Intention, beliefs and mood assessed using electronic diaries predicts attendance at cardiac rehabilitation: an observational study

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***Background*:** Cardiac rehabilitation is effective in promoting physical/psychological recovery following acute coronary syndrome. Yet, rates of attendance at outpatient cardiac rehabilitation by eligible patients are low.

***Objectives*:** This study examined the determinants of attendance at outpatient cardiac rehabilitation in acute coronary syndrome patients following discharge until cardiac rehabilitation commencement.

***Design*:** A weekly electronic diary measured cardiac-related cognitions and mood and examined their relation to attendance at outpatient cardiac rehabilitation.

Settings: Three United Kingdom National Health Service secondary care settings in two Health Board areas in Scotland.

***Participants*:** Acute coronary syndrome patients were recruited from March 2012 to June 2013 prior to hospital discharge. Of 488 eligible patients referred for cardiac rehabilitation, 214 consented.

***Methods*:** Consecutive patients completed a pre-hospital discharge questionnaire targeting age, diagnosis, social class and smoking history. Acute coronary syndrome patients then completed a weekly electronic diary from the first week of discharge until the start of cardiac rehabilitation. Multilevel structural equation models estimated the effects of initial, i.e. baseline and rate of change in cardiac-related cognition and mood on attendance. Intention to attend cardiac rehabilitation was reflected, log transformed, reported thereafter as "do not intend". The role of "do not intend" was explored as a mediator of the relationship between cardiac-related cognition and mood on attendance.

***Results*:** 166 participants provided, on average, 5 weeks of diary entries before cardiac rehabilitation commenced. High intention (i.e. low "do not intend") to attend CR and its rate of

increase over time predicted attendance. Low negative emotional representation, high perceived necessity, high confidence in maintaining function, low negative affect, and high positive affect following discharge predicted attendance at cardiac rehabilitation. The rate of change in cardiac-related mood and these cognitions was not predictive. Baseline and rate of change in "do not intend" entirely mediated relationships between a) perceived necessity, b) negative affect and attendance at cardiac rehabilitation.

***Conclusions*:** Negative affect in the first weeks following discharge represents the key challenge to a patient maintaining their intention to attend cardiac rehabilitation. Intervention to improve attendance should focus on improving intention to attend following discharge and during recovery by improving patient understanding of cardiac rehabilitation and reducing negative affect.

Key words: Attendance at Cardiac Rehabilitation; Cardiac rehabilitation; Cardiac self-efficacy; Diary study; Ecological momentary assessment; Illness perceptions; Intention; Mood; Self-management; Treatment perceptions.

What is already known about the topic?

- Acute coronary syndrome affects large numbers of people with severe consequence to the person, healthcare and society.
- Cardiac rehabilitation is effective in reducing cardiac mortality and all-cause mortality in people with acute coronary syndrome, yet rates of attendance is poor in many countries.
- The contribution of patient and service-level characteristics to non-attendance is relatively well documented.
- Little is known about whether changes in cardiac-related beliefs and mood during the early acute phases of recovery relate to intention to attend and to subsequent attendance at cardiac rehabilitation.

What this paper adds?

- This paper examines areas of stability and change in cardiac-related beliefs and mood during recovery from acute coronary syndrome and examines their relation to attendance at cardiac rehabilitation.
- This paper identifies that intention to attend following discharge and its increase over time is a key predictor of attendance.
- This paper identifies that negative affect in the first weeks following discharge represents the key challenge to a patient maintaining their intention to attend CR.
- This paper identifies key areas for specialist community nursing and related services to target to improve intention to attend cardiac rehabilitation.

1. Background:

Cardiovascular disease (CVD) remains the leading cause of death in the United States (US), Europe and United Kingdom (UK) despite clinical advances (Nichols et al., 2014). Acute Coronary Syndrome (ACS), i.e. unstable angina and acute myocardial infarction, is estimated to affect 85.6 million people in the US and 2.5 million people in the UK, with severe consequence and cost to person, healthcare and society (Mozaffarian et al., 2015).

The effectiveness of Cardiac Rehabilitation (CR) is well established in reducing cardiac mortality, hospital admission (Anderson et al., 2016) and all-cause mortality (Sumner et al., 2017) and in promoting physical and psychological recovery following ACS (Oldridge, 2012). However a recent review suggests that the effects of CR may not be so great when patients have also access to modern surgical and medical interventions (Powell et al., 2018). Nevertheless, CR is recommended in the guidelines of many major professional associations (British Association for Cardiovascular Prevention and Rehabilitation (BACPR), 2017; Thomas et al., 2018). While CR may be offered to patients who have been hospitalised with ACS (Nichols, et al., 2014), access is not uniform and a range of personal and service-level barriers exist to attendance. Perhaps as a result, attendance in many countries remains poor (Sumner et al., 2016).

The reasons for this are complex and relate to a combination of patient characteristics including age, gender, diagnosis, social deprivation and service characteristics such as referral rates with social factors being at least as important as clinical factors. Older patients are less likely to be referred to and thereafter attend CR (Sumner et al., 2017). Younger patients may not attend CR due to work commitments or to low expectations regarding the perceived benefit of CR (Clark et al., 2012). Women are less aware of cardiac risk, tend to report atypical ACS symptoms, may experience less chest pain, show delay seeking help, and are less likely to be referred to CR (Clark

et al., 2012). Patients with Non-ST Segment Elevation Myocardial Infarction (NSTEMI) are less likely to intend to attend CR and to subsequently change lifestyle (Dullaghan et al., 2014). Patients from areas of deprivation and some ethnic minority communities are less likely to engage in health behaviours that reduce cardiac risk and are less likely to attend CR (National Clinical Guideline Centre, 2013).

People may also not attend CR as a consequence of their representations or perceptions of ACS and CR and an evaluation of their belief in their ability, i.e. self-efficacy, to self-manage their ACS condition. Patient representations of their illness and the threat it represents generally motivates help-seeking and care-related behaviour including clinic attendance (Hagger & Orbell, 2003). ACS patients who view their condition as controllable, symptomatic with severe consequences and who understand their condition are those most likely to attend CR (French, et al., 2006). The treatment-related beliefs that are positively related to attendance include a recognition of the necessity and effectiveness of CR (Cooper, et al., 2007) and having few doubts about personal suitability, i.e. not believing that CR is for the younger, more active person. Perceiving many barriers to attendance and having concerns that exercise may be harmful are also associated with poorer CR attendance (Cooper, et al., 2005). Cardiac-related measures of self-efficacy that positively relate to CR attendance include confidence in maintaining function (i.e. maintaining usual activities at home, at work and social activities) and in controlling symptoms during recovery (Sullivan, et al., 1998; O'Neil et al., 2013).

Intention is a key predictor of health behaviours in ACS (Johnston, et al., 2004) including attendance at CR (Sniehotta, et al., 2010). Although intention to attend CR may change following discharge for some ACS patients (McKee et al., 2014), maintaining a positive intention to attend is a key determinant of attendance at infrequent screening clinics (Connor, et al., 2000). Intention

to attend CR may itself be influenced by a person's ongoing evaluation of the threat represented by their cardiac condition, and personal evaluation of CR as a suitable form of treatment (Sheeran, et al., 1999). In other words, intention to attend CR may transmit, or mediate, the effects of other factors to actual attendance.

The effects of mood or affect on CR attendance appear inconsistent. Patients who are highly anxious or depressed at discharge are more likely to attend CR (Zullo et al., 2017). Other studies report that poor mood is associated with avoidance of CR (Beckie & Beckstead, 2010). While mood or affect following discharge is thought to fluctuate producing patterns of improvement and deterioration, little is known about how any changes in mood relate to CR attendance (Whitmarsh et al., 2003).

A key limitation of current knowledge on the determinants of attendance at CR is when and how often the determinants are measured. Typically determinants are assessed once prior to hospital discharge, often well before the start of CR. Few studies measure subsequent changes, and those that do, e.g. (Sheldrick et al., 2006), do so in a very limited way with infrequent measurement across the recovery process. This largely ignores the possibility that cardiac-related beliefs such as patient representations of ACS and CR, cardiac self-efficacy perceptions, intention to attend CR and mood may change critically following discharge and prior to the start of CR. As a consequence, little is known about whether, or how, changes in cardiac-related beliefs and mood during the early acute phases of recovery relate to intention to attend and to subsequent attendance at CR, or indeed how such changes may inter-relate. Quite how relatively stable demographic and clinical variables influence such dynamic relationships is also unknown. A different approach is required to understand whether within-person changes in cardiac-related beliefs and mood predict attendance at CR. In this study ecological momentary assessment (EMA) has been employed to

allow the capture of such dynamic real-time, within-person variation or change, enabling a test of such key relationships within the individual, thereby revealing effects that cannot be estimated using temporally limited, cross-sectional data (Johnston & Johnston, 2013).

1.1. Objectives

The objective of this study, therefore, was to explore the influence of weekly changes in patients' cardiac-related beliefs and mood on attendance at CR. More specifically, we wished to evaluate the following:

Do Objective 1a) starting levels (initially following discharge) and, Objective 1b) within-person changes in illness perceptions, treatment beliefs, cardiac self-efficacy, intention and mood over time (i.e. following discharge to the start of CR) predict attendance at outpatient CR?

Objective 2: Is the relationship between illness perceptions, treatment beliefs, cardiac self-efficacy and mood over time (i.e. following discharge to the start of CR) and CR attendance mediated by intention to attend?

2. Methods

2.1. Design

This observational study combined real-time repeated measures of cardiac-related beliefs and mood based on an electronic diary with additional self-report of patient demographic and clinical characteristics measured by questionnaire, or gathered from casenotes, prior to hospital discharge (Herber et al., 2012). Ethics and Research & Development (R&D) approval were obtained (11/AL/0250 & 2010CV24).

2.2. Settings

All ACS patients living in two National Health Service (NHS) Health Boards in Scotland who were admitted to one of three hospitals and were eligible for outpatient CR were approached by CR specialist nurses or a local Research Nurse to seek their co-operation for the research team to approach them to discuss the study.

2.3. Recruitment to main study

ACS patients who consented to be approached, and agreed to participate, were recruited prior to discharge, (OH, MW) (March 2012 to July 2013). All patients were eligible for and invited or referred to CR, i.e. had physician endorsement.

2.4. Questionnaire and electronic diary

Data was gathered across 3 of the 4 phases of CR (National Audit of Cardiac Rehabilitation, 2017). Patients who consented completed a pre-discharge questionnaire to gather demographic and clinical information. This was delivered by research assistants (OH, MW), following training to maximise the reliability of data collection between research assistants and across multiple sites, as a structured interview prior to hospital discharge, i.e. in phase 1 of CR. Participants also received training on diary use, before leaving hospital. Patients were followed from the first week of hospital discharge (phase 2 of CR) to the end of CR (phase 3) with diary data collection ending in January 2014, although we only report here on data collected during phase 2 of CR, i.e. following discharge up until to the start of, or initiation of CR. Diary data was collected in participants' homes as part of their everyday life. Research assistants phoned patients at weeks 1, 4 and 12 following discharge to confirm data collection. Diary data was collected on a weekly basis, with

participants free to choose the time, but not the day of data collection. The weekly personalised diary signal bleep was preceded by a same-day text reminder. The diary remained open for entries for 25 hours and provided three alarm reminders. Each patient returned their diary following post CR review or at 16 weeks following their ACS event if they had not attended CR, reflecting the median end of Phase 3 of CR in this study. **See supplemental detail regarding CR in this setting**.

2.5. Measures:

2.5.1. *Electronic diary measures:*

Data was gathered using handheld computers (personal digital assistants (PDAs) and mobile phones running "Pocket Interview"software developed by the research group (Morrison et al., 2009). Cardiac-related beliefs and mood were measured weekly using psychometrically reduced short-scale diary measures. See **Figure 1** for diary screenshots.

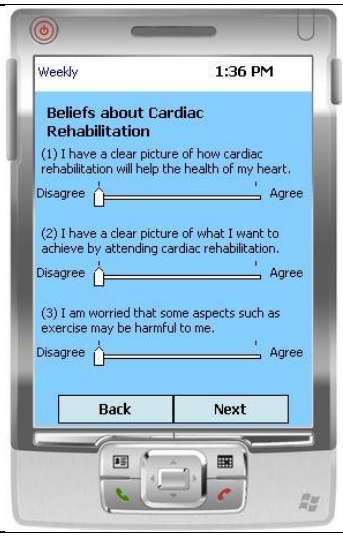
Weekly electronic diary measures:

(1) Illness perceptions were assessed using a shortened version of the Illness Perceptions Questionnaire-Revised (IPQ-R), i.e. the IPQ-Psychometrically Shortened (IPQ-PS), using three items with the highest factor loading on each of seven subscales (Sniehotta et al., 2010). A Visual Analogue Scale response format was used ranging from 0 (Disagree) to 100 (Agree). Subscales were a) timeline (acute/chronic), i.e. beliefs about how long the heart condition will last; b) timeline (cyclical), i.e. beliefs regarding the fluctuation and variation of symptoms and heart condition; c) consequences, i.e. beliefs about the outcome of the heart condition; d) personal control, i.e. beliefs regarding personal capacity to control the condition; e) treatment control, i.e. beliefs regarding treatment efficacy; f) illness coherence, i.e. personal understanding of the illness;

and g) emotional representation, i.e. the degree to which the heart condition depresses or concerns the person.

(2) Patients' treatment beliefs were measured using two items that loaded most highly on four subscales from the 'Beliefs about Cardiac Rehabilitation Questionnaire' (Cooper et al., 2007): a) perceived necessity, i.e. how necessary and effective is CR; b) concerns about exercise, i.e. concerns regarding the harmfulness of the exercise component of CR; c) practical barriers, i.e. presence of barriers to attendance at CR; and d) perceived personal suitability of CR for the patient. A visual analogue scale, 0 (Disagree) to 100 (Agree) response format was used.

(3) Cardiac self-efficacy was assessed using the top three loading items from each of the two factors of a) controlling symptoms and b) maintaining function from the 'Cardiac Self-Efficacy

<table>
<tr><td>Illness perceptions:</td><td>Treatment beliefs:</td><td>Cardiac Self-Efficacy: Maintaining function</td></tr>
<tr><td> 
</td><td> 
</td><td> 
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<tr><td>Cardiac Self-Efficacy: Controlling symptoms</td><td>Intention:</td><td>Mood:</td></tr>
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Figure 1: Examples of screenshots for electronic diary variables

Questionnaire*'* (Sullivan et al., 1998). Respondents indicated their confidence in controlling symptoms and managing their rehabilitation, respectively. This 5 point scale ranged from 0 (Not at all confident) to 5 (Completely confident).

(4) Intention to attend outpatient CR was assessed using a single-item measure (*Do you intend to attend Phase 3 of your cardiac rehabilitation programme?*) with a Visual Analogue Scale (VAS) ranging from 0 (No) to 100 (Yes) (Maddison & Prapavessis, 2004).

(5) Positive and Negative affect or mood items came from The Diary of Ambulatory Behavioural States (Kamarck et al., 1998) rather than using long scale measures of anxiety and depression. Five scales measured a) negative (stressed, angry, sad, frustrated, nervous) and three measured b) positive affect (alert, happy, energised) using a 0 (No) – 100 (Yes) response format.

(6) Attendance at CR was objectively confirmed from NHS records and was defined as completing an initial risk screening (shuttle walk test) and attendance at the first CR session as others have done (French et al., 2005). This measure of access to, or initiation of CR is distinct from CR completion, which represents a different concept.

2.5.2. Pre-discharge questionnaire and case note measures:

(1) Socio-demographic characteristics included age, sex, a clinical profile of cardiovascular risk, diagnosis, exercise prior to the ACS event and co-morbidity, all gathered pre-discharge. Distance to the CR was calculated.

(2) Social deprivation was captured using the Scottish Index of Multiple Deprivation (SIMD) based upon participant postcode (Scottish Government, 2015). This provided 5 categories of geographical deprivation from areas of greatest deprivation (SIMD1) to the least (SIMD5).

(3) Smoking status was assessed by self-report and verified using carbon monoxide monitoring (Smokelyzer®). Smoking dependence was assessed using the 6-item Fagerstrom Test for nicotine dependence (Heatherton et al., 1991).

2.6. Analysis methods

The weekly EMA electronic diary data and subsequent attendance at CR were analysed using multilevel structural equation models (SEM). For each measure of cardiac-related beliefs and mood, an SEM with two components was fitted: i) a growth model for post-discharge change in a given belief/mood which accounts for variation across people (i.e. nomothetic) and within-people (i.e. idiographic) (Johnston & Johnston, 2013), and ii) a logistic model for CR attendance including as predictors the baseline level and change in the belief/mood (from the growth model), and in some analyses time-invariant demographic variables. A multilevel SEM allows these two components to be estimated simultaneously, and accounts for the different levels of measurement of the key variables (time-varying beliefs and mood and time-invariant attendance). The individual-specific random intercepts in the growth model captured a person's baseline (initial)

level of each key cardiac-related belief and mood (Objective 1a), while the random slope for time captured the rate of change in a person's value for each variable (Objective 1b). The effects of these intercepts and slopes on CR attendance are hereafter referred to as "baseline" and "rate of change" effects. These analyses were conducted using the aML program (Lillard & Panis, 1998-2003). Steele et al. (2017) provide a full description of this approach (with aML syntax). Extensions to the multilevel SEM were then applied to test for the mediation effects of intention to attend in the relationship between CR attendance and selected belief (i.e. perceived necessity) and mood (i.e. negative affect) variables (Objective 2). The mediation models were fitted using Mplus (Muthén & Muthén, 1998-2010). Further details, with annotated syntax, are provided **in methods supplementary materials**.

2.7. Reliability and validity of the weekly electronic diary

Reliability of the diary was evaluated using methods described by Cranford et al. (2006), who draw on generalisability theory to decompose the variance in EMA measures into variability across people, time, items and their interactions. This is then used to provide between and within person estimates of reliability, akin to a Cronbach Alpha coefficient. The construct validity of the short scale ambulatory scales was confirmed by examining the relationship between diary items and questionnaire equivalents also gathered prior to hospital discharge but not reported here. Diary data was retained and reported if diary scales exceeded between-person reliabilities of 0.70 and within-person reliabilities of 0.60 (Nezlek, 2016).

3. Results:

3.1. Patient recruitment

Out of 488 patients contacted, 262 patients (53.7%) consented to our approach and were given study information. Some 214 agreed to participate and completed a pre-discharge questionnaire in hospital and received training on the diary, i.e. 81.7% of those who consented to our approach. While 184 returned diaries, the analysis is based on data from 166 patients, i.e. 77.5% of those who agreed to participate, after merging of questionnaire and diary data and removal of patients with missing questionnaire data. Participants provided an average of 5 weeks of complete diary entries before CR commenced (range 2 to 20 weeks) with 92.5% completion of diary entries.

3.2 Demographic details.

Descriptive statistics for age, gender, deprivation category, diagnosis, smoking history, exercise history and clinical characteristics of participants who did and did not attend CR are in **Table 1 (supplemental)**. The 65 smokers reported medium levels of nicotine dependence (Fagerstrom dependence; M=4.58, s.d.=2.79; range 0-10).

The study sample was representative in terms of age and diagnostic profile compared with institutional accounts of the target population. The mean age of the sample was 61.98 years, with s.d.=11.07 and range 23.85 to 86.15yrs; 38% had a diagnosis of ST elevation myocardial infarction (STEMI), 54.2% with non-ST elevation myocardial infarction (NSTEMI), and 7.2% with Unstable Angina Pectoris (UAP). The target population had a mean age of 64 years; 34% were diagnosed with STEMI; 54% with NSTEMI; and 11% with UAP. We under-recruited non-attenders (18.0%) compared with service figures of 28.7%. All UAP patients attended CR, precluding the inclusion of diagnosis in the SEM analysis. Diagnosis was related to attendance, with NSTEMI patients

significantly less likely to attend CR than those with STEMI (Chi^2=4.47, df=1, p=.034). Distance to CR was not related to attendance (β=-0.004, p=.91).

3.3. Diary predictors of attendance (Objective 1):

Table 2 (**supplemental files**) provides descriptive statistics and reliabilities for the electronic diary. Intention, as measured, had a pronounced ceiling effect and models using it frequently failed to converge. It was therefore reflected and log10 transformed and is referred to as "do not intend" hereafter. Between-person reliability was satisfactory on all measures. Within-person reliability was adequate for half the diary measures but not for consequences, personal control, treatment control, illness coherence, timeline (cyclical), concerns regarding exercise, practical barriers and perceived suitability. Hence, these measures were not used as predictors and results for these variables are not reported. Questionnaire and diary measures were significantly related, supporting the validity of the shorter diary scales, see **Table 3 (supplemental materials)**.

3.3.1. Growth models: There was significant between-person variation in the initial value of each measure of cardiac-related beliefs and mood following discharge, **see Table 1a** (see between-person standard deviation (s.d.) in baseline). There was little consistency in the rate of change over time across these variables, with only emotional representation (t=-3.02, p<.005), CSE-maintaining function (t=2.79, p<.005) and positive affect (t=1.96, p=.05) changing linearly (see Slope for weeks). On average, people became less concerned by their condition over time, reported more confidence in their capacity to self-manage their ACS and were more positive and energised. There was significant between-person variation in the rate of change for all variables except CSE-maintaining function and perceived necessity. There was significant within-person variation over time in all variables.

3.3.2. Logistic models of attendance: The results are shown in **Table 1b**.

Illness perceptions: Only the baseline values of emotional representation predicted attendance (β=-0.62, p<.005, Odds ratio (OR) for effect of 1 SD increase in the baseline=0.54): those with a higher negative emotional representation were 46% less likely to attend CR. The rate of change over time did not predict attendance.

Treatment beliefs: Attendance was predicted by high perceived necessity at baseline (β=0.93, p<.005, OR=2.53). The effect of the rate of change in perceived necessity was not significant.

Cardiac Self-Efficacy (CSE): CSE-controlling symptoms was unrelated to attendance (baseline (β= 0.40, NS) or change (β=0.15, NS). Greater confidence in maintaining functioning initially after discharge predicted attendance (β=0.46, p<.05, OR=1.58). The model testing the effect of the rate of change in maintaining function did not converge, most likely because of the small and non-significant between-person variance in the effect of time (**see Table 1b**).

Do not intend: The baseline level of "do not intend" was a significant predictor of attendance with those high in "do not intend" at baseline less likely to attend (β=-1.32, p<.005, OR=0.27). The rate of change in "do not intend" was also predictive (β=-1.72, p<.05, OR=0.18). The more a person's intention declined (i.e. the quicker their reports of "do not intend" increased), the less likely they were to attend, i.e. 82% less likely to attend for every 1 standard deviation increase in the (negative) rate of change in "do not intend".

Table 1a: Growth models for change in cardiac-related beliefs and mood

	Timeline Acute/chronic		**Emotional representation**		**Perceived necessity**		**CSE_CS**	
Parameter	E	T	E	T	E	T	E	T
Intercept (baseline)	56.41	21.95	33.17	15.76	74.46	45.56	2.69	40.04
Slope for weeks (rate of change)	0.18	0.59	**-0.75**	**-3.02***	0.43	1.87	-0.001	-0.10
Btw-person s.d. in baseline	**31.42**	**16.41**$^{\#}$	**25.79**	**16.49**$^{\#}$	**18.63**	**14.36**$^{\#}$	**0.78**	**15.31**$^{\#}$
Btw-person s.d. in rate of change	**1.74**	**3.53**$^{\#}$	**1.37**	**4.66**$^{\#}$	0.82	1.83	**0.05**	**3.90**$^{\#}$
.								
Correlation btw baseline & change	-0.17	-0.97	-0.21	-1.22	-0.003	-0.01	-0.04	-0.19
Within person s.d.	**14.65**	**32.04**$^{\#}$	**11.76**	**33.47**$^{\#}$	**14.28**	**33.71**$^{\#}$	**0.45**	**31.57**$^{\#}$
	CSE _MF		**Do not Intend**		**Negative affect**		**Positive affect**	
Parameter	E	T	E	T	E	T	E	T
Intercept (baseline)	2.41	31.85	0.73	16.26	21.67	15.	63.70	38.81
Slope for weeks (rate of change)	**0.02**	**2.79***	0.008	1.05	0.02	0.08	**0.52**	**1.96**$^{+}$
Btw-person s.d. in baseline	**0.91**	**15.98**$^{\#}$	**0.53**	**15.01**$^{\#}$	**16.40**	**14.81**$^{\#}$	**19.09**	**15.01**$^{\#}$
Btw-person s.d. in slope	0.01	0.49	**.048**	**5.66**$^{\#}$	**1.59**	**5.41**$^{\#}$	**1.39**	**4.12**$^{\#}$
Correlation btw baseline & change	0.02	0.031	-0.20	-1.32	-0.06	-0.35	-0.12	-0.63
Within person s.d.	**0.51**	**34.31**$^{\#}$	**0.34**	**33.56**$^{\#}$	**11.44**	**33.40**$^{\#}$	**12.76**	**33.18**$^{\#}$

Key: Significance <.05^{+}; <.005*;<.001$^{\#}$; E=Standardised parameter estimate; T= Robust t-statistic
CSE-CS: Cardiac Self-Efficacy Controlling Symptoms, CSE-MF: Cardiac Self-Efficacy Maintaining Function

Table 1b: Logistic models of attendance: Effects of baseline and rate of change in cardiac-related beliefs and mood

	Timeline Acute/chronic		**Emotional representation**		**Perceived necessity**		**CSE_CS**	
Parameter	E	T	E	T	E	T	E	T
Intercept (logistic model)	1.82	5.22	1.74	7.12	2.00	4.36	1.66	7.31
Baseline	-0.28	-1.04	**-0.62**	**-2.83***	**0.93**	**2.94***	0.40	1.81
Rate of change	-0.87	-1.39	0.14	0.29	0.75	0.73	0.15	0.30
	CSE _MF		**Do not Intend**		**Negative affect**		**Positive affect**	
Parameter	E	T	E	T	E	T	E	T
Intercept (logistic model)	1.66	7.48	2.52	3.94	1.78	7.14	1.74	6.85
Baseline	**0.46**	**2.07**$^{+}$	**-1.32**	**-2.81***	**-0.66**	**-3.34**$^{\#}$	**0.57**	**2.66***
Rate of change	n/a	n/a	**-1.72**	**-2.00**$^{+}$	-0.29	-0.67	0.36	0.66

Key: Significance <.05^{+}; <.005*;<.001$^{\#}$; E=Standardised parameter estimate; T= Robust t-statistic
CSE-CS: Cardiac Self-Efficacy Controlling Symptoms, CSE-MF: Cardiac Self-Efficacy Maintaining Function
n/a: The effect of change over time in CSE_MF could not be estimated due to non-convergence.

Mood: Attendance was predicted by the baseline negative affect (β=-0.66, p<.001, OR=0.52) and positive affect (β=0.57, p<.005, OR=1.77). Low negative and high positive affect predicted CR attendance. The rates of change in affect were unrelated to attendance.

3.3.3. Logistic models of attendance allowing for demographic, clinical and cardiovascular risk factors: Logistic models controlled for a variety of demographic and other potential predictors of attendance at CR. A preliminary logistic model fitted prior to including the EMA data suggested that the individuals from areas of least deprivation, those who had never smoked and those who exercised regularly where all more likely to attend CR. Each of these factors was included in the logistic models of attendance along with the traditional predictors of age and gender, although there was no evidence that either was predictive in this sample. Inclusion of these demographic factors in the models markedly reduced the effects of the previously significant predictors. Only the baseline levels for perceived necessity (β=0.93, $p<.005$), negative affect (β=-0.49, $p<.05$) and "do not intend" (β=-1.34, $p<.05$) remained significant, see **Table 2.**

3.4. Mechanisms (Objective 2)*:* The possible role of intention in mediating the effects of the most robust predictors, perceived necessity and negative affect, **see Table 3,** was examined. For perceived necessity, a sequence of three multilevel structural equation models (SEM) were fitted. As both perceived necessity and the putative mediator "do not intend" were time-varying, the multilevel SEMs incorporated growth models with random intercepts (and additionally random slopes for "do not intend") to define time-invariant latent variables. For perceived necessity the latent variable represents a person's average level over the post-discharge period, while for "do not intend" there are latent variables for a person's baseline level and rate of change. Model 1 included the direct effect of perceived necessity on attendance. Model 2 included both direct effects of perceived necessity, and the effects of baseline and rate of change in "do not intend" on attendance. Model 3 extended Model 2 by allowing for an indirect effect of perceived necessity on attendance through "do not intend". A similar set of models was tested including negative affect

in place of perceived necessity (see **Table 4).** In the growth model for negative affect, there was significant between-person variation in both the intercept (baseline) and slope of weeks (rate of change), and therefore the effects of both baseline and rate of change in negative affect on attendance were estimated.

For perceived necessity, Model 1 consisted of a logistic model for attendance with average perceived necessity (from a random intercepts growth model for the observed repeated measures of perceived necessity) as the only predictor (**Table 3**). Higher perceived necessity was associated with higher chance of attendance (β=0.94, $p<0.001$). In Model 2 the introduction of the effects of baseline and rate of change in "do not intend" on attendance reduced the effect of perceived necessity (β=0.79, p=0.03). Model 3 included the same predictors of attendance as in Model 2, but allowed for associations between perceived necessity and "do not intend". As a result, the effect of perceived necessity on attendance was further reduced and became non-significant (β=0.70, p=0.08), suggesting that the effect of perceived necessity on attendance was mediated by "do not intend". The regressions of "do not intend" at week t (in any one week) on perceived necessity at t (in that same week) showed that reports of higher perceived necessity were associated with lower "do not intend" in the same week (β=-0.07, p=0.053). The relationship between "do not intend" and perceived necessity was also captured by correlations between average perceived necessity and baseline and rate of change in "do not intend" from their respective growth models.

Table 2: Logistic models of attendance: Effects of baseline and rate of change in cardiac-related beliefs and mood with socio-demographic controls

	Emotional representation		**Perceived Necessity**		**CSE_MF**	
Parameter	E	T	E	T	E	T
Intercept (logistic model)	2.01	1.18	0.55	0.37	2.08	1.19
Baseline	-0.34	-1.32	**0.93**	**2.80***	0.38	1.41
Rate of change	0.18	0.26	0.64	0.62	-	-
Age	-0.03	-1.05	0.003	0.14	-0.03	-1.03
Gender	0.83	1.37	0.45	0.74	1.05	1.70
SIMD2 vs SIMD1 (most deprived)	0.53	0.62	1.23	1.40	0.53	0.61
SIMD3 vs SIMD1	0.96	1.17	1.36	1.69	1.04	1.33
SIMD4 vs SIMD1	0.45	0.67	1.04	1.50	0.34	0.51
SIMD5 (least deprived) vs SIMD1	**2.04**	**2.09**$^{+}$	**2.29**	**2.28**$^{+}$	**1.91**	**1.99**$^{+}$
Ex smoker vs non-smoker	1.05	1.55	-	-	1.09	1.59
Current smoker vs non-smoker	-1.01	-1.70	-	-	**-1.26**	**-2.08**$^{+}$
<20 min x3 vs no exercise	0.34	0.45	-	-	0.33	0.44
>20 min x3 vs no exercise	0.74	1.38	-	-	0.72	1.34
	Do not Intend		**Negative affect**		**Positive affect**	
Parameter	E	T	E	T	E	T
Intercept (logistic model)	2.19	1.12	3.18	1.60	2.32	1.30
Baseline	**-1.34**	**-2.53**$^{+}$	**-0.49**	**-1.99**$^{+}$	0.57	1.88
Rate of change	-1.57	-1.56	-0.46	-0.78	0.46	0.67
Age	-0.008	-0.28	-0.04	-1.47	-0.03	-1.15
Gender	0.77	1.03	0.81	1.29	1.07	1.67
SIMD2 vs SIMD1 (most deprived)	1.22	1.15	0.55	0.59	0.46	0.52
SIMD3 vs SIMD1	1.54	1.52	0.67	0.80	0.91	1.16
SIMD4 vs SIMD1	0.75	0.91	0.36	0.52	0.37	0.55
SIMD5 (least deprived) vs SIMD1	**2.49**	**1.98**$^{+}$	**1.95**	**1.98**$^{+}$	**1.97**	**2.04**$^{+}$
Ex smoker vs non-smoker	0.64	0.76	0.94	1.36	1.14	1.62
Current smoker vs non-smoker	-1.66	-1.95	-1.15	-1.85	-1.18	-1.91
<20 min x3 vs no exercise	-	-	0.38	0.49	0.37	0.48
>20 min x3 vs no exercise	-	-	0.69	1.19	0.78	1.39

Key: Significance <.05^{+}; <.005*;<.001$^{\#}$; CSE-MF: Cardiac Self-Efficacy Maintaining Function; E=Standardized parameter estimate; T= Robust t-statistic

Table 3: Mediating effect of "do not intend" (DNI) in relationship between perceived necessity (PNEC) and attendance: Selected parameter estimates from SEMs

	Model 1		Model 2		Model 3	
	E	T	E	T	E	T
Effects on log-odds of attendance						
PNEC[a]	**0.94**	**3.83**[#]	**0.79**	**2.16**[+]	0.70	1.73
DNI baseline[b]	-	-	**-1.05**	**-2.01**[+]	-0.92	-1.91
DNI rate of change[b]	-	-	**-1.66**	**-1.96**[+]	-1.49	-1.83
Effect on DNI at week *t*						
PNEC at week *t*			-	-	-0.07	-1.94
Random effect correlations						
DNI baseline/ PNEC	-	-	-	-	**-0.42**	**-4.68**[#]
DNI rate of change/ PNEC	-	-	-	-	-0.14	-0.75
-Log-likelihood (No. parameters)	1479.6 (12)		1473.0 (14)		1444.4 (17)	
2 Δ log-likelihood, d.f (p-value)[c]	-		13.2, 2 (.001)		57.2, 3 (<.001)	

Key: Significance <.05[+]; <.005*;<.001[#] ; E=Standardised parameter estimate; T= Robust t-statistic:· [a]Standardised coefficient: effect of 1 SD increase in PNEC (from random intercept growth model for PNEC) on log-odds of attendance:· [b]Standardised coefficients: effects of 1 SD increase in baseline and rate of change in DNI (individual-specific intercepts and slopes from growth model for DNI) on log-odds of attendance:

[c]Comparisons are for Model 2 vs Model 1 and Model 3 vs Model 2

Table 4: Mediating effect of "do not intend" (DNI) in relationship between negative affect (NA) and attendance: Selected parameter estimates from SEMs

	Model 1		Model 2		Model 3	
	E	T	E	T	E	T
Effects on log-odds of attendance						
NA baseline[a]	**-0.75**	**-3.14***	-0.65	-1.90	-0.40	-0.99
DNI baseline[b]	-	-	**-1.29**	**-2.24+**	**-1.07**	**-2.47+**
DNI rate of change[b]	-	-	**-1.72**	**-1.98+**	-1.25	-1.68
Effect on DNI at week *t*						
NA at week *t*			-	-	**0.07**	**2.52+**
Random effect correlations						
DNI baseline/ NA baseline	-	-	-	-	0.20	1.91
DNI rate of change/ NA baseline	-	-	-	-	**0.36**	**2.30+**
DNI baselinet/ NA rate of change	-	-	-	-	-0.09	-0.57
DNI rate of change/ NA rate of change	-	-	-	-	-0.13	-0.49
-Log-likelihood (No. parameters)	1456.2 (14)		1447.3 (16)		1431.5 (21)	
2 Δ log-likelihood, d.f (p-value)[c]	-		17.8, 2 (<.001)		31.6, 5 (<.001)	

Key: Significance <.05+; <.005*;<.001#. E=parameter estimate; T= Robust t-statistic: [a]Standardised coefficient: effect of 1 SD increase in baseline NA (the individual-specific intercepts from a random slope growth model for NA) on log-odds of attendance. A model with an effect of the individual's rate of change in NA (slope) was fitted, but the slope effect was not significant.

[b]Standardised coefficients: effects of 1 SD increase in baseline and rate of change in DNI (individual-specific intercepts and slopes from growth curve for DNI) on log-odds of attendance

[c]Comparisons are for Model 2 vs Model 1 and Model 3 vs Model.

The significant correlation between average perceived necessity and baseline "do not intend" (r =-0.42, p<0.001) implied that patients who tend to have high scores for perceived necessity also tend to have lower scores on "do not intend" at baseline. However, there was no evidence of an association between high perceived necessity and the rate of subsequent change in "do not intend" (r=-0.14, p=0.44).

Higher negative affect at baseline was directly associated with lower probability of attendance, see Model 1 (β=-0.75, p=0.002), **(Table 4)**. The effect of the rate of change in negative affect was found to be non-significant. The effect of baseline negative affect reduced after controlling for baseline and rate of change in "do not intend" (Model 2, β=-0.65, p=0.057). In Model 3 the effect of baseline negative affect was further reduced and became non-significant (β=-0.40, p=0.32) after allowing for an association between "do not intend" and negative affect, suggesting that the effect of negative affect on attendance was mediated through "do not intend". Higher negative affect in week t was associated with higher "do not intend" in week t (β=0.07, p=0.012). Correlations between the baseline levels and rate of change for negative affect and "do not intend" provided some evidence that patients who tend to have high scores for negative affect at baseline tend also to have higher scores on "do not intend" at baseline (r=0.20, p=0.056), and also steeper positive slopes for "do not intend" (r=0.36, p=0.021).

4. Discussion

This study used an innovative repeated measures, real-time data collection design to examine the influence of cardiac-related cognitions and mood, and their change during recovery, in the prediction of attendance at CR. A series of logistic models of attendance revealed a complex pattern of predictors at the first week of discharge (baseline effects) (Objective 1a) along with a

significant effect of the rate of change in "do not intend" over the period prior to the start of CR (Objective 1b). The entry of demographic details, particularly social deprivation, attenuated some of these effects. Mediational analysis revealed that "do not intend" entirely mediated the relationships between a) perceived necessity, b) negative affect and attendance (Objective 2).

Attendance at CR was influenced by patient representations or perceptions of ACS and CR and their ability to self-manage their ACS condition. Low starting or baseline levels of negative emotional representation of ACS, i.e. feeling concerned or depressed regarding ACS were significantly associated with CR attendance (Objective 1a). This is a new finding, one not seen in review (French et al., 2006). Beliefs regarding how long the heart condition will last, i.e. Timeline (acute/chronic) (baseline and rate of change) were unrelated to CR attendance, in line with French et al. (2006). Treatment perceptions in the first week following discharge were predictive of CR attendance, with high levels of perceived necessity at this time predicting attendance (Objective 1a). It was not possible to comment on whether other aspects of treatment perceptions were not related to CR attendance due to measurement issues, i.e. low within-person reliabilities.

Cardiac self-efficacy in maintaining function at baseline, was positively related to CR attendance, whereas confidence in controlling symptoms such as chest pain and breathlessness was not (Objective 1a). Confidence in controlling symptoms may be less pertinent to CR attendance than in the past (Sullivan et al., 1998). Contemporary patients may have less chest pain and have less need to control it by reducing activity levels or taking medication due to advances in ACS treatment, e.g. early revascularisation and improved symptom control.

Mood, in the form of low negative affect and high positive affect (both with baseline effects only (Objective 1a), was an important predictor of attendance, suggesting non-attendance was a consequence of poor mood early following discharge. This contrasts with reports that high levels

of anxiety and depression just before CR commencement were associated with attendance at CR (e.g. Zullo et al, 2017), and supports the possibility that distress following discharge may lead to avoidance of CR (Beckie & Beckstead, 2010). Changes in clinical practice, e.g. advances in primary percutaneous coronary intervention and secondary preventive medical therapy, differences in the timing and method of data collection between studies may all explain or contribute to these differences in these reported relationships between mood and attendance.

This study extends previous literatures by systematically examining the dynamic nature of cardiac related beliefs and mood as they change during recovery from ACS. Areas of stability and change have now been identified. Although emotional representation became less negative over time (Weeks effect, **Table 1a**), its rate of change did not predict CR attendance (Objective 1b) (**Table 1b**). This suggests that starting levels of emotional representation of CR (i.e. soon after discharge) are most critical regarding CR attendance, although the magnitude of this effect was reduced with the introduction of demographic variables, including social deprivation. Illness perceptions were measured following discharge when they are most likely to relate to CR attendance (French et al., 2006). The rate of change in perceived necessity was not related to attendance suggesting that these key cardiac-related beliefs are also formed early following discharge and then do not change (Objective 1b). This level of detail extends previous research (Cooper et al., 2005; Cooper et al., 2007). It was not possible to estimate the effect of the rate of change in CSE-maintaining function on attendance due to its low within-person variation. The rate of change in negative and positive mood were not significant, suggesting that neither *directly* affect attendance.

People were more likely to attend CR the more they intended to do so shortly after discharge (Objective 1a) and if this intention increased, or diminished less over the period before CR

commenced (Objective 1b). In other words, higher reports of "do not intend" shortly after discharge and the more "do not intend" increased over time the less likely a person was to attend CR. A patient was 73% and 82% less likely to attend CR with every 1 standard deviation increase in baseline values and change the rate of change in "do not intend", respectively. The findings for Objective 1a and Objective 1b that the rate of change in key cardiac-related beliefs and mood do not relate to CR attendance suggests the relative stability of these variables. With the exception of "do not intend", only the baseline levels of cardiac-related beliefs and mood variables were predictive of attendance.

Intention is the critical proximal predictor of behaviour in highly influential theories of the determinants of behaviour (Ajzen, 1991) and in this study baseline intention and its rate of change were both predictive of attendance, unlike the other measures that were only predictive at baseline. It is therefore of interest to determine if intention mediated the effects of the other predictive measures to attendance. This was examined in a series of mediational analyses (**see Tables 3 and 4)**. This confirmed the key mediational role of "do not intend" in the relationship between a) perceived necessity, b) negative affect (Objective 2) and attendance. This analysis also explored the predictors of an increase in "do not intend" during recovery.

Patients who understood the need for and effectiveness of CR, i.e., who tended to report high perceived necessity, tended also to report low scores of "do not intend" at baseline. While the correlation of weekly values of high perceived necessity and low "do not intend" approached significance, high perceived necessity was unrelated to the rate of change in "do not intend". This suggests that if a patient believes that CR is necessary and effective early following discharge, their intention to attend remains stable thereafter. Perceived necessity at baseline was not,

however, related to the increase in "do not intend", i.e. it was not related to a further weakening of intention.

The relationship between negative affect on attendance was mediated entirely by "do not intend" (Objective 2). Patients experiencing high negative mood following discharge were more likely to report high "do not intend" scores at baseline and thereafter to report increasing levels of "do not intend" as their recovery progresses. This new finding suggests that negative affect in the first weeks following discharge represents the key challenge to a patient maintaining their intention to attend CR. In other words, negative affect early in the recovery process was the key driver of subsequent weakening of intention. This finding complements assertions of the importance of affect as an enduring driver of intention to perform important health behaviours (e.g. (Connor et al., 2006)).

4.1. Implications for practice

The pattern of results suggest that specialist nursing services should assess intention following discharge and track its change over time as a critical predictor of CR attendance. Attempts to improve CR attendance should focus on improving intention to attend early in the weeks following discharge in two ways: (1) by supporting the patient to adjust their understanding of the necessity and effectiveness of CR treatment at baseline, and (2) by reducing high levels of negative affect following discharge which is associated with high "do not intend" at baseline and increased "do not intend" over time (Objectives 1, 2). The literature on emotional support post CR plus the risk that depression may lead to further ACS events further supports this need for early intervention (Broadbent et al., 2009; Johnston et al., 1999; Petrie et al., 2002). Interventions to improve

intention and CR attendance based upon action planning and goal setting may be appropriate, given their effectiveness in the area of physical activity (Luszczynska, 2006; Heron et al., 2016).

This study has revealed the characteristics of patients who are eligible and have been referred to CR, who are most at risk of not attending. Patients from areas of high social deprivation, current smokers and patients with NSTEMI diagnosis are most likely to not attend CR. There remains, however, a lack of evidence on how best to engage with this under-represented group in CR.

4.2. Strengths and weaknesses

This study has many strengths. The primary study outcome of attendance at CR was gathered from service level records confirming patient attendance at the first session of CR and did not depend on self-report. This represents a key strength. This study is unique in exploring the prediction of CR attendance combining enduring patient characteristics and repeated real-time measures. This extends the literature based on traditional questionnaires that capture beliefs and mood only once, and often retrospectively (Cooper et al., 1999; Cooper et al., 2007). This study integrated key theoretical approaches to understanding decision making early in the ACS recovery process, and uses a form of data collection and analysis that captured the dynamic processes thought to underpin decisions to attend CR. The study sample was based on a consecutive series of admissions, with good rates of participation, and was representative in terms of age, gender and diagnosis of service users, capturing the full range of ACS diagnoses, across two UK NHS Health Boards and several hospital settings. While the exact form of CR varied between these two UK NHS Health Boards, the form of CR in each was consistent with recent national audits of UK CR provision (National Audit of Cardiac Rehabilitation, 2017). The study analysis was rigorous, based

upon models that included key socio-demographic, clinical and cognitive variables implicated in previous research. To minimise burden EMA studies often use single item measures. We largely avoided this by using shortened scales with good between-group and within-person reliabilities and with evidence of concurrent validity. Our use of trained research assistants to deliver the pre-discharge questionnaire as a structured interview and to train and support participants in diary use minimised bias. Gathering of EMA data was highly acceptable to participants, the data gathered was both reliable and valid and of value to clinicians (McKeon et al., 2018). Our approach to the gathering of diary data was relatively low-cost, based on a "Pocket interview" format that has been refined and developed over several years (Morrison et al., 2009). This approach does require expertise in computer programming, however, the feasibility of this approach has been improved recently by the emergence of a range of proprietary computing solutions for the gathering of EMA data using smart phones (e.g. Mareva et al., 2016).

This study has several limitations. We under recruited non-attenders and it may be that different factors are predictive in these difficult to reach non-attenders. We did not capture ethnic variation, since our sample was largely white, reflecting service users in this setting. Our inclusion criteria required understanding of English language. The attenuation of some baseline and rate of change effects (**see Table 2**), mainly by social deprivation, warrants further exploration. While the significant baseline effect of "do not intend" was sustained following the addition of demographic controls, the effect of its rate of change was attenuated and became non-significant after the entry of covariates, indicating that background variables such as deprivation may be involved in the relationship between "do not intend" and attendance. However, such exploration is highly complex and beyond the scope of this current paper. We will explore this in a subsequent paper. The study was also limited to initial attendance at CR. Completion of CR is also an important issue and may

well have different determinants from initial attendance. This will also be the subject of a subsequent paper.

5. Conclusions:

This study is the first to demonstrate that intra-individual changes in intention to attend CR following discharge and early in ACS recovery are predictive of future objectively confirmed episodic health behaviour of CR attendance. The rate of reduction in intention to attend during recovery was primarily related to high negative affect initially following discharge, whereas the positive relationship between perceived necessity and intention to attend endured over time. Attempts to improve CR attendance should focus on maintaining and improving intention to attend CR by improving patient understanding of the necessity and effectiveness of CR and by improving negative mood, particularly following ACS discharge. Early, repeated intervention targeting intention to attend CR seems warranted.

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