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Theoretical Perspectives of Adherence to Web-Based Interventions: a Scoping Review

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Abstract

Purpose The purpose of this paper is to review the literature as this relates to theoretical perspectives of adherence to web-based interventions, drawing upon empirical evidence from the fields of psychology, business, information technology and health care.

Methods A scoping review of the literature utilising principles outlined by Arksey and O'Malley was undertaken.

Results Several relevant theoretical perspectives have emerged, eight of which are charted and discussed in this review. These are the Internet Intervention Model, Persuasive Systems Design, the 'PERMA' framework, the Support Accountability Model, the Model of User Engagement, the Technology Acceptance Model, the Unified Theory of Acceptance and Use of IT and the Conceptual Model of User Engagement.

Conclusions The findings of the review indicate that an interdisciplinary approach, incorporating a range of technological, environmental and individual factors, may be needed in order to comprehensively explain user adherence to web-based interventions.

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Introduction

The potential of web-based interventions to improve public health across a range of domains, such as alcohol consumption [1], weight loss [2], substance abuse [3] and mental well-being [4] is increasingly recognised. However, it is well-established that interventions delivered via web-based modalities are susceptible to low levels of adherence by their users [5–8]. This is problematic as low adherence is associated with reduced intervention efficacy [9–11].

Recent years have seen increased efforts to develop a theoretical understanding of adherence and to incorporate features which may increase adherence into the design and delivery of web-based interventions [5]. The value of theoretical models in this context is that they facilitate an efficient synthesis of existing evidence and enable determinants of adherence to web-based interventions to be identified, targeted and subsequently refined [12]. Intervention components relevant to adherence could then be subsequently tailored to a range of different populations and settings [13]. This would be particularly useful in the case of web-based interventions due to their potential to reach a wide range of users [11]. To date, there has been no review of the literature as this relates to theoretical perspectives of adherence to web-based interventions. This paper addresses that gap.

User Determinants of Adherence to Web-Based Interventions

Though several studies have attempted to identify demographic characteristics which may explain why some users adhere to

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a web-based programme while others do not engage at all, few consistent patterns have emerged [14]. There is, however, some evidence to indicate that older users and highly educated females are most likely to adhere to web-based programmes [15–18]. Systematic reviews have also considered the impact of programme features on user adherence. Schubart et al. [19] for example found that the frequency of user contact with a clinician, perceived personal relevance of an intervention and an individually tailored approach were associated with increased user adherence to web-based interventions for chronic ill health conditions. Brouwer et al. [20] reported that peer and counsellor support, regular intervention updates and email and phone interaction enhanced adherence. Other features such as dialogue support and the frequency of programme updates have also been associated with user adherence [17]. A recent review of both quantitative and qualitative literature as this relates to predictors of adherence to online psychological interventions [21] reported that gender, treatment expectancy, time and personalised content were all associated with adherence (although most variables investigated were not predictive). While it would appear that demographic, psychological and technological factors are associated with adherence to web-based interventions, much of these findings are contradictory and too preliminary to draw firm conclusions.

Conceptualising Adherence to Web-Based Interventions

A seminal paper by Gunther Eysenbach [6] entitled the 'Law of Attrition' was among the first to argue the case for a systematic study of adherence to web-based interventions. A core premise of this paper was that adherence to web-based interventions is typically low and that the level of engagement with such programmes is largely dependent on the user themselves. Discontinuation tends to be quite easy and with little sanction.

Eysenbach highlighted the importance of Rogers' [22] 'Diffusion of Innovation' theory as a key underlying framework for explaining continued use of a web-based intervention. 'Diffusion of Innovation' asserts that adoption and usage of a web-based programme are predicated on several factors such as compatibility, benefits to the user and complexity. Eysenbach detailed a range of factors arising from this model which are proposed to influence non-usage attrition, including 'Push' factors [cues such as reminders and social support] and participant variables [e.g. educational attainment or socioeconomic status]. Such factors have been shown to be associated with the adherence of users to interventions [17, 19, 23]. However, a limitation may be the failure to attend to the role of individual user characteristics (e.g. motivation to engage) with regard to adherence. These have been shown to assume a pertinent role [24].

Cavanagh [25], drawing upon Eysenbach's [6] early work, describes adherence as the active use of an intervention as prescribed by those delivering the programme. Significantly,

Eysenbach also clarified the difference between 'non-usage attrition' (i.e. users who fail to complete a programme as prescribed) and 'drop-out attrition' where users fail to complete a study protocol. This clarification was a noteworthy advance as it facilitated a more organised study of the factors underlying adherence to an intervention as opposed to those related to study drop-out.

Another concept related to adherence and highly relevant within the context of this review is that of engagement, which Cavanagh [25] described as efforts by a user to start and continue with an intervention. However, this definition of engagement is not consistently observed across the literature. Thus, a recent systematic review of engagement with digital behaviour change interventions [13] identified two distinct conceptualisations within the literature: engagement as a mental state of 'flow' (i.e. the level of user enjoyment or attention in the use of an interactive technology) and engagement as a behaviour, which focuses on the frequency, depth or duration of intervention usage.

The following review does not seek to identify conceptual frameworks which relate to the concept of 'drop-out attrition' as outlined by Eysenbach [6] in terms of the failure of participants to follow a research protocol, such as completing follow-up measures in a study. It focuses rather on the concepts of adherence and engagement, which in this context are broadly considered to refer to the sustained usage of an intervention or using an intervention as prescribed by those delivering the programme, congruent with conceptualisations as outlined by Cavanagh [25] and Perski et al. [13].

Methods

Scoping studies are a prevalent method for the conduct of a broad search of the literature on a defined topic [26]. The framework for this scoping review is based on that described by Arksey and O'Malley [27], which charts and summarises a range of research in a particular area of study. Specifically, this review seeks to identify, describe and evaluate key theoretical perspectives which are relevant to understanding adherence to web-based behavioural and psychological interventions.

Defining Terms

'Theoretical perspectives' for the purposes of this review are defined as any type of organising structure attempts to explain the key concepts and variables with regard to user adherence to web-based interventions and the relationships between those variables. The definition is guided by the work of Maxwell [28] on research design and encompasses a range of terms including theories, models and conceptual frameworks. 'Web-based interventions' are defined as programmes

delivered online through technological platforms such as email, website, computer programme or smartphone application.

Database Search

The published literature was identified by searching the following electronic databases from inception to 30 September 2016:

- PsycINFO
- PsycARTICLES
- Medline
- Science Direct Key

Terms such as 'adherence", "engagement", "compliance", "attrition" and "usage" were combined with the terms "web-based", "online", "digital" and "technology". The following inclusion and exclusion criteria were applied:

Inclusion criteria:

- Describes a theory, model or framework
- Relevant to understanding 'adherence', in terms of usage to at least some extent or as prescribed by the delivers or
- 'Engagement' in a behavioural context, in relation to usage of web-based interventions in terms of frequency, duration or depth of use
- Delivered via 'web-based' modalities
- Published in English

Web-based interventions were defined as any intervention delivered via a website, email or smartphone application.

Exclusion criteria:

- Non web-based interventions
- Papers not published in English
- Theoretical perspectives of behaviour change or programme design without reference to adherence or engagement
- Focused solely on adherence to a research protocol (e.g. completion of follow-up measures)

The initial search output returned 3864 papers. Following title and abstract screening, 2394 papers were removed due to duplication or not meeting inclusion criteria. The full texts of the remaining 1470 papers were retrieved and screened, from which, a further 1362 papers were excluded after assessment. This left a total of 8 papers included in the final review, articulating eight theoretical perspectives. One review author independently selected the studies to include in the review according to the inclusion and exclusion criteria. If there was any uncertainty concerning the inclusion of a study, this was

discussed with the two other review authors and a decision was agreed.

Results

Eight theoretical perspectives were identified from this literature search. These were the Internet Intervention Model, Persuasive Systems Design, the PERMA framework, the Supportive Accountability Model, the Model of User Engagement, the Technology Acceptance Model, the Unified Theory of Acceptance and Use of IT and the Conceptual Model of User Engagement. The central components, disciplinary underpinnings and conceptualisations of adherence or otherwise as these relate to each of these theories and models are outlined in Table 1. The following section of this paper describes and compares these theories in terms of their conceptual origins, central propositions and relevant empirical applications. The relative merits of these models and implications for both future research and current delivery of web-based interventions are then discussed.

The Internet Intervention Model

The Internet Intervention Model [29] is considered one of the earliest attempts to model mechanisms of behaviour change as this relates to web-based health interventions [45]. The model proposes that behaviour change and maintenance develop through a series of nine non-linear steps, in which a user (who may be influenced by environmental factors) affects website use and adherence, which are themselves impacted by support and website characteristics. Website use leads to behaviour change and symptom improvement through various mechanisms of change. Behaviour change is sustained by treatment maintenance.

Although the model is essentially focused on mechanisms of behaviour change in a web-based context, it incorporates components which are relevant to developing a systematic understanding of user adherence to web-based interventions. Adherence forms a central aspect of the website use component of the model and is determined by a combination of user characteristics (e.g. motivation to engage), environmental factors (e.g. family encourages use), website elements (e.g. simple, clear and engaging design) and support (e.g. communication with a clinician). These factors are proposed to indirectly influence behaviour change via increased adherence.

The Internet Intervention Model is a cohesive theoretical perspective which focuses on how user, environmental, website and support variables operate and interrelate in the context of adherence to web-based interventions. The development of the model represented a significant progression from the prevailing fragmented literature which had primarily sought to identify individual predictors of adherence without

20

Int.J. Behav. Med. (2018) 25:17–29

Table 1 Theoretical perspectives of adherence

Model/theory	Discipline	Description of model	Conceptualisation of adherence
Internet Intervention Model, Ritterband et al. [29]	Behavioural medicine	Behaviour change is produced and maintained through non-linear nine steps. The user, influenced by environmental factors, affects website use and adherence, which is influenced by support and website characteristics. Website use leads to behaviour change and symptom improvement through various mechanisms of change. The improvements are sustained via treatment maintenance.	Adherence forms a central aspect of the model and in particular 'website use' (actual utilisation of the intervention) and is determined by a combination of user characteristics (e.g. motivation to engage); environmental factors (e.g. family encourage use); website elements (e.g. simple, clear and engaging design) and support (e.g. communication with a clinician). These factors are proposed to indirectly influence behaviour change via increased adherence.
Persuasive Systems Design (PSD) Model, Oinas-Kukkonen and Harijumaa [30]	Persuasive technology, information technology (behaviour change support systems)	Conceptualises the role of technology in behaviour and attitude change. Four key persuasive features, namely Primary Task Support (supporting the user to carry out the primary task); Dialogue Support (degree of feedback provided to users); System Credibility (how credible a system is in terms of, for example, trustworthiness, expertise and authority) and Social Support (motivating users through social influence). Proposes seven postulates in system design: that information technology is always available and should be open, incremental; unobtrusive, useful and easy to use; that the system must foster user commitment and cognitive consistency and that persuasion can occur via direct and indirect routes. Three key concepts in user context— 'intent' (i.e. objective of a web-based intervention), 'event' (i.e. context and characteristics of the target users and 'strategy' (i.e. the route and message of an intervention).	Persuasive Systems Design is primarily a model of behaviour change though it has been used successfully to predict adherence to web-based interventions (adherence defined as the proportion of participants that use and keep using the intervention in the desired way)
'PERMA' Framework Ludden et al. [31]	Multiple theoretical underpinnings but draws primarily from the fields of Persuasive Technology, Positive Psychology and Information Technology	Proposes that effective, appealing and compelling design can increase adherence to web-based interventions. Five components purported to be relevant to the design of web-based interventions are positive emotion, engagement, relationships, meaning and accomplishment (PERMA). Three strategies which may increase adherence are proposed: 'personalisation'; 'ambient information' and 'use of metaphor'. Personalisation refers to tailored messages, effective system design and providing user control; ambient information refers to a flow of content order to foster a desire to continue accessing a web-based programme while use of metaphor emphasises the importance of abstract concepts such as accomplishment, challenge and perseverance.	Describes a framework can be applied to the design of web-based interventions in order to increase adherence. Adherence per se is not operationally defined though the authors refer to the issue of nonadherence, whereby 'many people do not follow a treatment online as it was intended by the therapist'. Engagement is integrated into the model in line with Seligman's well-being theory as an element which can have a positive impact on participant well-being.

Table 1 (continued)

Model/theory	Discipline	Description of model	Conceptualisation of adherence
Model of User Engagement Short et al. [32]	Health psychology, though the model is built on research stemming from multiple strands including social psychology, persuasive technology, information technology and business	Draws upon the Elaboration Likelihood Model [33], Persuasive Systems Design [30], the Internet Intervention Model [34] and the Conceptual Model of User Engagement [35] to model the impact of individual, environmental and design components on adherence to web-based interventions [36]. Environmental factors such as time, access and online features (i.e. the tone, feel and function of the programme) influence individual factors such as user expectations, internet self-efficacy, affect and expectations. These in turn impact upon intervention factors such as usability and persuasiveness. Individual characteristics such as personal relevance, demographic variables and current and past health behaviours are also proposed to shape intervention engagement.	Not expressly a model of adherence but rather of engagement. Engagement in the context of this model is defined as 'the quality of a user experience, characterised by increased attention, positive affect, sensory and intellectual satisfaction and mastery'. Sustained engagement results when an intervention is perceived by the user as usable, relevant, interactive, motivating and persuasive.
Supportive Accountability Model Mohr et al. [37]	Derived from the fields of social and organisational psychology and computer-mediated communication	Proposes that adherence to eHealth interventions is influenced by seven key human support factors, namely 'accountability', 'social presence', 'expectations', 'performance monitoring', 'goal setting' and 'legitimacy'. The impact of these factors is in turn moderated by user motivation and computer-mediated communication. Adherence is highest when the user feels accountable to a coach who is perceived as expert, trustworthy and caring.	Adherence is defined here as the use of the eHealth intervention over time and has been operationalized in a variety of ways such as the number of logins, time on site, the number of modules completed and the number of characters typed into the site.
Technology Acceptance Model (TAM) Davis [38]	Psychology (adapted from the Theory of Reasoned Action) and information systems design	Adoption and usage of a technological platform are predicated on the attitude of the user towards the programme. Draws on Theory of Reasoned Action [39] and identifies two key determinants of attitude, namely perceived usefulness, which independently determines behavioural intention, and perceived ease of use, which impacts perceived usefulness.	Not expressly a model of adherence to web-based interventions, it is likely to be of significant relevance here is due to its focus on explaining the adoption and sustained usage of a technological programme.
Unified Theory of Acceptance and Use of IT (UTAUT) Venkatesh et al. [40]	Psychology and information systems design (integrates numerous well-established models in these fields including the Technology Acceptance Model (TAM) [10] and diffusion of innovation (DOI) into one cohesive model)	Integrates eight social cognitive theories into four key constructs which explain acceptance and use of IT. These constructs are 'performance expectancy' (the degree to which an individual believes that the system will help him or her to attain gains in job performance), 'effort expectancy' (the degree of ease associated with the use of the system), 'social influence' (the degree to which an individual perceives that important others believe he or she should use the new systems) and 'facilitating conditions' (perceptions of the resources and support available to perform a behaviour). These constructs are	As with the Technology Acceptance Model, UTAUT is not expressly a model of adherence though is highly relevant as focused on the adoption and sustained usage of a technological programme.

Table 1 (continued)

Model/theory	Discipline	Description of model	Conceptualisation of adherence
		moderated to varying extents by age, gender and voluntariness of use and serve as direct determinants of acceptance and usage behaviour.	
Conceptual Model of User Engagement O'Brien and Toms [35]	Information systems design: Incorporates a range of theories, including Flow Theory [41], Aesthetics [42], Play Theory [43] and Information Interaction Theory [44] into a cohesive model	Proposes four stages of user engagement and the relevant attributes associated with each stage. At the first stage, 'Point of Engagement', variables such as novelty, aesthetics, interest and motivation are considered key, while the 'Engagement' phase is also influenced by these variables plus control, feedback, positive and negative affect, challenge and connectedness. The model also proposes a 'Disengagement' stage which is influenced by user demands, affect, time and usability, and a 'Re-engagement' stage, which may be short- or long term and may occur more than once during use.	Essentially, a model of engagement rather than adherence. Engagement is defined as 'a category of user experience characterised by attributes of challenge, positive affect, durability, aesthetic and sensory appeal, attention, feedback, variety/novelty, interactivity, and perceived user control'.

reference to a wider psycho-social framework [45]. While there is limited empirical investigation of the efficacy of the overall model in terms of predicting adherence, there is empirical evidence that the various factors described within a website usage component of the model (i.e. user characteristics, environmental factors, website elements and support) are associated with user adherence to web-based health interventions [7, 19, 20, 34].

Persuasive Technology

The emergence of the field of persuasive technology can be traced to the early work of BJ Fogg [46, 47] who proposed that interactive technological systems can serve to influence the behaviour and attitudes of users in their own right. Fogg suggested that persuasive technologies operate in three ways: as tools which facilitate the ease of completing tasks, as media which provide content to users and as social actors which create social relationships with and between users.

A triadic behavioural model [48] was later proposed which detailed three key determinants of human behaviour that have a special relevance to persuasive technology, namely motivation, ability and triggers. The model suggests that a 'trade off' occurs between motivation and ability and that a sufficient level of both in the presence of effective triggers is needed to produce a behaviour. Fogg also detailed key elements associated with these three factors such as time, money, social acceptance, effort and pleasure. While persuasive technology is primarily focused on the role of technology for behaviour change, two frameworks (Persuasive Systems Design and

'PERMA') have emerged from the field which are relevant in explaining adherence to web-based programmes and are therefore reviewed here [49].

PSD Model

Persuasive Systems Design is a conceptual framework and process model outlined by Oinas-Kukkonen and Harijumaa [30] which seeks to clarify the role technology itself may play in changing behaviour and attitudes. The framework is underpinned by seven core 'postulates' in systems design. These are that information technology is always available and should be open, incremental, unobtrusive, useful and easy to use; that the system must foster user commitment and cognitive consistency and that persuasion can occur via direct and indirect routes (i.e. through careful consideration by the user and/or by simple cues).

The framework accounts for both the impact of context on the user and the technological design of the intervention in changing behaviour and maintaining adherence. With regard to context, three key concepts have emerged—'intent', 'event' and 'strategy'. 'Intent' refers to the specified primary objective of a web-based intervention (i.e. the desired behavioural or psychological changes), while 'event' refers to the context and characteristics of the target users and the technological modalities harnessed. Finally, 'strategy' is taken to encompass the route and message of an intervention, including theoretical basis and the source and style of intervention.

Although the framework is conceptual by nature, practical applications are also incorporated. To this end, a comprehensive

taxonomy, including implementation examples, of four key persuasive feature qualities are outlined within the framework, namely Primary Task Support (supporting the user to carry out their primary task), Dialogue Support (the degree of feedback provided to users), System Credibility (how credible a system is in terms of, for example, trustworthiness, expertise and authority) and Social Support (motivating users through social influence). These four qualities relate to 28 design guidelines, which are derived in part from Fogg's [47] functional triad.

As with the Internet Intervention Model, Persuasive Systems Design is primarily a model of behaviour change that offers a practical guidance in terms of explaining adherence to web-based interventions [50]. A systematic review by Kelders et al. [17] found that differences in intervention characteristics and persuasive technology (e.g. increased interaction with a counsellor, the frequency of intended usage, more frequent programme updates and more extensive employment of dialogue support) were predictive of adherence to web-based interventions.

'PERMA' Design Framework

The 'PERMA' framework incorporates the theoretical foundations of Pohlmeyer's [51] 'Well-being Matrix' and Seligman's [52] 'Well-being Theory' and is built on the premise that effective, appealing and compelling design can increase adherence to web-based interventions [31]. The framework comprises five components purported to be relevant to the design of web-based interventions and which impact on user adherence. These components are positive emotion, engagement, relationships, meaning and accomplishment. The development of the framework arose from a need to translate a research focus on identifying user needs and persuasive techniques into effective design guidelines that could enable the deliverer of a web-based intervention to shape the experience of the target users.

In line with the 'PERMA' framework, three strategies which may increase adherence are proposed: 'personalisation', 'ambient information' and 'use of metaphor'. Personalisation suggests that the impact of design on adherence can be imparted through the delivery of tailored messages, effective system design and providing user control (i.e. providing users with a flexible design that can be tailored to match their preferences). 'Ambient Information' refers to an approach that acknowledges that users may be overburdened with information and persuasive messages and that the flow of content should be tailored in order to foster a desire to continue accessing a web-based programme. Finally, 'Use of Metaphor' emphasises the importance of abstract concepts such as accomplishment, challenge and perseverance, and that providing a personally meaningful and engaging programme may increase user motivation to follow an intervention and thus increase their programme adherence.

The predictive utility of the 'PERMA' framework in terms of increasing adherence has yet to be tested empirically. However, the value of the framework would appear to lie in its focus on both users' personal needs and persuasive design, through the integration of practical guidelines for shaping the experience of the target user.

Model of User Engagement

The Model of User Engagement with online behaviour change interventions proposed by Short et al. [32] is the result of an amalgamation of several theoretical perspectives into one unified model. The model draws upon the Elaboration Likelihood Model [33]; Persuasive Systems Design [30]; the Internet Intervention Model [29] and the Conceptual Model of User Engagement [35]. As such it unifies increasing empirical evidence that individual, environmental and design components impact upon adherence to web-based interventions [36]. Short and colleagues assert that comprehensive web-based intervention development must account for engaging the user and should do so holistically (i.e. encompass a wider perspective beyond the individual characteristics of the user). The proposed model is reciprocal in nature and incorporates environmental, individual and intervention components which interact with and influence each other and subsequently impact upon user engagement.

Environmental factors such as time, access and online features (i.e. the tone, feel and function of the programme) influence individual factors such as user expectations, internet self-efficacy, affect and expectations. These in turn impact upon intervention factors such as usability and persuasiveness. Individual characteristics such as personal relevance, demographic variables and current and past health behaviours are also proposed to shape intervention engagement. As such, sustained engagement results when an intervention is perceived by the user as usable, relevant, interactive, motivating and persuasive.

Importantly, the model also suggests that disengagement from an online intervention may occur as a result of negative emotions, failure to match user expectations and a lack of perceived usability or usefulness. Positive emotions may also encourage disengagement. For example, users may become satisfied with what they have achieved and may not feel the need to adhere to the online programme any further.

The strength of this model is that while there has been much focus on theorising mechanisms of behaviour change in the context of web-based interventions, this model is perhaps the first to specifically conceptualise sustained user engagement with such programmes. As such, it addresses a key research gap. Although the model is yet to be operationally tested, Short and colleagues assert that it is congruent with existing behaviour change theories, drawing upon an

24

Int.J. Behav. Med. (2018) 25:17–29

established body of literature in fields such as social psychology and information technology.

Supportive Accountability Model

The Supportive Accountability Model is a conceptual framework of the role of human support in enhancing adherence to eHealth interventions [37]. Considerable evidence points to the value of support in fostering adherence and the effectiveness of web-based interventions [53–55] though much of this research is not guided by a clear theoretical model. The model, drawing from the fields of motivational theory, computer-mediated communication and organisational psychology, proposes that adherence to eHealth interventions is influenced by seven key human support factors; namely 'accountability'; 'social presence';' expectations'; 'performance monitoring'; 'goal setting' and 'legitimacy'. The impact of these factors is in turn moderated by user motivation and computer-mediated communication.

Supportive Accountability proposes that adherence to web-based interventions will be higher if user feels accountable to a coach with requisite expertise and who is perceived to be trustworthy and caring. Clearly defined goals and benefits, reciprocity and a strong therapeutic bond are also essential factors for promoting adherence. Preliminary empirical evidence supports the utility of the model, with significantly greater adherence reported for participants who received a web-based intervention for depressive symptoms with support provided compared to participants who received a self-directed programme [56]. Similar support for the model has also been reported in other studies with cancer survivors [57], patient with multiple sclerosis [58], in trials for weight management [39] and in interventions for depression [59] and stress management [60].

Information Systems Design

Three models, namely the Technology Acceptance Model [38], the Unified Theory of Acceptance and Use of IT [40] and the Conceptual Model of User Engagement with Technology [35] were identified from the fields of information systems design, business and computing. Meaningful implications for understanding adherence to web-based interventions may be garnered from this body of research and their potential relevance in terms of presenting a theoretical foundation of adherence to web-based interventions is considered here.

Technology Acceptance Model [TAM]

The Technology Acceptance Model [38] purports that the intended adoption and continued use of a technological platform is predicated on the attitude of the user towards the programme. TAM is adapted from the Theory of Reasoned Action [61]. The model identifies two key determinants of attitude; namely perceived usefulness, which independently determines behavioural intention; and perceived ease of use, which itself impacts upon perceived usefulness. Several modifications of the model have been outlined, most notably perhaps TAM-2 [62] which removed the attitude construct and incorporated subjective norms [i.e. perceived social pressures on an individual to engage in a behaviour], which is proposed to directly influence perceived usefulness and behavioural intention.

A meta-analysis of 88 studies by King and He [63] identified TAM as a 'complete mediating model', in that the impact of perceived ease of use was primarily through perceived usefulness, which itself was found to have a profound influence on behavioural intention. Reviews by Yarbrough and Smith [64] and Holden and Karsh [65] on clinician use of health IT also support the utility of the model. These reviews indicate that IT systems need to be perceived to be both easy to use and capable of facilitating the achievement of desired outcome in order for users to accept and consistently engage with them. Other meta-analytic reviews [66, 67] also support the predictive power of the mode. However, they do suggest that while the core strength of the model may lie in its parsimony and easily understood nature, this may also be a significant limitation. For example, more effort is needed to identify additional moderating variables, such as perceived control and self-efficacy. These may have an external impact on perceived usefulness and ease of use [41] and to understand how the model may operate in different contexts and settings. In addition, the utility of model in predicting adherence to or sustained usage of web-based behavioural interventions is yet to be evaluated.

Unified Theory of Acceptance and Use of IT

The Unified Theory of IT Acceptance (UTAUT) aims to explain individual intention to use a technological platform and their subsequent usage behaviour [40]. This theory emerged from the well-established field of information systems research, amalgamating several competing theoretical models within this field into one unified perspective. The model integrates eight social cognitive theories into four key constructs - 'performance expectancy'; 'effort expectancy'; 'social influence' and 'facilitating conditions'. These constructs are moderated to varying extents by age, gender and voluntariness of use and serve as direct determinants of acceptance and usage behaviour.

Empirical applications of UTAUT with regard to mobile communications, banking and education fields are numerous [42]. Two meta-analytic reviews have provided somewhat conflicting evidence for the strength and robustness of the

model. Taiwo and Downe [43] reviewed 37 studies which used UTAUT and found that while the relationship between performance expectancy and behavioural intention was strong, the relationships between behavioural intention and the constructs 'effort expectancy', 'social influence' and 'facilitating conditions' were much weaker. A later review by Khecine et al. [44] included 74 empirical studies, and found that the strength of four central constructs of UTAUT in predicting behavioural intention to use a technological platform ranged from medium to large in size, while the relationship between intention and usage was itself medium was in size. These reviews supported the premise that users are more likely to use a technological platform if they perceive that it will improve their productivity, efficiency and effectiveness on a regular basis.

UTAUT has been updated and extended several times with additional constructs added. Murugesh-Warren et al. [68] for example, applied the extended UTAUT-2 to a focus on healthcare, incorporating 17 additional mechanisms such as 'outcome expectance', 'support 'and 'usage enjoyment'. However, these numerous extensions have resulted in the model becoming quite convoluted and lacking parsimony. In addition, the model has yet to be applied to web-based behavioural or psychological intervention. Therefore, the robustness of the model in this domain is untested.

Conceptual Model of User Engagement with Technology

The Conceptual Model of User Engagement with Technology [35] synthesises various theoretical perspectives and empirical research within the information systems field into a single conceptual model of user engagement. Incorporated into the formulation of this model are key features from Flow Theory [69], Aesthetics [70], Play Theory [71] and Information Interaction Theory [72] combined with findings from research into consumer behaviour, web searching and educational software. The model utilises a holistic framework, taking into account not only individual user cognitions but also programme design and content.

The model proposes four stages of user engagement and the relevant attributes associated with each stage. At the first stage, 'Point of Engagement', variables such as novelty, aesthetics, interest and motivation are considered key to engagement, while the 'Engagement' phase is also influenced by these variables plus control, feedback, positive and negative affect, challenge and connectedness. The model also proposes a 'Disengagement' stage which is influenced by user demands, affect, time and usability, and a 'Re-engagement' stage, which may be short- or long term and may occur more than once during the use of the technology platform.

The conceptual model derives from a considerable volume of research on user engagement with technology, a field from which numerous behavioural models have emerged (see [73]

for a review). A qualitative evaluation of middle-aged males' user engagement with a web-based health intervention [74] found that personal attributes (i.e. motives and goals) and intervention materials (usability and control) were associated with user engagement. Positive and negative experiences were guided by initial expectations, indicating the importance of managing user outcome expectations in order to improve engagement and retention to web-based interventions. Components of the model have also been applied to understanding engagement with online information retrieval [75], digital media [76] and video game environments [77].

The stages of engagement process proposed within the model differentiate it from other frameworks reviewed here, and although this is yet to be empirically tested within the domain of health-related behaviour change, it may have practical implications for those delivering web-based interventions.

Discussion

Adherence is a complex and multi-faceted concept. In this regard, two important findings have emerged from this review. Firstly, a cohesive and robust theoretical framework of adherence should address a multitude of integrating factors, including environmental, technological and support variables, as well as individual user demographics and psychological characteristics. In order to achieve this, an interdisciplinary approach incorporating empirical findings and best practices from different fields of research such as information systems design, business, psychology and eHealth is needed [78].

Secondly, it is notable that there is a lack of agreement in the literature with regard to conceptualisation of adherence and related models and theories such as engagement and 'non-usage' attrition [2, 79]. Though behavioural conceptualisations of engagement [13] are closely related to adherence, it is important to note that they should not be considered identical. Guetler et al. [80] for example distinguished between engagement (described as the frequency and duration of involvement with an intervention) and non-usage attrition (defined as the point at which users had stopped using the intervention altogether).

Donkin and Glozier [81], however, referred to engagement as the level of persistence with an intervention, in terms of the extent to which individuals completed the intervention or required modules. Furthermore, Donkin et al. [82] question the validity of relying on exposure or usage of an intervention as a type of proxy measure for engagement and note that it is not strictly correct to assume that greater adherence equates to a more engaged user. As such, while this review identifies the key theoretical perspectives relevant to explaining adherence to web-based interventions, there is an equal need to develop

agreed conceptualisation and frameworks of engagement and clarify the boundary between the two concepts [83, 84]. Caution should therefore be exercised when considering the relevance of specific models of engagement, such as the Conceptual Model of User Engagement, in explaining adherence to web-based interventions.

This lack of consensus is perhaps unsurprising considering that the various research strands draw upon multiple disciplines, ranging from social and health psychology, information technology, business and marketing. Indeed, within the field of health-related behaviour change alone, numerous overarching terms are in use, including eHealth [37], mHealth, digital health behaviour change interventions [84], behavioural information technology [48] and health behaviour change support systems [85]. The diversity of terminology and underpinning theory makes it difficult to unify the current body of research.

The strength of this review is that models from wider fields such as information technology are considered as they have specifically focused on both adoption and continued use of digital platforms. In this context, therefore, this review may now facilitate a greater co-ordination of future research that goes beyond the traditional theory boundaries as this relates to adherence to treatment protocols and interventions and encourage a more comprehensive and wider examination with regards to theory development and its applied value.

It is significant that the Supportive Accountability Model [37] was the only model identified through this review which specifically sought to explain sustained adherence to web-based interventions. The Internet Intervention Model and the persuasive technology frameworks are primarily models of behaviour change which incorporate components relevant to explaining usage of web-based interventions. The Model of User Engagement [32] is perhaps the most comprehensive model identified, as it draws upon a range of models, including the Elaboration Likelihood Model [33], Persuasive Systems Design [30], the Internet Intervention Model [29] and the Conceptual Model of User Engagement [35]. As such, it spans several disciplines including social psychology, information technology and persuasive technology. However, it is conceptually focused on engagement [described by Short and colleagues as the quality of a user's interaction with web-based programme] and not specifically adherence or 'non-usage attrition' in line with the conceptualisations articulated by Eysenbach [6].

Several models reviewed here are largely untested and as such, their validity as cohesive frameworks is unknown. While it is beyond the scope of this review to systematically examine the empirical evidence underpinning each of these theories/models, it is evident that the field is in a state of development [5] and that some models (e.g. Technology Acceptance Model, UTAUT and Persuasive Systems Design) have been more rigorously tested than others (e.g.

the Model of User Engagement). This is especially significant considering that an increasing body of evidence associates greater adherence with improved intervention outcomes. There is now a need to test these frameworks, identify what factors need to be considered and how to target them, and understand in what context they are most useful in relation to adherence.

A further issue to be addressed is that adherence data from web-based interventions are not always readily reported or even collected. Comprehensive analysis tends not to be conducted and studies which report adherence data as well as outcomes (e.g. [86, 87]) remain the exception rather than the norm. Often, it is only differences in demographic or psychosocial characteristics between adherers and non-adherers that are reported [6]. The reasons for this are unclear. It may be because adherence is assumed to be embedded within the programme itself or that user confidence or motivation with regard to using a web-based programme is taken for granted. However, it may be because there is a lack of agreement in terms of the definition and measurement of key concepts such as engagement, adherence and attrition [21].

An effective theory or model of adherence should operate in conjunction with an empirically supported model of behaviour change and technology design [45]. The purported benefits of web-based interventions versus other formats in terms of reduced costs, wider reach, ease of access [in terms of time and location] and the prevention of stigma may be undermined if only a minority of the target population engage meaningfully with the programme and adhere to it as required. As such, the development of useful and comprehensive models of user adherence is essential to ensure that the added value of web-based interventions are maximised.

Conclusion

Much research has sought to explore the concept of user adherence to web-based interventions. This scoping review identified and described eight theoretical perspectives relevant to understanding adherence to web-based interventions, namely the Internet Intervention Model, Persuasive Systems Design, the 'PERMA' framework, the Support Accountability Model, the Model of User Engagement, the Technology Acceptance Model, the Unified Theory of Acceptance and Use of IT and the Conceptual Model of User Engagement. An interdisciplinary approach, incorporating a range of technological, environmental and individual factors may be needed in order to comprehensively model user adherence to web-based interventions. Further evaluation is also required in order to determine the extent to which the core proposals of these theoretical perspectives are supported by empirical evidence.

Compliance with Ethical Standards

Conflict of Interest   The authors declare that they have no conflict of interest.

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