, this effect was not sustained once number of
312 diabetes complications was added as a covariate to both the depression and anxiety models.

313 Consistent with the CS-SRM (Leventhal et al., 1980) and CBT treatment models
314 (Beck et al., 1979), we identified a reciprocal relationship between cognitions and emotions.
315 Diabetes medication concerns had a longitudinal effect on depressive and anxious symptoms.
316 Equally higher levels of depression and anxiety influenced diabetes cognition domains over

317 time, specifically: timeline cyclical, medication necessity (anxiety only), and medication
318 concerns (anxiety only). These relationships identify potentially salient mechanisms to target
319 when managing negative emotions in the context of Type 2 diabetes. However, contrary to
320 our hypotheses, our findings did not support the combined effects of these cognition-emotion
321 pathways on diabetes self-care. More specifically negative emotions had no direct effect on
322 diabetes self-care. Despite finding that medication concerns increased both depressive and
323 anxious symptoms over time, neither depression nor anxiety mediated the effect of
324 medication concerns on diabetes self-care, as indicated by these pathways being absent from
325 the models. Conversely, we found no evidence to support the hypothesis that diabetes
326 cognitions mediate the effect of depression and anxiety on diabetes self-care. Although we
327 identified an explanatory effect of depression and/or anxiety on three illness cognition
328 domains over time, none of these domains demonstrated associations with diabetes self-care.

329 *Strengths and limitations*

330

331 Our study used a longitudinal design, thus our findings about the directional relationships
332 in the models are robust (Kenny, 1979). A relatively large sample was recruited (n=261) of
333 which 73.3% (n=194) were retained at six months follow-up. A quarter of our sample were
334 individuals from black and minority ethnic groups, making it representative of the wider UK
335 diabetes outpatient population. The use of SEM enabled multiple pathways to be modelled
336 simultaneously, yielding a more valid representation of the competing relationships between
337 cognitions, emotions, and diabetes self-care (Kline, 2005) and allowed a theoretically driven
338 approach to our analyses. The validity of our findings is bolstered further due to confirmation
339 that observed directional pathways between variables remained unchanged when potential
340 demographic and clinical confounders were accounted for, excluding the confounding roles

341 of diabetes complications, diabetes duration, and medication type - the implications of which
342 are discussed below.

343 Limitations of our study include a relatively short follow up period, which may have
344 prevented the detection of important associations. Participants' health in this study was likely
345 stable given their mean diabetes duration of 14 years and because they were recruited from
346 ambulatory outpatient clinics as opposed to settings that care for more severely ill patients.
347 The temporal relationships that exist between illness cognitions, emotions, and diabetes self-
348 care are largely unknown. There may be critical incidents in a person's diabetes illness
349 trajectory that trigger change (e.g. complication onset), but to measure this would require
350 approaches with much longer follow-up intervals. Relatedly, this study was limited to two
351 data collection time points, which prevented the full testing of theoretically driven indirect
352 pathways across three time points. We attempted to overcome this issue by implementing the
353 Cole and Maxwell (2003) two-step procedure, which allowed us to test each hypothesised
354 directional pathway longitudinally. However, we need to be mindful that our findings from
355 our hypothesised mediators to diabetes self-care may not accurately reflect relationships that
356 could have occurred had we been able to obtain data from a third follow-up time point.
357 Second, because this study was exploratory, specifically in relation to identifying the
358 longitudinal cognition-emotion profiles relevant to a Type 2 diabetes outpatient population,
359 we did not want to discount potentially important relationships (Rothman, 1990), so no
360 adjustments for multiple testing (bonferroni corrections) were made.

361 ***What are the combined effects of negative emotions and illness cognitions on self-care in***
362 ***adults with type 2 diabetes?***

363

364 Our findings have identified that illness cognitions can remain independent of emotions
365 and have directional effects on diabetes self-care. Contrary to previous cross-sectional

366 findings showing an association between high levels of confidence in personal capabilities for
367 managing diabetes (personal control) and improved adherence (Broadbent et al., 2011;
368 Watkins et al., 2000); our findings showed that patients who felt more confident in their
369 ability to manage diabetes demonstrated *reduced* adherence to their diabetes self-care
370 behaviours over time. The mean diabetes duration of our sample was 14 years, therefore
371 participants may have developed automatic habitual coping behaviours for managing
372 diabetes, consistent with findings in hypertension, where habit strength was the strongest
373 predictor of adherence (Phillips, Leventhal, & Leventhal, 2013). Participants in our sample
374 possibly felt confident in undertaking their day-to-day diabetes management routines, but
375 these routines likely deviated from the recommendations of health care professionals,
376 identifying the need for regular reviews of diabetes self-care behaviours during clinical
377 consultations. The role of clinical confounders warrants attention. The directional effect of
378 personal control on diabetes self-care was no longer statistically significant when number of
379 diabetes complications was included as a covariate in both the depression and anxiety
380 models. This finding may not be surprising given that the presence of diabetes related
381 complications has been identified as a key motivator for change in diabetes self-care
382 behaviours (van Puffelen et al., 2015). This has important clinical implications about how we
383 can support the *prevention* of future diabetes complications and identified the need to harness
384 patients personal control beliefs effectively using intervention techniques such as
385 motivational interviewing (Miller & Rollnick, 2012).

386 Our study reinforces the claims of the CS-SRM (Leventhal et al., 1980) and highlights the
387 salience of reciprocal relationships between cognitions and emotions, which can contribute to
388 the maintenance and exacerbation of depression and anxiety in diabetes. Consistent with
389 cognitive-behavioural therapy (Beck, 1964) and our hypotheses, having a pessimistic
390 appraisal of diabetes treatments heightened participant's experience of depression and anxiety

391 over time. But equally depression and anxiety influenced participants beliefs about diabetes
392 in a pessimistic manner, likely occurring because of altered attentional control processes in
393 response to arousal (Cameron, 2003). In heightened states of arousal attention can become
394 focussed on somatic symptom detection, thus a person's diabetes cognitive illness
395 representation is updated in response to identified somatic changes. But equally mood may be
396 unhelpfully used as a heuristic for physical health (Leventhal et al., 1980). Somatic symptoms
397 of depression and anxiety (including shaking, sweating, low energy) overlap with symptoms
398 of hypoglycaemia, thus leading to the misattribution of physical symptoms provoked by
399 emotions, to diabetes. The longitudinal relationships observed in our study between
400 cognitions and emotions are largely consistent with cross-sectional findings (Hudson et al.,
401 2014). However we did not identify longitudinal associations between increased perceived
402 consequences and poorer emotional health and likewise lower perceptions of personal control
403 and poorer emotional health, despite cross-sectional studies consistently reporting these
404 effects (Hudson et al., 2014).

405 It is important to acknowledge that depression made no statistically significant
406 contribution to the timeline cyclical cognition domain when modelled alongside a person's
407 diabetes medication treatment regimen. The intensity of a person's medication regimen varies
408 as a function of their degree of blood glucose dysregulation. Thus it is plausible that
409 individuals with poorer blood glucose control who as a result are prescribed more intensive
410 diabetes medication regimens experience greater levels of depression. As such diabetes
411 treatment regimens have the potential to moderate the degree of depression experienced and
412 ultimately the extent to which this goes on to influence a person's appraisal of their diabetes
413 in a moderated-mediation pathway. In addition, the explanatory effect of medication
414 concerns on anxiety became statistically non-significant when diabetes duration was included
415 as a model covariate. Consistent with the CS-SRM, it is likely that individuals with a longer

416 diabetes duration have developed effective coping strategies for managing their threatening
417 diabetes medication perceptions and thus have emotionally adjusted to these concerns. As
418 such it is important to consider how salient mechanisms of action within CS-SRM differ
419 depending on the context of a person's illness trajectory (e.g. newly diagnosed vs stable
420 condition).

421 Whilst our findings identified the importance of reciprocal relationships between
422 cognitions and emotions, the absence of their combined effects on diabetes self-care is
423 surprising and contrary to our research hypotheses. Among individuals who are experiencing
424 more severe symptoms of depression and anxiety, these cognition-emotion pathways and vice
425 versa, may well go on to influence diabetes self-care behaviour. Indeed, it is worthy to note,
426 that these relationships were identified in our study, when neither emotions nor cognitions
427 were explicitly manipulated. Thus the degree of explanatory effects is attenuated. In addition
428 participants in our sample showed relatively low levels of depression and anxiety symptoms,
429 which may at least partly account for our null findings. Previous studies that have shown a
430 relationship between depression and diabetes outcomes over time have included clinically
431 depressed populations (Dirmaier et al., 2010; Katon et al., 2010; Lin et al., 2004).
432 Nonetheless, our sample's mean levels of depression and anxiety are consistent with others
433 who have used the DWBQ in people with Type 2 diabetes (French et al., 2008; Paschalides et
434 al., 2004), and thus can be considered representative of a general diabetes outpatient
435 population.

436 *Clinical implications*

437 Psychological interventions to date that have addressed depression and anxiety in the
438 context of diabetes have improved mental health outcomes but corresponding achievements
439 in diabetes health outcomes (HbA1c) are lacking (Harkness et al., 2010). By testing the CS-

440 SRM longitudinally a comprehensive model the illness specific cognitive-behavioural
441 pathways through which depression and anxiety operate in the context of diabetes can be
442 developed. This will allow the development of modified interventions that better integrate the
443 management of physical and mental health, a priority identified for health care
444 commissioners (Imison et al., 2011), whilst also decreasing the burden of care for patients
445 with multimorbidity (Mercer et al., 2012). Cognitive-behavioural therapy (Beck, 1976) is a
446 treatment that can target the causal mechanisms outlined in the CS-SRM. Our study should
447 be replicated in a larger sample with moderation analyses to compare cognition, emotion, and
448 behavioural outcome profiles among people who meet diagnostic thresholds for depression
449 and/or anxiety with those who do not. This will help to isolate pathways that need to be
450 addressed in self-management interventions based on patient clinical presentations and will
451 lead to the development of more personalised and efficient psychological medicine.

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References

- Anderson, R. J., Freedland, K. E., Clouse, R. E., & Lustman, P. J. (2001). The prevalence of comorbid depression in adults with diabetes - A meta-analysis. *Diabetes Care*, *24*(6), 1069-1078.
- Arbuckle, J. (2007). *AMOS 16.0 User's Guide*. Chicago: Amos Development Corporation, SPSS Inc.
- Barnes, L., Moss-Morris, R., & Kaufusi, M. (2004). Illness beliefs and adherence in diabetes mellitus: a comparison between Tongan and European patients. *The New Zealand medical Journal*, *117*(1188), 743-751.
- Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and social Psychology*, *51*(6), 1173.
- Beck, A. T. (1964). Thinking and depression: II. Theory and Therapy. *Archives of General Psychiatry*, *10*, 561-571.
- Beck, A. T. (1976). *Cognitive therapy and the emotional disorders*. New York: Penguin Group.
- Beck, A. T., Rush, A. J., Shaw, B. F., & Emery, G. (1979). *Cognitive therapy of depression*. New York: The Guilford Press.
- Bradley, C. (1994). The Well-being Questionnaire. In C. Bradley (Ed.), *Handbook of Psychology and Diabetes* (pp. 89-109). Berkshire: Harwood Academic Press.
- Broadbent, E., Donkin, L., & Stroh, J. C. (2011). Illness and treatment perceptions are associated with adherence to medications, diet, and exercise in diabetic patients. *Diabetes Care*, *34*(2), 338-340.
- Cameron, L. (2003). Anxiety, cognition, and responses to health threats. In L. Cameron & H. Leventhal (Eds.), *The self-regulation of health and illness behaviour* (Vol. 1, pp. 157-183). New York: Routledge.
- Cole, D. A., & Maxwell, S. E. (2003). Testing mediational models with longitudinal data: questions and tips in the use of structural equation modeling. *Journal of Abnormal Psychology*, *112*(4), 558-577.
- de Groot, M., Anderson, R., Freedland, K. E., Clouse, R. E., & Lustman, P. J. (2001). Association of depression and diabetes complications: A meta-analysis. *Psychosomatic Medicine*, *63*(4), 619-630.
- Dirmaier, J., Watzke, B., Koch, U., Schulz, H., Lehnert, H., Pieper, L., & Wittchen, H. U. (2010). Diabetes in primary care: prospective associations between depression, nonadherence and glycemic control. *Psychotherapy and psychosomatics*, *79*(3), 172-178.
- French, D., Wade, A. N., Yudkin, P., Neil, H. A. W., Kinmonth, A. L., & Farmer, A. J. (2008). Self-monitoring of blood glucose changed non-insulin-treated Type 2 diabetes patients' beliefs about diabetes and self-monitoring in a randomized trial. *Diabetic Medicine*, *25*(10), 1218-1228.
- Gonzalez, J. S., Peyrot, M., McCarl, L. A., Collins, E. M., Serpa, L., Mimiaga, M. J., & Safren, S. A. (2008). Depression and Diabetes Treatment Nonadherence: A Meta-Analysis. *Diabetes Care*, *31*(12), 2398-2403. doi: 10.2337/dc08-1341
- Grigsby, A. B., Anderson, R. J., Freedland, K. E., Clouse, R. E., & Lustman, P. J. (2002). Prevalence of anxiety in adults with diabetes - A systematic review. *Journal of psychosomatic research*, *53*(6), 1053-1060.
- Hagger, M. S., & Orbell, S. (2003). A meta-analytic review of the common-sense model of illness representations. *Psychology & Health*, *18*(2), 141-184.
- Hampson, S. E., Glasgow, R. E., & Foster, L. S. (1995). Personal Models of Diabetes Among Older Adults: Relationship to Self-Management and Other Variables. *The Diabetes Educator*, *21*(4), 300-307. doi: 10.1177/014572179502100407
- Hampson, S. E., Glasgow, R. E., & Toobert, D. J. (1990). Personal models of diabetes and their relations to self-care activities. *Health Psychology*, *9*(5), 632-646.

- Harkness, E., Macdonald, W., Valderas, J., Coventry, P., Gask, L., & Bower, P. (2010). Identifying Psychosocial Interventions That Improve Both Physical and Mental Health in Patients With Diabetes A systematic review and meta-analysis. *Diabetes Care*, *33*(4), 926-930.
- Horne, R., Weinman, J., & Hankins, M. (1999). The beliefs about medicines questionnaire: The development and evaluation of a new method for assessing the cognitive representation of medication. *Psychology & Health*, *14*(1), 1-24.
- Hudson, J., L, Bundy, C., Coventry, P., A, & Dickens, C. (2014). Exploring the relationship between cognitive illness representations and poor emotional health and their combined association with diabetes self-care. A systematic review with meta-analysis. *Journal of psychosomatic research*, *76*(4), 265-274.
- IBM SPSS Statistics. (2010). *IBM SPSS Statistics for Windows, Version 19*. Armonk, NY: IBM Corp.
- Imison, C., Naylor, C., Buck, D., Curry, N., Addicott, R., & Zollinger-Read, P. (2011). Transforming our healthcare system. *London: The King's Fund*.
- Katon, W. J., Russo, J. E., Heckbert, S. R., Lin, E. H. B., Ciechanowski, P., Ludman, E., . . . Von Korff, M. (2010). The relationship between changes in depression symptoms and changes in health risk behaviors in patients with diabetes. *International journal of geriatric psychiatry*, *25*(5), 466-475. doi: 10.1002/gps.2363
- Kenny, D. A. (1979). Correlation and causality. *New York: Wiley*, 1.
- Kline, R. B. (2005). *Principles and Practice of Structural Equation Modelling*. New York: The Guildford Press.
- Leventhal, H., Meyer, D., & Nerenz, D. R. (1980). The Common Sense Model of Illness Danger. In S. Rachman (Ed.), *Medical Psychology* (Vol. 2, pp. 7-30). New York: Pergamon.
- Lin, E. H. B., Katon, W., Von Korff, M., Rutter, C., Simon, G. E., Oliver, M., . . . Young, B. (2004). Relationship of depression and diabetes self-care, medication adherence, and preventive care. *Diabetes Care*, *27*(9), 2154-2160.
- Lustman, P. J., Anderson, R. J., Freedland, K. E., de Groot, M., Carney, R. M., & Clouse, R. E. (2000). Depression and poor glycemic control - A meta-analytic review of the literature. *Diabetes Care*, *23*(7), 934-942.
- Mercer, S. W., Gunn, J., Bower, P., Wyke, S., & Guthrie, B. (2012). Managing patients with mental and physical multimorbidity. *Bmj*, *345*(sep03 1), e5559-e5559.
- Miller, W. R., & Rollnick, S. (2012). *Motivational interviewing: Helping people change*: Guilford press.
- Mooney, C. Z., & Duval, R. D. (1993). *Bootstrapping. A nonparametric approach to statistical inference*. London: Sage Publications Inc.
- Moss-Morris, R., Weinman, J., Petrie, K. J., Horne, R., Cameron, L. D., & Buick, D. (2002). The revised Illness Perception Questionnaire (IPQ-R). *Psychology & Health*, *17*(1), 1-16.
- Park, M., Katon, W. J., & Wolf, F. M. (2013). Depression and risk of mortality in individuals with diabetes: a meta-analysis and systematic review. *General hospital psychiatry*, *35*(3), 217-225.
- Paschalides, C., Wearden, A., Dunkerley, R., Bundy, C., Davies, R., & Dickens, C. (2004). The associations of anxiety, depression and personal illness representations with glycaemic control and health-related quality of life in patients with type 2 diabetes mellitus. *Journal of psychosomatic research*, *57*(6), 557-564. doi: <http://dx.doi.org/10.1016/j.jpsychores.2004.03.006>
- Phillips, L. A., Leventhal, H., & Leventhal, E. A. (2013). Assessing Theoretical Predictors of Long-Term Medication Adherence: Patients' Treatment-Related Beliefs, Experiential Feedback, and Habit Development. *Psychology & Health*, *In press*.
- Pincus, T., Griffiths, J., Isenberg, D., & Pearce, S. (1997). The WellBeing Questionnaire: Testing the structure in groups with rheumatoid arthritis. *British journal of health psychology*, *2*(2), 167-174.
- Rothman, K. J. (1990). No adjustments are needed for multiple comparisons. *Epidemiology*, *1*(1), 43-46.

- Rustad, J. K., Musselman, D. L., & Nemeroff, C. B. (2011). The relationship of depression and diabetes: Pathophysiological and treatment implications. *Psychoneuroendocrinology*, *36*(9), 1276-1286.
- Searle, A., Norman, P., Thompson, R., & Vedhara, K. (2007). A prospective examination of illness beliefs and coping in patients with type 2 diabetes. *British journal of health psychology*, *12*, 621-638. doi: 10.1348/135910706x164935
- Toobert, D. J., Hampson, S. E., & Glasgow, R. E. (2000). The summary of diabetes self-care activities measure - Results from 7 studies and a revised scale. *Diabetes Care*, *23*(7), 943-950.
- van Puffelen, A. L., Heijmans, M. J., Rijken, M., Rutten, G. E., Nijpels, G., & Schellevis, F. G. (2015). Illness perceptions and self-care behaviours in the first years of living with type 2 diabetes; does the presence of complications matter? *Psychology & Health*(just-accepted), 1-24.
- Walker, R. J., Gebregziabher, M., Martin-Harris, B., & Egede, L. E. (2015). Understanding the influence of psychological and socioeconomic factors on diabetes self-care using structured equation modeling. *Patient education and counseling*, *98*(1), 34-40. doi: <http://dx.doi.org/10.1016/j.pec.2014.10.002>
- Watkins, K. W., Connell, C. M., Fitzgerald, J. T., Klem, L., Hickey, T., & Ingersoll-Dayton, B. (2000). Effect of adults' self-regulation of diabetes on quality-of-life outcomes. *Diabetes Care*, *23*(10), 1511-1515.
- World Health Organization. (2010). International Statistical Classification of Diseases and Related Health Problems 10th Revision. Retrieved 15 May, 2013, from <http://apps.who.int/classifications/icd10/browse/2010/en>
- Zung, W. W. (1974). The measurement of affects: depression and anxiety. *Modern Problems of Pharmacopsychiatry*, *7*, 170-188.
- Zung, W. W., Richards, C. B., & Short, M. J. (1965). Self-Rating Depression Scale in an Outpatient Clinic: Further Validation of the SDS. *Archives of General Psychiatry*, *13*(6), 508-515. doi: 10.1001/archpsyc.1965.01730060026004

Table 1: Goodness of Fit Indices used to evaluate models

Goodness of fit index	Statistical interpretation
Model chi-square χ^2	Smaller χ^2 = better model fit. Requires a true null hypothesis.
Comparative Fit Index (CFI)	Values close to 0.95 indicate a good fit.
Root Mean Square Error of Approximation (RMSEA)	Values ≤ 0.06 indicate good fit.
Standardised Root Mean Square Residual (SRMR)	Values ≤ 0.10 indicate good fit.

Table 2: Demographic and clinical characteristics of participants at 6 months follow-up

Variable		Mean/ Frequency	Standard Deviation/ Percentage
Gender	Male	120	61.9
	Female	74	38.1
Age/years	mean	62.8	11.9
	median	63.0	55.0-72.0
Ethnicity	White	140	72.2
	Black	25	12.9
	Asian	24	12.4
	Mixed race	4	2.1
	Other/prefer not to say	1	0.52
Diabetes duration/years	mean	14.3	8.8
	median	13.0	8.3-19.0
Diabetes treatment regimen	Diet/oral hypoglycaemics	53	27.3
	Injections/Combination	128	66.0
	No access to medical records/missing data	13	6.7
Clinical outcomes			
HbA1c mmol/mol		65.6	16.7
Number of complications		2.0	1.2
Number of other co-morbidities		1.5	1.2

Table 3: Follow-up scores on self-report measures of depression, anxiety, diabetes cognitions, and diabetes self-care

Variables	Mean	Standard Deviation	Cronbach's alpha
<i>Well-being questionnaire</i>			
Depression	4.7	3.6	0.84
Anxiety	5.4	4.2	0.83
Illness Perception Questionnaire-Revised			
Identity	3.8	3.2	0.77
Timeline acute/chronic	4.2	0.7	0.73
Timeline cyclical	2.9	1.0	0.82
Consequences	3.3	0.8	0.80
Personal control	4.0	0.7	0.77
Treatment control	3.6	0.6	0.53
Illness coherence	3.6	0.9	0.90
Emotional representations	2.7	1.0	0.88
<i>Beliefs about Medicines Questionnaire</i>			
Medication necessity	4.1	0.8	0.89
Medication concerns	2.8	1.0	0.80
<i>Summary of diabetes self-care activity scale</i>			
General diet	5.0	2.1	0.92
Specific diet (fruit & veg)	4.7	2.3	Single item NA
Specific diet (saturated fat)	4.5	2.0	Single item NA
Exercise	2.3	2.3	0.79
Self-monitoring of blood glucose	4.6	2.7	0.90
Foot care	3.7	2.6	0.65
Medication adherence	6.8	0.9	Single item NA
Global diabetes self-care	3.9	1.3	0.62

Figure headings and captions

Figure 1: Flow chart of participants recruited and retained at each stage of the study

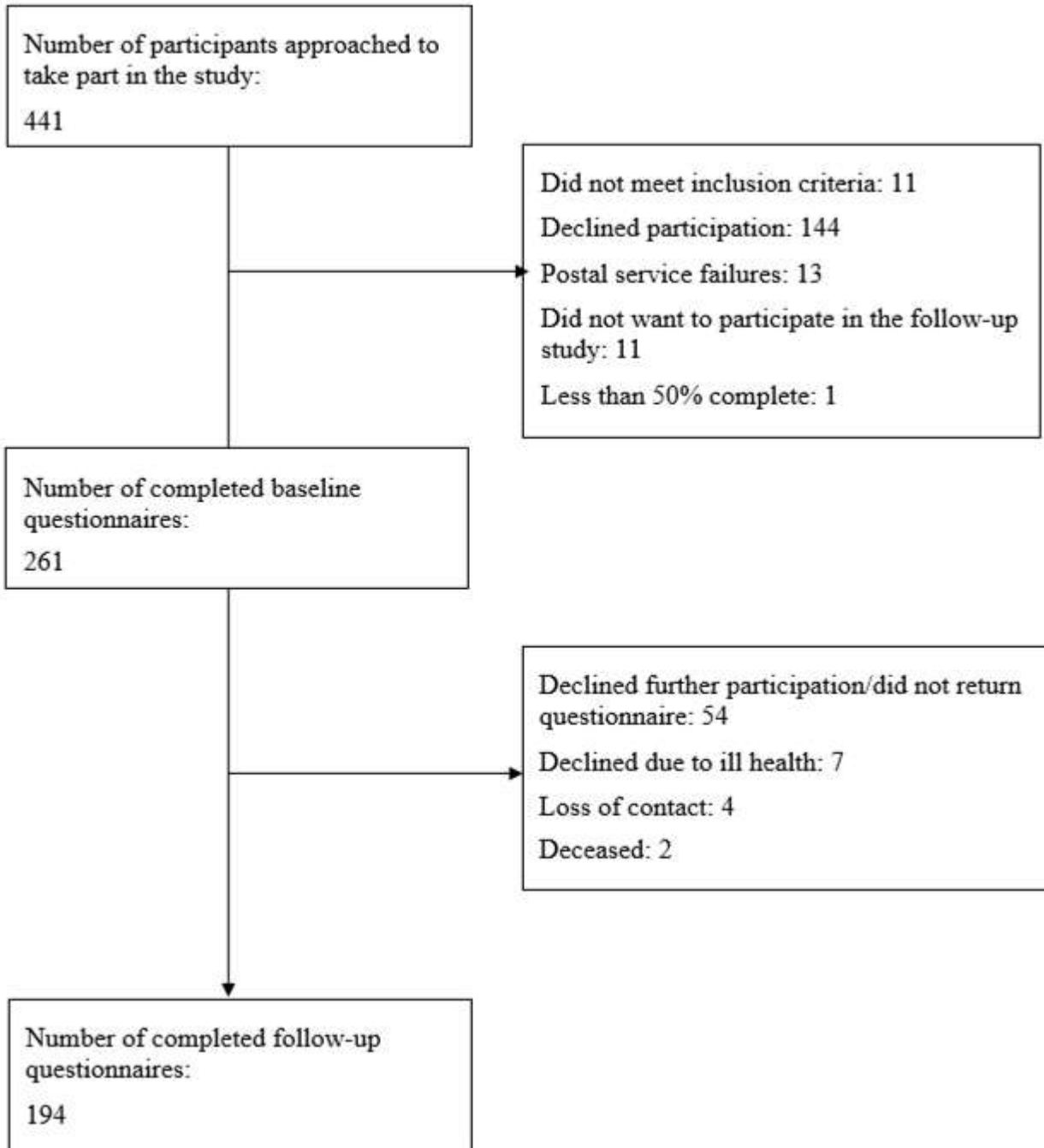


Figure 2: Final model of the simultaneous effect of cognitions and depression on diabetes self-care

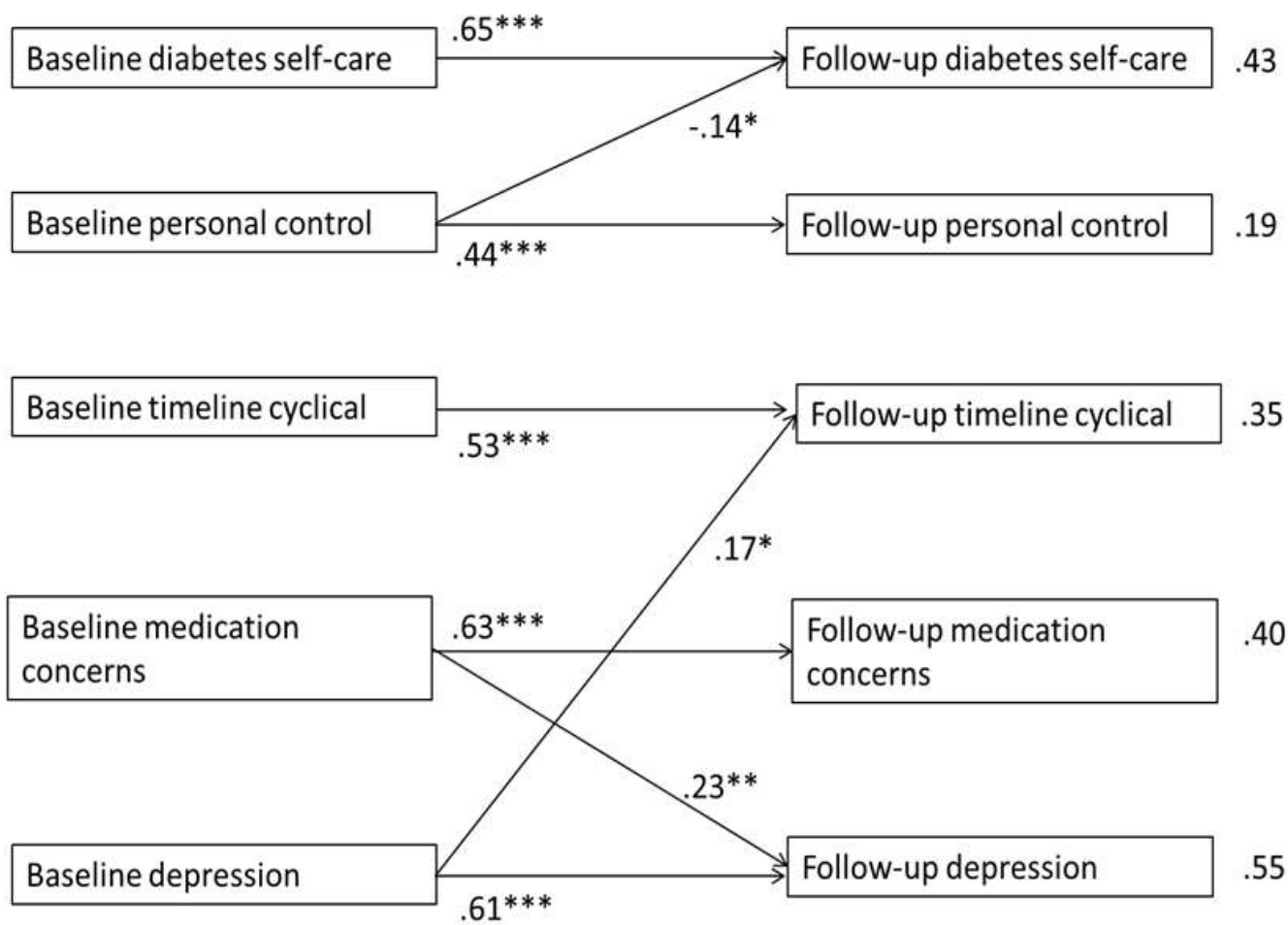


Figure 3: Final model of the simultaneous effect of cognitions and anxiety on diabetes self-care

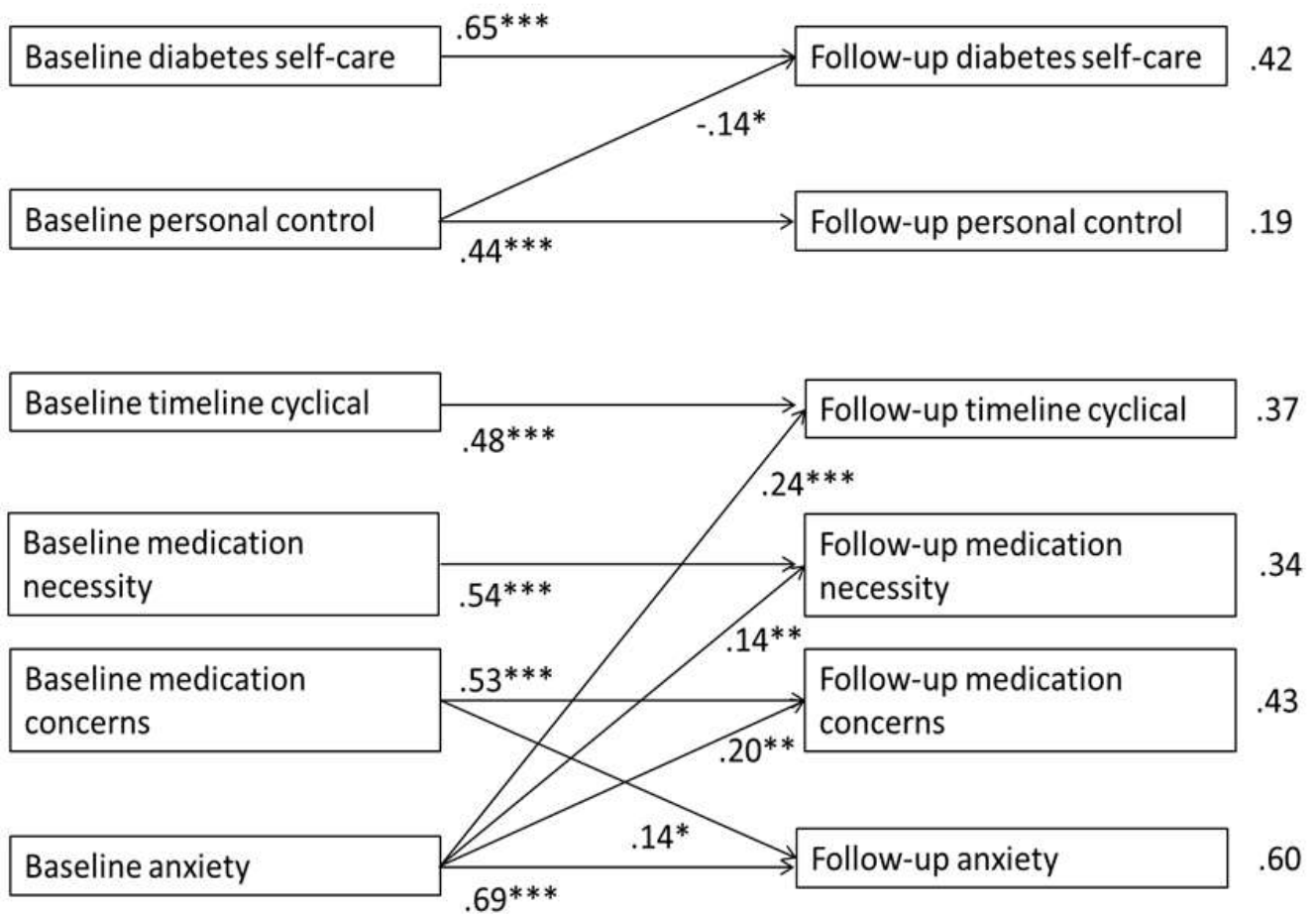


Figure captions:

Figure 1: Recruitment and retention flow diagram

Figure 2 & 3: Statistics reported next to directional arrows are standardised regression coefficients. Those aligned left refer to auto-regressive pathways. Those aligned right refer to directional pathways. Statistics adjacent to outcome variable detail the percentage variance explained. All baseline variables were specified to correlate with each other.

Key: * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$