Health Psychology Review

ISSN: 1743-7199 (Print) 1743-7202 (Online) Journal homepage: https://www.tandfonline.com/loi/rhpr20

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To cite this article: Taylor Willmott, Bo Pang, Sharyn Rundle-Thiele & Abi Badejo (2019) Reported theory use in electronic health weight management interventions targeting young adults: a systematic review, Health Psychology Review, 13:3, 295-317, DOI: 10.1080/17437199.2019.1625280

To link to this article: https://doi.org/10.1080/17437199.2019.1625280

HEALTH PSYCHOLOGY REVIEW
2019, VOL. 13, NO. 3, 295–317
https://doi.org/10.1080/17437199.2019.1625280

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Reported theory use in electronic health weight management interventions targeting young adults: a systematic review

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ABSTRACT

This review assesses the extent of reported theory use in electronic health weight management interventions targeting young adults aged 18–35 years. Twenty-four eligible studies were identified. Two independent reviewers extracted data and coded for theory use using the Theory Coding Scheme. Overall, the mean total use of theory score was 6/23 (SD = 5; Min. = 0, Max. = 17); 17 studies were classified as having weak application of theory, five as moderate, and two as strong. The majority (N = 18) of studies mentioned theory, however, most (N = 14) did not report how intervention techniques related to theoretical base. No study used theory to select intervention recipients and only four used theory to tailor intervention techniques to recipients. Limited studies reported theory testing (N = 6) and no study used intervention results to build and/or refine theory. Results indicate that weight-related outcomes may be enhanced when at least one or more theoretical constructs are explicitly linked to an intervention technique and when theoretical constructs are included in evaluations. Increases in theory application and reporting are needed to assist the scientific research community in systematically identifying which theories work, for whom, how, why, and when; thereby delivering an advanced understanding of how best to apply theory to enhance intervention outcomes.

ARTICLE HISTORY
Received 26 July 2018
Accepted 26 May 2019

KEYWORDS
Behaviour change; electronic health; theory; weight management; young adults

Introduction

Worldwide, the prevalence of overweight and obesity has been exponentially increasing since 1975 (NCD Risk Factor Collaboration, 2016). In 2016, more than 1.9 billion adults were overweight or obese, and of these, over 650 million were obese (NCD Risk Factor Collaboration, 2016). Alarmingly, experts have warned that obesity is far more common than the NCD Risk Factor Collaboration (2016) study suggests, owing to the conservative nature of body mass index (BMI) based estimates (Reilly, El-Hamdouchi, Diouf, Monyeki, & Somda, 2018). As a result of the established health risks of excess weight (Ng et al., 2014) and substantial increases in prevalence (NCD Risk Factor Collaboration, 2016), overweight and obesity have become a major public health challenge (Dobbs et al., 2014); and rates of overweight and obesity highlight that overweight is the new normal. The causes, prevention, and management of overweight and obesity are complex (Swinburn et al., 2011); and include a myriad of social, cultural and environmental factors, industry practices and public policies, personal attitudes and behaviours, and human biology (McGlashan et al., 2018). Targeting high-risk groups with prevention interventions forms a fundamental component of the comprehensive programme of action required (WHO, 2011).

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Supplemental data for this article can be accessed at https://doi.org/10.1080/17437199.2019.1625280.

Young adults are particularly vulnerable with the most rapid weight gain in the life-course observed during the early twenties to mid-thirties (Flegal, Kruszon-Moran, Carroll, Fryar, & Ogden, 2016; Zheng et al., 2017). Population trends in adults indicate that obesity develops as a result of gradual weight gain during early adulthood (McTigue, Garrett, & Popkin, 2002), with most obese individuals becoming so before the age of 35 (Sheehan, DuBrava, DeChello, & Fang, 2003). Moreover, incident obesity at a younger age carries an increased risk of chronic disease and mortality in later adult life (Adams et al., 2014; de Mutsert, Sun, Willett, Hu, & van Dam, 2014; Zheng et al., 2017). Therefore, interventions aimed at promoting effective weight management have the potential to prevent the early onset of obesity and associated chronic disease in young adults (Spring et al., 2014).

The potential of electronic health to deliver prevention strategies

Despite the recognised importance of prevention measures (Dobbs et al., 2014), recruiting and engaging young adults in weight management interventions has proven to be a particularly difficult task (Partridge, Balestracci, et al., 2015). Given the current generation of young adults are among the highest users of digital technologies such as social media, mobile phones, and wireless information sharing platforms (Lenhart, Purcell, Smith, & Zickuhr, 2010), an *electronic health* (eHealth) based approach offers considerable potential for engaging large numbers of young adults in weight management. Known as the 'digital natives,' Generation Y actively contributes, shares, searches for, and consumes content online (Bolton et al., 2013). eHealth refers to the use of information communication technologies (ICTs) to deliver, or support the delivery of, health services (WHO, 2018). eHealth interventions typically ascend from behaviour change interventions which have been operationalised and transformed for delivery via an Internet-enabled device (Michie, Yardley, West, Patrick, & Greaves, 2017). The popularity, mobility, and capability of modern ICTs enables the delivery of individually-tailored, context-specific behaviour change interventions, with time-unlimited feedback, coaching, and support (Free et al., 2013; Vandelanotte et al., 2016). Although, it should be noted that not all eHealth-based interventions are adaptive, with varying levels of technological sophistication (Riley, Serrano, Nilsen, & Atienza, 2015).

Previous research

Previous reviews (Hebden, Chey, & Allman-Farinelli, 2012; Hutchesson, Hulst, & Collins, 2013; Laska, Pelletier, Larson, & Story, 2012; Oosterveen, Tzelepis, Ashton, & Hutchesson, 2017; Partridge, Juan, McGeechan, Bauman, & Allman-Farinelli, 2015; Poobalan, Aucott, Precious, Crombie, & Smith, 2010) of obesity lifestyle prevention interventions (in-person and technology-supported) targeting young adults point to limited effectiveness. Limitations identified within these reviews include: small sample sizes (Hebden et al., 2012; Poobalan et al., 2010); differences in participant characteristics (Hebden et al., 2012) including gender bias (Poobalan et al., 2010); varied intervention durations (Hebden et al., 2012; Poobalan et al., 2010); risk of bias or low methodological quality (Hutchesson et al., 2013; Partridge, Juan, et al., 2015); and large heterogeneity across intervention design and outcomes (Hebden et al., 2012; Laska et al., 2012; Oosterveen et al., 2017; Poobalan et al., 2010). These reviews focused primarily on pooling primary outcome results to obtain one overall estimate of effectiveness. Currently, our knowledge of the extent that theory is reported and applied in eHealth weight management interventions targeting young adults is limited.

Review rationale and aim

To better understand how interventions are (or are not) achieving the desired outcomes it is necessary to unpack the 'black box' (Tate et al., 2016). Theory is a critical aspect of being able to deconstruct interventions and theory can identify the underlying mechanisms of action – that is, the mediators and moderators of change (Davis, Campbell, Hildon, Hobbs, & Michie, 2015; Tate et al., 2016).

Theory provides a framework within which to identify appropriate intervention targets (i.e., theoretical predictors of behaviour) and component behaviour change techniques (BCTs) (Hardeman et al., 2005; Michie & Abraham, 2004; Michie & Prestwich, 2010; Michie, Johnston, Francis, Hardeman, & Eccles, 2008; Michie, Carey, et al., 2017); enables hypothesis testing and accumulation of evidence (Michie et al., 2008; Rothman, 2004, 2009); informs the refinement and/or tailoring of theory and component BCTs to enhance intervention efficiency (Michie & Abraham, 2004; Rothman, 2004, 2009); and facilitates the advancement of the cumulative knowledge base (Michie & Prestwich, 2010).

Some researchers suggest that behaviour change interventions may be enhanced by applying theory (Craig et al., 2008; Davis et al., 2015; Glanz & Bishop, 2010). Several reviews indicate that using theory as a basis for developing interventions generates larger effects than interventions which do not use theory at all (Avery, Donovan, Horwood, & Lane, 2013; Bluethmann, Bartholomew, Murphy, & Vernon, 2017; Protogerou & Johnson, 2014; Taylor, Conner, & Lawton, 2012; Webb, Joseph, Yardley, & Michie, 2010). There are, however, other reviews that provide equivocal or inconsistent support (Ayling, Brierley, Johnson, Heller, & Eiser, 2015; Bhattarai et al., 2013; Black, Mullan, & Sharpe, 2016; Dalgetty, Miller, & Dombrowski, 2019; Diep, Chen, Davies, Baranowski, & Baranowski, 2014; Lara et al., 2014; McEwan et al., 2019; Prestwich et al., 2014); some even suggest theory-based interventions are less effective than interventions that do not apply theory at all (Gardner, Wardle, Poston, & Croker, 2011; Mehtälä, Sääkslahti, Inkinen, & Poskiparta, 2014; Portnoy, Ferrer, Bergman, & Klein, 2014).

Scholars have provided several explanations for this mixed picture including: limited and/or poor use of theory; inappropriate selection of theory and/or combining multiple theories with no conceptual justification; poor reporting of theory use; and confounds (Prestwich, Webb, & Conner, 2015). Reviewers often deem an intervention as 'theory-based' if the authors simply mention a theory in relation to the intervention, with little consideration given to exactly *how* theory has informed the intervention (Michie & Prestwich, 2010). Given very few authors explicitly explain *how* theory is applied in sufficient detail (Michie & Prestwich, 2010; Painter, Borba, Hynes, Mays, & Glanz, 2008), discussions regarding the potential role of theory in enhancing intervention effectiveness may be premature.

eHealth interventions aim to change behaviours (e.g., sleep, eating, physical activity, alcohol use and more) linked to an outcome (e.g., weight management) by using information (data) about a person and their environment to adapt and tailor the delivery of intervention content to the changing needs of the individual and their environment (Hekler et al., 2016a). Theories are key to effectively organising this information (data) in a meaningful way that accounts for what is known about the causal mechanisms and moderators of behaviour and behavioural change within the individual context (Hekler et al., 2016b). eHealth interventions offer a basis for the development of precise theories that take into account variations over time in individual characteristics and contexts (Hekler et al., 2016a). For example, *just-in-time adaptive interventions* (JITAI) quickly collect and compute data on an individual's current state, situational context, and prior intervention experiences to deliver the most appropriate intervention at the most optimal time (Intille, Kukla, Farzanfar, & Bakr, 2003; Riley et al., 2011). While further research is needed to establish exactly how current behaviour and behavioural change theories can be applied and used to evaluate such dynamic types of interventions (Riley et al., 2011), theoretical underpinnings remain critical for understanding the complexity of real-world behaviour and behavioural change (Hekler et al., 2016b; Michie, Yardley, West, Patrick & Greaves, 2017).

This review evaluates the extent that theory use is reported in eHealth weight management interventions targeting young adults using a previously validated *Theory Coding Scheme* (TCS) (Michie & Prestwich, 2010). The TCS is used to assess the reported use of theory in intervention design, implementation, and evaluation (Michie & Prestwich, 2010). The TCS was developed to inform evidence syntheses and has been applied previously (Black et al., 2016; Garnett et al., 2018; Prestwich et al., 2014; Webb et al., 2010). The four research questions underpinning the review were:

RQ1: Which theories are mentioned?

RQ2: How is theory applied in the design and implementation of the intervention?

RQ3: Is theory measured and tested in the evaluation of the intervention?

RQ4: Are intervention results used to further develop and/or refine theory to better inform the design of future interventions?

Methods

Studies used in this comprehensive assessment of reported theory use were identified through a systematic search strategy and review that are reported in detail elsewhere (Willmott, Pang, Rundle-Thiele, & Badejo, 2019). The aim of the previously published review was to locate and synthesise the evidence on eHealth weight management interventions targeting young adults, with a particular focus on eHealth intervention components and outcomes. The systematic search strategy and review were conducted in accordance with the *Preferred Reporting Items for Systematic Reviews and Meta-analyses* (PRISMA) guidelines (Liberati et al., 2009) and the completed PRISMA checklist is available as supplementary material (see Willmott et al., 2019). The present study assesses the extent of reported theory use in eHealth weight management interventions targeting young adults using the TCS (Michie & Prestwich, 2010) and examines how theory may be applied to enhance weight-related outcomes in interventions.

Information sources and search strategy

The systematic literature search was completed in September 2018 and executed across 14 electronic databases (reported in Willmott et al., 2019). The reference lists of all included papers and pertinent systematic reviews (Hebden et al., 2012; Oosterveen et al., 2017; Partridge, Juan, et al., 2015) were hand searched to identify additional studies for inclusion and Google Scholar was used to screen papers citing included studies.

Study selection

All retrieved records were downloaded to EndNote Version X8, duplicates were removed, and the remaining studies were assessed for eligibility by two independent reviewers. The results were categorised by title and abstract into (i) papers appearing to meet study selection criteria; (ii) papers that should be retrieved for further examination; and (iii) excluded papers (see Figure 1). In cases where there were several publications from the same cohort, the study with the longest follow-up was selected; if the follow-up was equivalent, the most recent study was selected. The full text of potentially relevant papers was then obtained and assessed for eligibility by two independent reviewers. At all stages, any discrepancies were discussed and resolved by consensus.

Eligibility and inclusion criteria

To be eligible for this review, studies had to be (i) published in the English language; (ii) peer-reviewed; (iii) report evaluations of eHealth weight management interventions targeting young adults (aged 18–35 years old), including randomised controlled trials (RCTs), controlled clinical trials (CCTs), and cohort studies (pretest-posttest and post-test only); (iv) include participants who were healthy and free of acute illness or chronic disease, and not pregnant; and (v) report a measure of weight pre- and post-intervention.

In the present review, eHealth referred to behaviour change interventions which were operationalised and transformed for delivery via ICTs including computers, tablets, mobiles, smartphones,

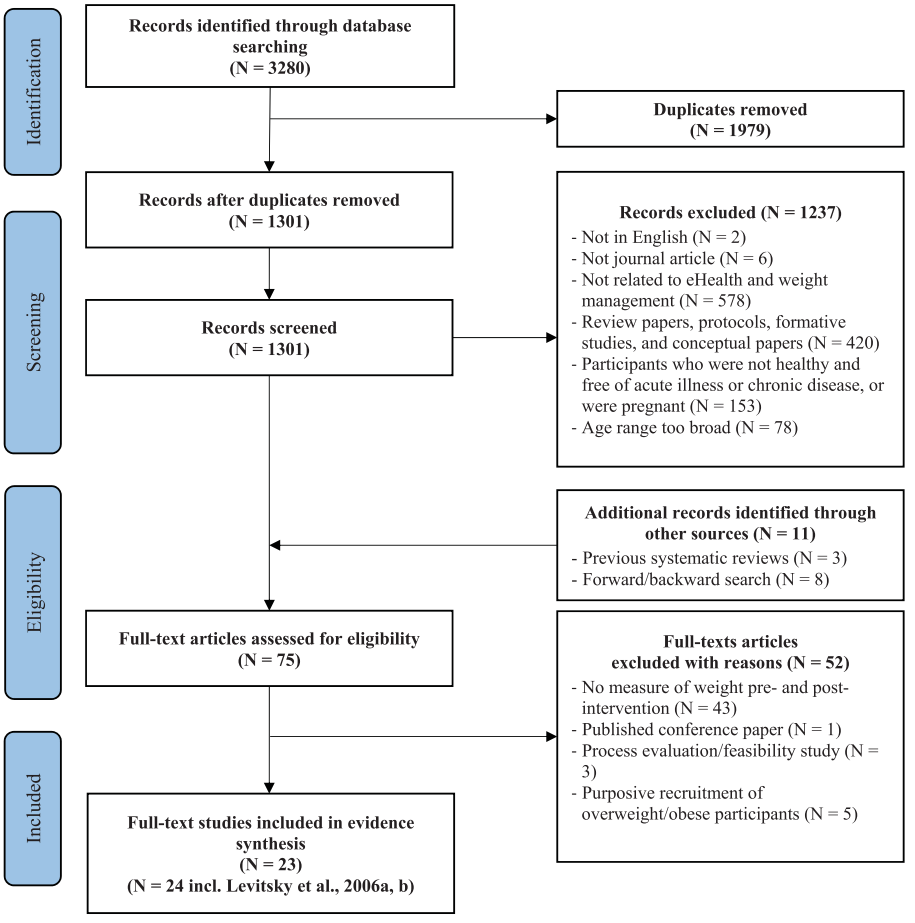

Figure 1. PRISMA flowchart of review process.

wearable and non-wearable tracking devices, and digital games. To be eligible, eHealth had to form the primary means of intervention delivery in *at least one* treatment arm in the prevention-focused study. The technology could be used as both a tool to enable a process, function or service, or as the embodiment of eHealth itself (Oh, Rizo, Enkin, & Jadad, 2005). For the purposes of the present review, weight management was defined as the prevention of weight gain via the maintenance of a healthy body weight and/or the reversal of small gains in order to maintain a healthy body weight (Gill, King, & Webb, 2005). Studies which evaluated weight loss and/or weight loss maintenance interventions among the obese (mean BMI > 30 kg/m^2) were excluded as weight gain prevention (i.e., management) was the focus of this study and participants who have lost significant amounts of weight do not represent the general young adult population (AIHW, 2017).

The published literature indicates that approaches to weight gain prevention differ from those aiming to treat individuals who are already obese (Nguyen & Lau, 2012). The prevention of weight gain relies on the behavioural modification of diet and activity patterns (WHO, 2011). The treatment of obesity (via weight loss) after it has fully developed is much more complex. Although weight loss can also be achieved through dietary restriction and/or increased physical activity, such conservative approaches have demonstrated limited effectiveness among the obese (de Zwaan, 2012), with the overwhelming majority of people regaining the weight lost over the long-term (Dombrowski, Knittle, Avenell, Araujo-Soares, & Sniehotta, 2014; Fildes et al., 2015; Sumithran & Proietto, 2013). The physiological adaptions experienced during weight loss are thought to be responsible for

weight regain (Sumithran & Proietto, 2013). As a result, conservative approaches promoting healthy eating and regular physical activity are unlikely to impact the weight status of overweight and obese individuals in the long term (Proietto, 2011). Therefore, adjunctive measures are sought such as pharmacotherapy and bariatric surgery (Nguyen & Lau, 2012). Currently, there are no non-surgical treatments available with demonstrated long-term safety and efficacy to circumvent physiological changes and assist weight-reduced people with obesity who are unable to maintain weight loss (Sumithran & Proietto, 2013). Obesity is associated with significantly increased morbidity and mortality risk, which rises with increasing BMI, and further complicates treatment. A BMI > 35 kg/m^2 with obesity-associated co-morbidities is a traditional indication for bariatric surgery (the most effective method for weight loss), particularly when attempts at conservative treatment have failed (de Zwaan, 2012). Conservative approaches are rarely successful among the obese and surgical weight loss options are currently the only weight loss methods with medium- and long-term success (de Zwaan, 2012). The extremely high somatic and mental comorbidity, and the significantly increased mortality in the morbidly obese, necessitate effective methods to reduce weight and rule out conservative approaches (de Zwaan, 2012). Given secondary prevention is extremely difficult to achieve, a primary prevention focus among children and young adults is required (Proietto, 2011; Spring et al., 2014; Zheng et al., 2017).

In the present review, the age range of 18–35 years was selected based on the protocol included in the National Heart, Lung, and Blood Institute's *Early Adult Reduction of Weight through Lifestyle* (EARLY) intervention trials (Loria, Arteaga, Belle, Signore, & Riley, 2011). Weight gain is most rapid during these years (Flegal et al., 2016; Zheng et al., 2017) and increasing BMI in young adulthood increases the risk of developing metabolic syndrome over the subsequent 15 years almost 20-fold (Lloyd-Jones et al., 2007).

Studies were excluded on the basis of the following criteria: (i) not peer-reviewed; (ii) not published in the English language; (iii) not related to eHealth *and* weight management; (iv) not an intervention evaluation; (v) inclusion of participants who had a mean BMI > 30 kg/m^2, a chronic or acute illness, self-disclosed mental illness, or were pregnant; (vi) did not report a measure of weight pre and postintervention; or (vii) did not specifically target young adults (aged 18–35 years). Studies that did not report an age range, the mean age of the sample, or the percentage of the sample who were within a given age range, were also excluded (see Figure 1).

Data collection process

A PRISMA-informed data extraction spreadsheet was developed for abstracting study characteristics in Excel. Data included: study details (author, year of publication, and country); study design; theory use; participants (sample size, characteristics, setting, retention, and blinding); intervention and comparator details; duration; data collection methods, measures, and outcomes; and conclusions. Summary tables were thoroughly and independently reviewed by all authors for accuracy and relevance.

Extent of theory use

Extent of theory use was assessed using the 19-item TCS (Michie & Prestwich, 2010). The scheme assesses: (i) mentioning/referencing of theory; (ii) application of theory; (iii) measurement and testing of theory; and (iv) building and refining theory. For the purposes of the present review, Items 14 and 16 of the TCS were not assessed. Item 14 relates to randomisation and is not directly relevant to theory use; and Item 16 was considered superfluous to Item 15. The remaining 17 items were coded and used in the analysis reported in this review (see Supporting Information Table S1 for TCS item descriptions).

The TCS is a comprehensive tool that can be applied by researchers to identify the extent that theory is reported in behaviour change interventions (Michie & Prestwich, 2010). The TCS

was the chosen method of theory assessment for this review as it provides a 'detailed, objective, and reliable method' for assessing the extent to which behavioural interventions are reporting theory use in behavioural intervention design, implementation, and evaluation (Michie & Prestwich, 2010, p. 2). To permit objective assessment, the TCS provides a clear description for each item. Specifically, each item requires a 'yes,' 'no,' or 'don't know' response and supporting evidence (e.g., page number). Moreover, a glossary of terms (e.g., theory, theory-relevant constructs, predictor, and intervention technique) is provided to guide assessments of reported theory use. In the present review, two independent researchers assessed theory use in included studies to ensure reliability of coding, with a high-level of agreement (95%) reached. For any discrepancies, a third independent researcher acting as an arbitrator was consulted. Where applicable, development, feasibility, and/or protocol papers referenced in the included studies were also assessed to ensure the most comprehensive assessment of theory use was obtained.

Consistent with previous reviews (Garnett et al., 2018), an overall use of theory score was calculated as a sum of the total, with a maximum possible score of 23 (17 primary items plus six subitems). To ensure the representativeness of the composite scores, any item coded as present for detailing 'all' (Items 7, 10, 13a and 13c) was also coded as present for the equivalent item detailing 'at least one' (Items 8, 11, 13b and 3d). Lastly, each study was categorised as having weak, moderate, or strong levels of theory use based on total TCS scores (weak = 0–7; moderate = 8–15; and strong = 16–23).

Data synthesis

A narrative approach to data analysis was employed in this review. Narrative systematic reviews are useful for exploring the development of particular ideas (e.g., theoretical application) and for advancing our knowledge of a particular intervention, problem, or field of research (Gurevitch, Koricheva, Nakagawa, & Stewart, 2018). In order for systematic reviews to incorporate quantitative meta-analyses to assess the magnitude of outcome(s) across relevant primary studies, and to analyse the sources of variation among study outcomes, sufficient and appropriate quantitative data is needed from the studies that are being summarised (Gurevitch et al., 2018). Meta-regression requires a sufficient level of power to reliably detect effect size. Specifically, research indicates that more than 200 studies are required for 80% power to detect modest associations in meta-regressions (Hempel et al., 2013). With only 24 eligible studies retrieved from our systematic search, any meta-regressions would have insufficient power to reliably detect modest associations. Furthermore, considerable heterogeneity (clinical and methodological) across study designs, behaviours, and outcomes measured was evident. For example, the behavioural focus of the 24 included studies varied across nine different combinations: three focused on *self-weighing*, one focused on *diet only*, three focused on *PA only*, 10 focused on *diet and PA*, two focused on *diet, PA, responsible drinking, and not smoking,* one focused on *diet, PA, and stress*, two focused on *diet, PA, and self-weighing*, one focused on *diet, PA, sleep and stress*, and one focused on *stress, nutrition, alcohol, and physical activity*. In such cases, it is considered more appropriate to undertake a narrative systematic review as opposed to a meta-analysis (Liberati et al., 2009). Moreover, a large proportion of studies in this review did not rigorously apply theory. Specifically, 17 studies reported *weak* levels of theory use, five *moderate*, and two *strong*. Consequently, any meta-analytic comparisons between theory use and intervention effectiveness are premature. As such, this review focuses on describing the extent of reported theory use in included studies. This study aims to illuminate the need to increase levels of theory reporting and/or application to ensure the scientific research community can progress current knowledge of how best to apply theory to enhance intervention outcomes by systematically identifying which theories work, for whom, how, why, and when.

Results

Overall, 3280 records were retrieved from the initial search and following the removal of duplicates, 1301 records were assessed for eligibility via title and abstract. Following the application of exclusion criteria, 1237 records were excluded. Eleven additional records were identified from other sources, resulting in a total of 75 full-text articles retained and assessed for eligibility. Of these, twenty-four studies met the criteria for inclusion (refer to Figure 1).

Study characteristics

Table 1 provides a summary of individual study characteristics for the 24 included studies. Further detail on intervention (eHealth) components and outcomes is reported elsewhere (Willmott et al., 2019). The exclusive focus of this paper is on describing the extent of reported theory use in included studies. In terms of behavioural focus, 10 studies focused on both healthy eating and physical activity, seven focused on multiple behaviours (e.g., healthy eating, physical activity, stress management, sleep, etc.), three focused on self-weighing, three focused on physical activity only, and one focused on healthy eating only (refer to Table 1). Overall, 12 out of the 24 studies did not report any significant weight-related changes compared with control groups, 8 reported positive weight-related outcomes (e.g., prevention of weight gain and/or reversal of small gains), and four reported mixed effects (see Table 1).

Extent of theory use

Out of the 24 included studies in this review, the mean total use of theory score was 6/23 (SD 5; Min. = 0, Max. = 17); 17 studies were classified as having weak application of theory, five as moderate, and two as strong. Total use of theory scores suggests studies are not rigorously applying theory to intervention design, implementation, and evaluation, and/or are failing to explicitly report theory use in sufficient detail. The following section describes the results of the comprehensive theory use assessment in terms of (i) mentioning of theory; (ii) application of theory; (iii) testing of theory; and lastly (iv) building and refining of theory. Table 2 provides a high-level summary of the TCS results.

Mention of theory (Items 1–2)

Most studies (N = 18) mentioned a theory or model (Item 1, Table 2), however, only nine studies (Item 2, Table 2) referred to the referenced theory as a predictor of behaviour and presented evidence of the relationship between the theoretical constructs in the theoretical model cited and the behaviour of interest (see Table 3). Of the studies referencing a theory (or theories), *Social Cognitive Theory* (SCT) was most mentioned (N = 10), followed by the *Transtheoretical Model* (TTM) (N = 6), the *Theory of Planned Behaviour/Reasoned Action* (TRA/TPB) (N = 2), and *Self-Determination Theory* (SDT) (N = 2). References were also made to *Self-affirmation Theory*, *Model of Action Phases*, *Stealth Model*, *Rational Model*, *Control Theory*, the *Health Belief Model*, *Social Learning Theory*, *Social Network Theory (SNT)*, and *Ecological Theory*. Table 3 provides a summary of the theories mentioned, along with the location and evidence provided for the nine studies referring to (or explaining) the chosen theory as a predictor of the target behaviour(s) (Item 2, Table 2).

Application of theory (Items 3–11)

Of those studies mentioning a theory, 50% (N = 9) were reportedly based on a single theory (Item 3, Table 2) such as SCT or SDT, while the other 50% (N = 9) were reportedly based on a combination of predictors from multiple theories. For example, the CHOICES conceptual model was informed by ecological theories of health behaviour, SCT, and SNT. No study reported using theory/predictors to select recipients for the intervention (Item 4, Table 2). That is, no study screened/selected participants based on achieving a particular score/level on a theory-relevant construct/predictor (Michie &

Table 1. Summary of individual study characteristics.

Author/year	Country	Study type	Sample	Retention	Outcome	Behavioural focus	eHealth component (s)	Duration	Outcome effect	EPHPP rating	TCS rating
Levitsky, Garay, Nausbaum, Neighbors, and DellaValle (2006)	USA	CCT	N = 32	81%	Weight management	Self-weighing	Email	12 wks.	+	Weak	Weak
Levitsky et al. (2006)	USA	CCT	N = 41	78%	Weight management	Self-weighing	Email	12 wks.	+	Weak	Weak
Gow, Trace, and Mazzeo (2010)	USA	RCT	N = 159	69%[a]	Weight management	Diet & PA	eLearning website Email	6 wks.	+/-	Weak	Weak
Wadsworth and Hallam (2010)	USA	CCT	N = 91	78%	Weight management	PA	eLearning website Email	6 wks.	NIL	Weak	Strong
Dennis, Potter, Estabrooks, and Davy (2012)	USA	CCT	N = 45	87%	Weight management	Diet & PA	eLearning website	14 wks.	+/-	Weak	Moderate
Greene et al. (2012)	USA	CCT	N = 1689	67%	Weight management	Diet & PA	eLearning website	10 wks.	NIL	Weak	Weak
LaChausse (2012)	USA	CCT	N = 320	98%	Weight management	Diet & PA	eLearning website	12 wks.	NIL	Weak	Weak
Harvey-Berino, Pope, Gold, Leonard, and Belliveau (2012)	USA	Cohort study	N = 336	98%	Weight management	Diet & PA	eLearning website Online synchronous chat	12 wks.	+	Weak	Weak
Kattelmann et al. (2014)	USA	CCT	N = 1639	59%	Weight management	Diet, PA & stress	eLearning website Email	10 wks.	NIL	Weak	Moderate
Muñoz et al. (2014)	USA	RCT	N = 201	57%	Weight management	PA	Wearable tracking device Text messages	16 wks.	NIL	Weak	Weak
Hebden et al. (2014)	AUS	RCT	N = 51	90%	Weight management	Diet & PA	Text messages Emails Smartphone application Internet forum	12 wks.	NIL	Moderate	Weak
Epton et al. (2014)	UK	RCT	N = 1445	63%	Weight management	Diet, PA, responsible drinking & not smoking	eLearning website Smartphone application	12 mo.	NIL	Weak	Moderate
Bertz, Pacanowski, and Levitsky (2015)	USA	CCT	N = 167	78%	Weight management	Self-weighing	Email Wi-Fi scale	12 mo.	+	Weak	Weak
Cameron et al. (2015)	UK	RCT	N = 2621	42%	Weight management	Diet, PA, responsible drinking & not smoking	eLearning website	6 mo.	NIL	Weak	Moderate
Nikolaou, Hankey, and Lean (2015)	USA	RCT	N = 20975	83%	Weight management	Diet & PA	eLearning website Electronic forums/ mail	19 wks.	+	Weak	Weak

(*Continued*)

Table 1. Continued.

Author/year	Country	Study type	Sample	Retention	Outcome	Behavioural focus	eHealth component (s)	Duration	Outcome effect	EPHPP rating	TCS rating
Allman-Farinelli et al. (2016)	AUS	CCT	N = 250	81%	Weight management	Diet & PA	Telephone counselling Text messages Email Website Smartphone applications	12 wks.	+	Moderate	Weak
Schweitzer, Ross, Klein, Lei, and Mackey (2016)	USA	CCT	N = 148	72%	Weight management	Diet & PA	eLearning website Email	24 wks.	NIL	Weak	Weak
Wing et al. (2016)	USA	CCT	N = 599	87%	Weight management	Diet, PA & self-weighing	Website Email	24 mo.	+	Moderate	Moderate
Kerr et al. (2016)	AUS	RCT	N = 247	89%	Weight management	Diet	Text messages	6 mo.	+/-	Weak	Weak
West et al. (2016)	USA	CCT	N = 58	97%	Weight management	Diet, PA & self-weighing	eNewsletter SNS Wi-Fi scale Wearable tracking device	9 wks.	NIL	Weak	Weak
Lytle et al. (2017)	USA	CCT	N = 441	83%	Weight management	Diet, PA, sleep & stress	eLearning website SNS	24 mo.	+/-	Weak	Weak
Ashton et al. (2017)	AUS	RCT	N = 50	94%	Weight management	Stress, nutrition, alcohol & PA	Website Wearable tracking device Application SNS	3 mo.	+	Moderate	Weak
Chung, Skinner, Hasty, and Perrin (2017)	USA	Cohort[b]	N = 12	N/G	Weight management	Diet & PA	Wearable tracking device Application SNS	2 mo.	NIL	Weak	Weak
Simons et al. (2018)	Belgium	RCT	N = 130	92%	Weight management	PA	Smartphone application Wearable tracking device	9 wks.	NIL	Moderate	Strong

Weight related outcomes: + = positive effect; - = negative effect; +/- = mixed effect; NIL = no effect.
[a]Analyses of follow-up data were not conducted owing to high attrition (89%).
[b]Single arm intervention – owing to the small sample size, tests of difference between the groups were not examined.
Cut offs for TCS ratings – weak = 0–7; moderate = 8–15; and strong = 16–23.
Note: further detail on intervention components, outcomes, and methodological quality assessments (EPHPP QA Tool) is reported elsewhere (Willmott et al., 2019).
Abbreviations: CCT (controlled clinical trial); Effective Public Health Practice Project (EPHPP); PA (physical activity), RCT (randomised controlled trial); SMS (short message service); SNS (Social Network Sites); TCS (Theory Coding Scheme).

Table 2. Theory coding results.

	TCS item no.[a]																							
Study	1	2	3	4	5	6	7	8	9	10	11	12a	12b	13a	13b	13c	13d	13e	13f	14	15	16	17	Score
Levitsky et al. (2006)	×	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Levitsky et al. (2006)	×	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Gow et al. (2010)	✓	×	✓	×	×	×	×	×	×	×	×	×	×	–	–	–	–	–	–	–	×	–	–	2
Wadsworth and Hallam (2010)	✓	✓	✓	×	✓	×	×	✓	✓	×	✓	✓	✓	×	✓	✓	–	✓	✓	✓	✓	✓	×	16
Dennis et al. (2012)	✓	×	✓	×	✓	×	✓	+	×	✓	+	✓	✓	×	✓	×	✓	✓	✓	×	×	×	×	13
Greene et al. (2012)	✓	×	×	×	✓	×	×	✓	✓	×	✓	×	×	–	–	–	–	–	–	–	×	–	–	5
LaChausse (2012)	×	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Harvey-Berino et al. (2012)	✓	×	✓	×	✓	✓	×	✓	✓	×	×	×	×	–	–	–	–	–	–	–	×	–	–	6
Kattelmann et al. (2014)	✓	×	✓	×	✓	✓	×	✓	×	×	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	×	×	12
Muñoz et al. (2014)	×	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Hebden et al. (2014)	✓	✓	✓	×	✓	×	×	✓	×	×	✓	×	×	–	–	–	–	–	–	–	×	–	–	6
Epton et al. (2014)	✓	✓	×	×	✓	×	×	✓	×	×	✓	✓	✓	×	×	×	×	✓	✓	✓[b]	✓	×	×	11
Bertz et al. (2015)	×	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Cameron et al. (2015)	✓	✓	×	×	✓	×	×	✓	×	×	✓	✓	✓	×	×	×	×	✓	✓	✓[b]	✓	×	×	11
Nikolaou et al. (2015)	✓	×	×	×	✓	×	×	×	×	×	×	×	×	–	–	–	–	–	–	–	✓	–	–	3
Allman-Farinelli et al. (2016)	✓	✓	×	×	✓	✓	×	✓	✓	×	✓	×	×	–	–	–	–	–	–	–	×	–	–	7
Schweitzer et al. (2016)	✓	×	×	×	✓	×	×	✓	✓	×	✓	×	×	–	–	–	–	–	–	–	×	–	–	5
Wing et al. (2016)	✓	✓	✓	×	✓	×	✓	+	×	✓	+	×	×	–	–	–	–	–	–	–	×	–	–	8
Kerr et al. (2016)	✓	×	✓	×	✓	×	×	✓	×	×	✓	×	×	–	–	–	–	–	–	–	×	–	–	5
West et al. (2016)	✓	✓	×	×	✓	×	×	✓	✓	×	✓	×	×	–	–	–	–	–	–	–	×	–	–	6
Lytle et al. (2017)	✓	✓	×	×	✓	×	×	✓	✓	×	✓	×	×	–	–	–	–	–	–	–	×	–	–	6
Ashton et al. (2017)	✓	×	×	×	✓	×	✓	+	✓	✓	+	×	×	–	–	–	–	–	–	–	×	–	–	7
Chung et al. (2017)	×	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Simons et al. (2018)	✓	✓	×	×	✓	✓	✓	+	✓	✓	+	✓	✓	✓	+	✓	+	✓	✓	×	×	×	×	17

✓ = Yes; × = No; – = unable/inappropriate to score; + = scored ALL for previous item.
[a]Refer to Supporting Information 1 for TCS item descriptions.
[b]Intervention had a mixed effect on social cognitive (TPB) variables.

Table 3. Theories mentioned.

Study	Theory/model mentioned	Location and evidence
Levitsky et al. (2006)	N/G	–
Levitsky et al. (2006)	N/G	–
Gow et al. (2010)	Social Cognitive Theory	N/G
Wadsworth and Hallam (2010)	Social Cognitive Theory	p. 61 '*[SCT] provides a comprehensive theoretical framework for understanding exercise behaviour as it relates to these determinants and can be adapted to a website delivery.*'
Dennis et al. (2012)	Social Cognitive Theory	N/G
Greene et al. (2012)	Social Cognitive Theory; Transtheoretical Model	N/G
LaChausse (2012)	N/G	–
Harvey-Berino et al. (2012)	Social Cognitive Theory	N/G
Kattelmann et al. (2014)	Transtheoretical Model	N/G
Muñoz et al. (2014)	N/G	–
Hebden et al. (2014)	Transtheoretical Model	p. 324 '*Text messages were tailored to the processes of change identified in the Transtheoretical Model, and moved from addressing cognitive to behavioural processes to facilitate movement through stages of change.*'
Epton et al. (2014)	Self-Affirmation Theory; Theory of Planned Behaviour; Model of Action Phases	p. 2 '*… included three theory-based techniques to promote health behaviour change … self-affirmation manipulation was included to reduce defensive processing of health messages … theory-based (TPB) messages were designed to increase motivation to adopt healthy behaviours … and participants were prompted to form implementation intentions to help them to translate their intentions to change into behaviour.*'
Bertz et al. (2015)	N/G	–
Cameron et al. (2015)	Self-affirmation Theory; Theory of Planned Behaviour; Model of Action Phases	p. 2 '*… used three theory-based techniques to target the four health behaviours … a self-affirmation manipulation was used to reduce defensive processing of health messages … theory-based (TPB) messages were developed to target the key beliefs underlying the four health behaviours … implementation intention tasks were included to help translate good intentions into healthy behaviour.*'
Nikolaou et al. (2015)	Stealth Model; Rational Model	N/G
Allman-Farinelli et al. (2016)	Control Theory; Transtheoretical Model	[Methods] '*Goal setting and review were included in the coaching and modelled on Control Theory with their intake (input function) compared with recommended (comparator) … ' AND 'For each of the 4 key behaviours addressed, a staging algorithm based on the Transtheoretical Model was completed as part of the baseline survey by all participants [20,25] … Messages were stratified by sex and whether the participant was in pre-contemplation, contemplation, preparation, action, or maintenance stages for each of the 4 behaviours.*'
Schweitzer et al. (2016)	Health Belief Model; Theory of Reasoned Action; Social Cognitive Theory; Social Learning Theory; Transtheoretical Model[a]	N/G
Wing et al. (2016)	Control Theory[b]	p. 756 '*Both interventions were based on a self-regulation model shown previously to be effective in preventing weight regain [15]; both emphasised frequent self-weighing and changes in eating and activity to prevent weight gain.*'

(*Continued*)

Table 3. Continued.

Study	Theory/model mentioned	Location and evidence
Kerr et al. (2016)	Self-Determination Theory	N/G
West et al. (2016)	Social Cognitive Theory	
Lytle et al. (2017)	Ecological Theory; Social Cognitive Theory; Social Network Theory[c]	p. 70 '*The CHOICES conceptual model is informed by ecological theories of health behaviour, Social Cognitive Theory, and Social Network Theory. The model posits that weight-related factors are most proximately influenced by mutable behaviours including energy intake, energy expenditure, and other health-related behaviours. These behaviours occur within the context of individual factors, the home environment, and the social environment.*'
Ashton et al. (2017)	Social Cognitive Theory/Self-Determination Theory	N/G
Chung et al. (2017)	N/G	–
Simons et al. (2018)	Attitude–Social Influence–Self-Efficacy Model; Self-Determination Theory	[Feasibility Paper – Methods] '*The content of the app was developed to incorporate an autonomy-supportive communication style, based on the Self-Determination Theory. Self-Determination Theory suggests that the content of goals (ie, intrinsic vs extrinsic) and the way goal contents are communicated (ie, autonomy-supportive vs controlling) explain variance in people's motivation and performance.*'

N/G = none given.
[a]Based on a previous intervention (ALIVE) which was grounded in the several theories listed.
[b]Authors reportedly adopt Carver and Scheier's (1982) Control Theory approach.
[c]Based on several theories and formative research the authors created their own conceptual framework.

Prestwich, 2010). Seventeen studies used theoretical predictors to select/develop intervention techniques (Item 5, Table 2). Four studies reported using theory/predictors to tailor intervention techniques to recipients; that is, the intervention differed for different sub-groups that varied on a psychological construct or predictor at baseline (Item 6, Table 2). For example, in the *TXT2BFiT* intervention (Allman-Farinelli et al., 2016) survey data collected from participants at baseline were used to create a staging algorithm based on the TTM to generate a personalised set of text messages tailored to whether the participant was in the pre-contemplation, contemplation, preparation, action, or maintenance stage of change. More cognitive messages were sent if a participant was in the early stages of change (pre-contemplation, contemplation, and preparation stages) and more behavioural messages were sent if the participant was in the later stages of change (action or maintenance stages).

In terms of linking intervention techniques with theoretical constructs, only four studies explicitly linked all intervention techniques to at least one theory-relevant construct/predictor (Item 7, Table 2); with a further 12 (Item 8, Table 2) explicitly linking at least one, but not all, of the intervention techniques to at least one theory-relevant construct/predictor. Conversely, nine studies (Item 9, Table 2) linked a group or cluster of techniques to a group or cluster of constructs/predictors. Only four studies explicitly linked all theory-relevant constructs/predictors to at least one intervention technique (Item 10, Table 2), with a further 11 (Item 11, Table 2) explicitly linking at least one, but not all, theory-relevant constructs/predictors to at least one intervention technique. For example, many interventions that were based on SCT focused their intervention techniques on developing self-regulation behaviours (via self-monitoring and goal setting) but neglected other key concepts such as observational learning (i.e., social influences or reinforcements), outcome expectations (i.e., anticipated consequences of performing a behaviour), and self-efficacy (i.e., individual perceptions of confidence to successfully perform a behaviour). Therefore, these studies only partially utilised the full predictive (or explanatory) power of the stated theoretical model.

Testing of theory (Items 12–14)

Out of those studies reportedly based on a theory, only six studies measured theory-relevant constructs pre and postintervention (Items 12a and 12b, Table 2), and only three (Items 13a–13d) reported the reliability and/or validity of the psychometric scales used to measure theory-relevant constructs/predictors. In contrast, measures of behaviour generally had some evidence of their reliability and/or had been previously validated in the studies reporting pre and postintervention measurement of theory-relevant constructs (Items 13e and 13f, Table 2). Among the six studies measuring theory-relevant constructs pre and postintervention, four reported that the intervention led to a significant change in at least one theory-relevant predictor (construct) in favour of the intervention (Item 14, Table 2). For example, Wadsworth and Hallam's (2010) intervention focused on six self-regulation skills (self-monitoring, goal setting, social support, reinforcements, time management, and relapse) and reported a successful increase ($P = .002$) in participant's self-regulation skills postintervention.

Building and refining of theory (Items 15–17)

Out of those studies reporting a theory (or a combination of theories), five discussed study findings in relation to the theory mentioned (Item 15, Table 2), and one provided appropriate support for the theory (Item 16, Table 2). That is, theory-relevant constructs were reported to significantly mediate the relationship between the intervention and observed behavioural change. Namely, Wadsworth and Hallam (2010) reported a significant meditation between self-regulation and frequency of self-reported moderate physical activity postintervention. Conversely, an appropriate refutation of the theory would be based on obtaining null effects (i.e., changing behaviour without changing theory-relevant constructs). No study reported using intervention results to build and/or refine the theory upon which the intervention was based, or formulate suggestions for future refinement (Item 17, Table 2).

Post-hoc tests

Following TCS coding, the authors ran a series of non-parametric post-hoc tests to examine any potential associations between theory use and weight-related outcomes in included interventions. Pearson chi-square and Fisher's exact tests were performed in SPSS v25 with two binary variables: TCS item (present = yes/no) and outcome (effect = yes/no). Pearson chi-square tests are used to compare the distribution of a categorical variable in a sample or a group with the distribution of another to establish whether the categorically coded variables are statistically independent or associated with each other (Gravetter & Wallnau, 2016; Kim, 2017). While the chi-square test relies on an approximation, Fisher's exact test is an *exact* test and is therefore considered to be a more appropriate measure of independency when working with small samples (e.g., more than 20% of cells have expected frequencies < 5) (Kim, 2017). Crammer's V was used to gauge the strength of the significant associations identified (Gravetter & Wallnau, 2016).

Statistically significant ($p < .05$) associations were identified between TCS Items 11, 12a and 12b, and the binary outcome variable. Note: Items 14–23 did not have sufficient numbers (cell counts) to run chi-square tests. The association between Item 11, 'at least one, but not all, of the theory-relevant constructs/predictors are explicitly linked to at least one intervention technique,' and the binary outcome was significant; with a large effect size (χ^2 [1, N = 24], 5.657, $p = .043$, ϕ_c .561). Interestingly, the association between Item 8, 'at least one, but not all, of the intervention techniques are explicitly linked to at least one theory-relevant construct/predictor,' and the binary outcome was not significant (χ^2 [1, N = 24], 3.536, $p = 0.137$, ϕ_c .443). The association between Item 12a, 'at least one construct of theory (or predictor) mentioned in relation to the intervention is measured postintervention,' and the binary outcome was significant; with a large effect size (χ^2 [1, N = 24], 5.727, $p = .038$, ϕ_c .564). Similarly, the association between Item 12b, 'at least one construct of theory (or predictor) mentioned

in relation to the intervention is measured pre and postintervention,' and the binary outcome was significant; with a large effect size (χ^2 [1, N = 24], 5.727, $p = .038$, ϕ_c .564). All other associations were not significant ($p > 0.05$). The results of these tests must be treated with caution given overall levels of theory use were weak.

Discussion

The application of theory is advocated by many scholars within the behavioural and social sciences as an integral step in the design, implementation, and evaluation of behaviour change interventions (Craig et al., 2008; Davis et al., 2015; Glanz & Bishop, 2010; Prestwich et al., 2015), including technology-supported (i.e., eHealth) interventions (Webb et al., 2010). Findings from this review reveal that while the majority of eHealth weight management interventions targeting young adults (aged 18–35 years) mention theory (or a combination of theories), very few provide evidence to support the relationship between theoretical constructs and the target behaviour (e.g., stress, diet, PA, smoking, alcohol use), or desired outcome (weight management). Furthermore, many studies do not explicitly link theory to behaviour (Michie & Prestwich, 2010) and/or outcomes. In the absence of causal links, we cannot determine which constructs elicit (or not) the desired change in the focal behaviour(s) (Hardeman et al., 2005) and/or other desired outcomes.

A theory should be selected to inform intervention design because it is suited to the particular characteristics of the target behaviour, context, and population, not because it is the most commonly used or most 'popular' theory within the published literature (Davis et al., 2015). Moreover, changing behaviour requires a specific and concrete definition of the target behaviour (Michie & Johnston, 2004) *and* the final desired outcome. In the present review, only nine out of the 24 studies mentioned a targeted theoretical construct(s) as a predictor of behaviour. One explanation for this may be that little consideration was given to explicitly defining the target behaviour(s) pre intervention, or another may be that the intervention was actually targeting multiple behaviours (i.e., a complex intervention) and 'specific and concrete' definitions for each individual behaviour were subsequently overlooked. Indeed, 17 out of the 24 studies included in the review targeted multiple behaviours (e.g., diet, PA, sleep, stress, smoking, alcohol, etc.).

Selected theories (SCT, SDT, and TRA/TPB) were dominant in the review, which is consistent with other review findings (Davis et al., 2015; Luca & Suggs, 2013; Painter et al., 2008; Truong, 2014). Although these theories have been empirically proven to explain or predict a range of behaviours, there is a risk that with such popularity researchers may 'habituate to the perspective afforded by the theory in the way that one can forget that one is wearing glasses' (Rothman, 2009, p. 150S). For example, many of these theories centre research attention on the individual determinants of (behaviour) change, thereby failing to account for the wider behavioural influences originating from outside the individual such as the social and physical environments (Brennan, Previte, & Fry, 2016; Davis et al., 2015; Glanz & Bishop, 2010). An over reliance on dominant theories without direct empirical tests or questioning of underlying assumptions (Noar & Zimmerman, 2005), limits progress in the field (Rothman, 2004; Weinstein & Rothman, 2005).

Review findings also highlight the lack of rigorous application of theory to intervention design, implementation, and evaluation. In cases where an intervention was reportedly based on an explicit theory (e.g., SCT or SDT), the theoretical model was generally used sub-optimally; with many studies not explicitly linking all theoretical constructs with BCTs and vice versa. For instance, only one theoretical construct (e.g., self-regulation) in the model was targeted by an appropriate BCT (e.g., self-monitoring or goal setting). Theory should provide a means for selecting appropriate BCTs and ensuring these techniques are linked to the relevant theoretical constructs known to influence the behaviour of interest (Michie et al., 2008). Understanding the links between BCTs and relevant mechanisms of action (i.e., theoretical constructs representing the processes through which they affect behaviour) helps inform the systematic development of behaviour change interventions (Michie, Carey, et al., 2017). The authors of the *HEYMAN* intervention (Ashton, Morgan, Hutchesson, Rollo, & Collins, 2017)

provide a good example of how theoretical constructs can be linked with the BCTs employed in the intervention, and importantly, how this process can be explicitly reported within an evaluation paper (e.g., via a supplementary table).

Theory was not used to select recipients for the interventions included this review. According to the TCS framework intervention designers should survey a sample of the target population based on a set of key psychological constructs (e.g., motivation, outcome expectations, self-efficacy and/or self-regulation) prior to delivery and then use the pre-determined scores based on the selected psychological construct(s) measured to select participants whom are most likely to benefit from the intervention (e.g., participants with low levels of motivation or self-efficacy). Only three studies reported using theory to tailor the intervention to different subgroups that varied on the theoretical construct of interest measured at baseline. Tailoring has been shown to enhance the effectiveness of behaviour change interventions, including eHealth interventions (Lustria, Cortese, Noar, & Glueckauf, 2009; Noar & Zimmerman, 2005); and theory provides a guiding framework that may be applied to the tailoring process (Noar & Zimmerman, 2005). Using theory to inform the refinement and/or tailoring of an intervention can guide decisions on how to prioritise resources, and in so doing, ensures they are efficiently distributed (Rothman, 2009).

This review highlights a distinct lack of studies testing theory, with a limited number of studies measuring theoretical constructs pre and postintervention. Without appropriate theory testing, researchers are unable to isolate the underlying mechanisms of action, and in turn, identify which components of the intervention are driving observed outcomes (Michie & Abraham, 2004; Rothman, 2009). Moreover, in the absence of appropriate theory testing, theories are unable to be refined to enhance intervention effectiveness over time (Davis et al., 2015). Collecting empirical data within a theoretical framework permits the accumulation of evidence across different contexts, populations, and behaviours (Michie & Prestwich, 2010). eHealth-based interventions provide vast potential for testing and advancing behaviour change theories, generating large amounts of ecologically valid, real-time, and objective data (Michie, Yardley, et al., 2017).

Implications for research practice

While some interventions incorporated elements from a referenced theory, it was rare that all theoretical constructs within a particular theory were targeted by the intervention; and that valid measures of theoretical constructs were measured and tested pre and postintervention delivery. Intervention designers and evaluators need to improve theory reporting and application. Methods such as intervention mapping may assist (Eldredge et al., 2016; Kok et al., 2016) and ontologies that guide the specification of relationships between BCTs, mechanisms of action, modes of delivery, populations, settings, and types of behaviour are available (Michie, Carey, et al., 2017). Moving forward explicit and detailed reporting of theory use is recommended and called for. High levels of theory application and reporting enables empirical assessment of the utility of theories, facilitates the refinement of theory, and advances the cumulative knowledge base (Michie & Johnston, 2012; Michie & Prestwich, 2010).

In the same way tools such as the *Consolidated Standards for Reporting Trials* and the *Transparent Reporting of Evaluations with Non-Randomised Designs* promote transparency in the reporting of a trial's design, conduct, analysis and interpretation, the TCS can be used as a checklist by researchers when reporting how theory was used. Improved reporting of theory use will clarify how and where theory has been applied (or not) and will permit an evidence base to be accumulated. We recommend that theory application be reported to promote transparency and enable critical appraisal.

Strengths and limitations

This study assesses and quantifies the extent that theory use is reported in eHealth weight management interventions targeting young adults. Conducted in accordance with PRISMA guidelines, with a

well-defined set of research questions, this study provides a transparent, reproducible, and updatable review. The method of theory assessment was detailed, objective and reliable, permitting omissions in theory application and reporting to be identified. Moreover, papers with strong levels of reported theory use (e.g., Ashton et al., 2017 and Simons et al., 2018) were identified and these can serve as guides for other researchers to improve levels of theory application and reporting.

Furthermore, review findings highlight the importance (and urgency) of moving current practice away from the reporting of intervention effectiveness as one complete and cohesive entity, to unpacking the black box, and clearly reporting how and when theory has been applied. Explicit reporting of how and when theory is applied will permit identification of the underlying mechanisms of action and enable their subsequent effects to be confirmed via meta-analytic studies. Over time this will advance our understanding of which theories work, for whom, how, why, and when; and inform future prescriptions of how best to apply theory in order to enhance intervention outcomes.

Several limitations, many of which represent opportunities for future research, are acknowledged. First, the search parameters employed were specific to review objectives and consequently the number of studies was limited to eHealth weight management interventions targeting young adults. Future research in other behavioural change contexts is recommended to extend our understanding of reported theory use and alternate search strategies with broadened search terms are recommended. Conversely, behavioural outcomes identified in this study varied greatly; therefore, future reviews may opt to focus on one specific behavioural driver of weight management (e.g., physical activity or healthy eating) to permit direct comparisons across studies.

Second, Items 14 and 16 did not account for study-level variations, namely, sample size. As a consequence, studies reporting significant changes in theory-relevant predictors in favour of the intervention may inadvertently reject a true null hypothesis (Type I error) and similarly studies reporting null effects may fail to reject a false null hypothesis (Type II error) owing to a small sample size. A meta-analytic approach can assist. Ideally, meta-regression requires a sufficient level of power to reliably detect effect size. Research suggests that more than 200 studies are required for 80% power to detect modest associations in meta-regressions (Hempel et al., 2013). It is our hope that in time the scientific research community will be able to empirically test the theory-effectiveness hypothesis with sufficient power to better understand how and when theory should be applied to enhance intervention outcomes. However, in the absence of high levels of theory application and reporting across multiple studies, any attempts to test the theory-effectiveness hypothesis are premature. With only 24 eligible studies retrieved from our systematic search, and overall low levels of reported theory use, more work is needed before attempts to test the theory-effectiveness hypothesis can be undertaken in this context; and before we can begin building an accurate and reliable evidence base that can guide weight management efforts tailored to young adults.

Third, composite scores calculated for total reported theory use in this study are a crude measure giving all items in the TCS equal weight. While this approach can assess and quantify the extent of reported theory use, future research should be directed towards developing a scoring scheme that provides weightings based upon relative importance of TCS items. Measures of relativity could be obtained from meta-regressions examining the association between TCS items and intervention effectiveness. Lastly, in this study we could only code for reported theory use. We do note that a lack of reporting of theory use does not necessarily equate to a lack of theory use. Therefore, failures to clearly report theory use for studies identified in this review could have led to misclassifications and low scoring of included studies.

Conclusions

This study assessed the extent of reported theory use in eHealth weight management interventions targeting young adults using the TCS (Michie & Prestwich, 2010) and examined how theory may be applied to enhance weight-related outcomes in interventions. Guided by the comprehensive TCS,

this review identified *how* theory was applied in intervention development and evaluation. Findings from this review highlight that while most studies mentioned a theory, very few integrated the referenced theory (or theories) throughout *all* intervention stages. Furthermore, no study used intervention results to build and/or refine theory to improve future intervention design and evaluation. Results indicate that weight-related outcomes may be enhanced when at least one or more theoretical constructs are explicitly linked to an intervention technique and when theoretical constructs are included in evaluations. A number of TCS items did not have sufficient numbers to run chi-square tests for association; consequently, our understanding of which components of theory application are (or are not) driving weight-related outcomes in the context of eHealth weight management interventions targeting young adults remains limited. In sum, this review serves as a first attempt to evaluate extent of reported theory use in the context of eHealth weight management interventions targeting young adults, thereby providing a foundation for improving the theoretical base of future interventions in this context.

Disclosure statement

No potential conflict of interest was reported by the authors.

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