

# The transtheoretical model as applied to dietary behaviour and outcomes

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The transtheoretical model (TTM) is a behavioural theory that describes behaviour change as occurring in five stages, ranging from precontemplation to maintenance. The purpose of the present paper is to review and synthesise the literature published since 1999 on applications of the TTM to dietary behaviour so that the evidence for the use of assessment tools and interventions based on this model might be evaluated. Six databases were identified and searched using combinations of key words. Sixty-five original, peer-reviewed studies were identified and summarised in one of three tables using the following categories: population ( $n$  21), intervention ( $n$  25) and validation ( $n$  19). Internal validity ratings were given to each intervention, and the body of intervention studies as a whole was rated. The evidence for using stage-based interventions is rated as suggestive in the areas of fruit and vegetable consumption and dietary fat reduction. Valid and reliable staging algorithms are available for fruit and vegetable consumption and dietary fat intake, and are being developed for other dietary behaviours. Few assessment tools have been developed for other TTM constructs. Given the popularity of TTM-based assessments and interventions, more research is warranted to identify valid and reliable assessment tools and effective interventions. While the evidence supports the validity of the TTM to describe populations and to form interventions, evidence of the effectiveness of TTM-based interventions is not conclusive.

## Transtheoretical model: Dietary behaviour: Nutrition behaviour: Weight management

Introduced in 1981<sup>1</sup>, the transtheoretical model (TTM) has become one of the most popular and enduring theories in the field of health promotion and health education. The central concept within the theory is that behaviour change is most likely to happen when individuals engage in the right activities, or processes of change, at the right time, or stage. According to the theory, individuals are most likely to experience success in changing behaviour when they engage in strategies that are appropriate to their stage of readiness to make the change. It has been applied to diverse health behaviours, including the cessation of addictions, participation in cancer screening, and the adoption of positive lifestyle behaviours<sup>2</sup>.

### Overview of the transtheoretical model

Many published papers provide a detailed description of the TTM, therefore only a brief overview of the model is offered here. The TTM is comprised of the following constructs: stages of change, processes of change, decisional balance,

self-efficacy, and temptation. Stage of change refers to the degree of readiness an individual exhibits toward adopting healthful dietary behaviours. A generalised version of the five stages has been identified and used to classify behaviour<sup>3</sup>. The stages are: (1) precontemplation, in which an individual may or may not be aware that a behaviour change is warranted and has no intention of changing within the next 6 months; (2) contemplation, in which an individual is aware that a change is warranted and is intending to change within the next 6 months; (3) preparation, in which an individual is planning to change within the next 4 weeks; (4) action, which begins the day an individual makes the behaviour change and lasts until they have maintained the change for 6 months; (5) maintenance, which begins after an individual has successfully maintained a behaviour change for 6 months. For many behaviours to which the TTM has been applied, staging algorithms specific to the behaviour have been developed. Nutrition and dietary behaviours are no exception, and several versions of the staging algorithm have been identified in a recent literature review<sup>4</sup>.

**Abbreviation:** TTM, transtheoretical model.

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A second construct of the TTM is the processes of change<sup>5</sup>. The processes of change are ten strategies that individuals use to facilitate forward movement through the stages. The idea is that one must use the appropriate processes for each stage to be most effective in achieving maintenance of the new behaviour. According to the TTM, the five cognitive processes (dramatic relief, consciousness raising, self-re-evaluation, environmental re-evaluation, and social liberation) are most effective for those in precontemplation and contemplation. The five behavioural processes (helping relationships, self-liberation, counter-conditioning, stimulus control, and reinforcement management) are most effective for those in preparation, action or maintenance.

Decisional balance describes the balance of the pros and cons of changing a behaviour<sup>5</sup>. Based on the work of Janis & Mann<sup>6</sup>, decisional balance assumes that an individual will identify both reasons for changing a behaviour and reasons for not changing. Behaviour change is influenced by the relative weight of the perceived pros *v.* cons of change. For most behaviours, the pros of changing outweigh the cons of changing as an individual moves from contemplation into preparation. For those in precontemplation, the cons of changing usually outweigh the pros.

Developed by Bandura<sup>7</sup>, self-efficacy has been adopted as a TTM construct<sup>8</sup>. Self-efficacy is defined as the confidence one has in performing a behaviour. In dietary behaviour research, it could be assessed by a series of questions designed to determine how confident an individual is that he or she could successfully perform a diet-related behaviour if he or she wanted to.

Temptation is a TTM construct<sup>9</sup> that has been used in some, but not all, health behaviours to which the TTM has been applied. It is a measure of the degree to which an individual feels tempted to lapse from the new healthy behaviour. It has been applied to exercise and smoking behaviour<sup>10,11</sup> and may be applicable to dietary behaviour, although published studies have not attempted to measure this.

### Previous literature review of the transtheoretical model as applied to dietary behaviour

In 1999, Horwath<sup>4</sup> conducted a literature review of the TTM as applied to dietary behaviour that included thirty-four studies. Twenty-five studies tested the validity of the TTM as applied to dietary behaviour, five used the TTM to describe the dietary behaviour of populations, three used TTM constructs to assess a dietary intervention and one assessed a TTM-based dietary intervention (i.e. stage-matched intervention). Horwath<sup>4</sup> made six significant observations at the conclusion of her review: (1) there were insufficient TTM-based interventions or prospective studies to determine whether these types of interventions were warranted; (2) most studies focused solely on the stage-of-change construct and excluded the equally important construct of processes of change; (3) nutrient-based dietary intake was frequently misclassified by the staging algorithms used; (4) many studies focused on nutrient-based dietary intake rather than more easily measured food-based eating behaviours; (5) there was no agreement as to how to measure stage for dietary behaviour; (6) the

constructs decisional balance, processes of change, and self-efficacy appeared to be reliable in describing each stage of dietary behaviour.

### Purpose of the present literature review

Since the publication of Horwath's literature review<sup>4</sup>, the body of nutrition-based TTM literature has more than doubled. A review of the more recent studies is warranted to determine if Horwath's original six conclusions still apply and if new evidence exists to support the application of the TTM to dietary behaviour. The present paper is fifth in a series of literature reviews of the TTM as applied to select health behaviours (including substance abuse, exercise, tobacco and cancer screening) using a systematic review process<sup>10–13</sup>. The purpose of the present paper is to systematically review the studies of the TTM as applied to dietary behaviour that have been published since the 1999 Horwath review<sup>4</sup> to answer the following questions:

- (1) How has the TTM been used to describe the dietary behaviours of populations and their intentions with respect to following dietary recommendations? Have researchers been able to accurately classify participants according to stage for various dietary behaviour changes?
- (2) What is the evidence for using stage-based interventions with populations to achieve positive nutritional goals and behaviours?
- (3) Do valid and reliable measures exist to describe dietary behaviours using the TTM constructs other than stage of change?

### Identification of studies to be included

Using a system that has been developed and applied to published literature reviews of the TTM as applied to tobacco use<sup>10</sup>, cancer screening behaviour<sup>12</sup> and exercise<sup>11</sup>, the present body of literature on dietary behaviour was organised and evaluated. A database search was conducted using the following databases: CINAHL, Medline, Academic Search Premier, EMBASE, PsychInfo and ERIC. Combinations of the following keywords were used: transtheoretical model, stages of change, nutrition, diet, dietary behaviour, weight management, obesity and diabetes. Only original research studies published in peer-reviewed journals were included. All of the studies identified were in English, although this language restriction was not specified in the search. (We recognise that there is a growing body of non-English studies of the TTM, and that it is likely that some of these address dietary behaviour.) A total of sixty-five original research studies published between 1999 (the year that the previous literature review ended) and August 2006 were identified.

### Organisation of the literature

Studies were classified as population, intervention or validation based on their study design and purpose. Population studies (*n* 21) were either cross-sectional or longitudinal and sought to describe the dietary behaviour of

populations using TTM constructs. Intervention studies ( $n = 25$ ) featured a dietary behaviour-change programme that was evaluated using TTM constructs and, in some cases, based on the TTM (i.e. a 'stage-matched' intervention). Validation studies ( $n = 19$ ) attempted to test the validity of applying one or more TTM constructs to dietary behaviour. Each category of studies is summarised and presented in a table.

### Analysis of the literature

While the literature review is a qualitative process, we sought to make it as objective as possible to provide a useful and accurate response to the research questions guiding the present review. All studies are rated according to study design using five categories based on established criteria<sup>14</sup>. Experimental studies were clinical, controlled trials with random assignment of participants to control and intervention conditions. Quasi-experimental studies were clinical, controlled trials without random assignment. Non-experimental studies analysed the effectiveness of interventions without the use of a control group, and included cohort and case-control designs. Multiple time series studies included evaluation and comparison of participants in the absence of an intervention, such as correlation and regression analysis. Descriptive studies used cross-sectional survey designs.

The intervention studies are each assigned an internal validity rating, using previously established criteria<sup>14</sup>. Threats to internal validity are defined as a lack of any of the following: initial assembly of comparable groups, maintenance of groups throughout study, small sample size, loss to follow-up analysis or intention-to-treat analysis, evidence of the reliability and validity of measures, a clearly defined intervention, considering all important outcomes, or adjustment for confounding variables. Studies are given a rating of 'good' if they contain no significant threats to internal validity, 'fair' if they contain one threat and 'poor' if they contain two or more threats.

The body of intervention studies, as a whole, is then rated based on how strong the evidence is to support using stage-based dietary interventions, using criteria established by Anderson & O'Donnell<sup>15</sup>. Literature is rated as conclusive if it includes many well-designed clinical controlled trials that demonstrate a cause-and-effect relationship between the intervention and the outcomes. Literature rated as acceptable includes some well-designed clinical controlled trials demonstrating a cause-and-effect relationship between the intervention and outcomes, but more studies supporting this relationship are desired. Literature considered indicative includes many non-experimental studies that suggest a cause-and-effect relationship between the intervention and outcomes; however, there are threats to internal validity with many of the studies. Literature rated as suggestive includes some non-experimental studies that suggest a cause-and-effect relationship between the intervention and outcomes, but the studies are not well designed and may suffer from threats to internal validity. Literature identified as weak does not offer valid evidence for a cause-and-effect relationship between the intervention and outcomes, although experts may believe that a relationship is plausible.

### Summary of the literature

All of the studies included in the present review are summarised in one of three tables. Table 1 includes the twenty-one population studies<sup>16–36</sup>, Table 2 includes the twenty-five intervention studies<sup>37–61</sup> and Table 3 includes the nineteen validation studies<sup>62–80</sup>. A summary of each table is presented in this section.

#### Population studies

A summary of the twenty-one population studies is presented in Table 1. Populations represented included: a variety of low-income, ethnic populations; populations of patients with diabetes or obesity; a representative sample of US adults; one community-based sample of adults; international populations, including Spanish and Australian samples; older populations; cardiac populations. Compared with the study populations included in the review by Horwath<sup>4</sup>, the present group of studies provides more information on low-income populations, which received less representation in the body of literature before 1999. Importantly, the current group of studies includes a variety of specific populations, whereas the Horwath<sup>4</sup> review included many studies using general adult samples from communities and worksites.

When considering the aggregate of data from these studies, the TTM, particularly the stage-of-change construct, was consistent in describing either measured dietary intake or food-related habits and perceptions. All twenty-one studies included measures of the stage-of-change construct as applied to particular dietary behaviours, weight-loss behaviours or nutrient intakes. A minority of studies employed other TTM constructs, such as decisional balance ( $n = 5$ ; study numbers P8, P9, P10, P12 and P16), self-efficacy ( $n = 6$ ; study numbers P8, P10, P11, P16, P18 and P20) or processes of change ( $n = 6$ ; study numbers P4, P7, P8, P10, P15 and P20), limiting the ability to draw conclusions about the utility of these constructs.

The greatest number of studies ( $n = 9$ ; study numbers P2, P3, P4, P5, P8, P13, P17, P18 and P21) included assessments of fruit and vegetable intake. Only two studies focused on the intake of dairy or dairy products (study numbers P9 and P10). Four studies focused on broader eating patterns (study numbers P1, P12, P14 and P15), and two included portion size (study numbers P14 and P21). In relation to specific nutrients, ten studies considered dietary fat intake (study numbers P2, P5, P6, P7, P13, P16, P17, P18, P19 and P21). Finally, seven studies focused on other health-related behaviours (i.e. exercise or physical activity, smoking, alcohol use) and perceptions related to weight loss (study numbers P1, P2, P7, P11, P13, P16 and P21). Studies showed a fairly consistent pattern of increases in fruit, vegetable, or Ca intake, as well as decreases in fat intake or in the percentage of energy from fat across the stages of change, in a variety of populations. Researchers also demonstrated hypothesised relationships between later stages, such as preparation, action, and maintenance, and greater focus on health and health-related behaviours.

The prior literature review<sup>4</sup> noted inconsistency in application of the stages of change, perhaps due to a focus

**Table 1.** Summary of population studies of the transtheoretical model (TTM) as applied to dietary behaviour

Study no. and reference	Research question	Sample characteristics	Study design	Measures	Findings	Implications
P1 Burke <i>et al.</i> (2000) <sup>16</sup>	Is the stage-of-change construct related to physical activity and dietary intake valid among 18-year-old Australian men and women?	Volunteer sample of 583 subjects from a prior study sample (51.6% male; response rate 67%)	Participants were sampled from a larger longitudinal study of cardiovascular risk factors	Assessments included 2 d 24 h diet records, and a stage-of-change questionnaire for various behaviours <sup>91</sup>	Significant increases were noted in fibre intake across stages for males, and for fibre intake for women. Increases were also noted for fruit and vegetable intake for both men and women. A NS decrease in fat intake was noted in men and women. Similar results were noted for physical activity and fitness	The results of this study highlight the utility of stages of change for developing health promotion programmes targeted at individuals at different stages. Authors note the need to consider factors influencing the process of change as well
P2 Campbell <i>et al.</i> (2000) <sup>17</sup>	What is the relationship between health risks and stages of change for health behaviours?	Volunteer, worksite sample ( <i>n</i> 589; all females aged 18 years or older; participation rate 70%)	This was a cross-sectional study to assess health risks and behaviours in relation to stages of change in blue-collar women	Comprehensive questionnaire. Stages of change <sup>3</sup> , demographics, health status, BMI and health behaviours (including smoking, exercise, diet and cancer screening) were assessed	Participants were distributed across stages for increasing fruit and vegetable intake and decreasing fat intake. No significant differences were found for eating behaviours alone	Authors suggest that the stages-of-change model might not be effective in identifying readiness to change across health behaviours when women consider multiple behaviour choices
P3 Clark <i>et al.</i> (2005) <sup>18</sup>	What is the relationship between stages of change for exercise and fruit and vegetable consumption, and are they reflective of measures of exercise, intake and physical functioning in an older population?	Volunteer, community sample of 1274 older adults residing in RI, USA (69.6% female; mean age 75.4 years; participation rate 14% of all older adults within East Providence, RI, USA)	This was a descriptive study meant to provide baseline data for a large, multiple-behaviour intervention focusing on regular exercise and consumption of fruits and vegetables in older adults	Stages-of-change questionnaires for exercise <sup>92</sup> and for fruit and vegetable consumption <sup>81</sup> , National Institutes of Health fruit and vegetable intake assessment, physical functioning assessment, physical activity survey, and demographics questions were used	More than half of the sample was in action or maintenance stages for both fruit and vegetable consumption and for exercise. Stages of change for both exercise and fruit and vegetable consumption were associated with activity scores, servings of fruits and vegetables, and physical functioning in predicted directions. Stages of change for both behaviours were associated with each other, such that individuals in higher stages for one behaviour were more likely to be in higher stages of the other behaviour	In this assessment, stages of change were related to measures of physical activity and dietary intake, suggesting the utility of the construct in an older population
P4 Chung <i>et al.</i> (2006) <sup>19</sup>	Are processes of change different by stages of change for fruit and vegetable intake among college women?	Volunteer sample of 236 college women (age 18–24 years; participation rate 36%)	This was a cross-sectional study using a convenience sample of college-aged women	Stages-of-change questionnaire for fruit and vegetable consumption <sup>93</sup> , processes-of-change questionnaire <sup>94</sup> , and a 3 d food record were used	Intakes of fruits and vegetables were significantly different by stage, such that intake was higher in the combined action and maintenance stage compared with the combined precontemplation and contemplation stage. Those in precontemplation or contemplation used the process of self-evaluation more often, while those in action or maintenance used counter-conditioning more often	Fruit and vegetable intake was significantly related to stage of change in this population. Processes of change also related to stages of change, suggesting the utility of targeting interventions to particular processes based on stage

Table 1. Continued

Study no. and reference	Research question	Sample characteristics	Study design	Measures	Findings	Implications
P5 Frame <i>et al.</i> (2001) <sup>20</sup>	What is the stage distribution for cardiac patients in a rehabilitation programme regarding dietary fat and fruit and vegetable intake?	Volunteer sample of 226 cardiac patients from a rehabilitation centre (72.1% male; 89.9% white; mean age 63.5 years; participation rate 93%)	This was a cross-sectional, descriptive study using a convenience sample of patients in cardiac rehabilitation assessing reduction of dietary fat and increase in fruit and vegetable consumption	Stages of change for fruit and vegetable consumption <sup>81</sup> and a FFQ were used	Of subjects, 78.7% were in action or maintenance for decreasing fat intake, while only 15.6% were in action or maintenance for increasing fruit and vegetable intake. Overall, percentage energy from fat decreased, and fruit and vegetable consumption increased across stages	These results demonstrated contrasting stages of change for two heart-health-related behaviours. As such, interventions should focus on differing stage-matched methods for various behaviours
P6 Frenn <i>et al.</i> (2005) <sup>21</sup>	Do stages of change predict percentage dietary fat?	Volunteer sample of 100 African-American and Hispanic 7th graders in a school setting (mean age 12.8 years; 52% female; participation rate 71%)	This was a descriptive, cross-sectional study assessing predictive power of stages of change	A food habits questionnaire and a stage-of-change questionnaire <sup>82</sup> were used	Stage of change significantly predicted percentage energy as dietary fat	Stages-of-change construct might be reflective of dietary fat habits for this population
P7 Frenn & Malin (2003) <sup>22</sup>	What constructs and processes of change are related to stages of change for a low-fat diet in low- to middle-income adolescents?	Volunteer sample of 221 children in sixth, seventh, or eighth grade (57.5% male; participation rate not reported)	This was a descriptive, cross-sectional study assessing factors related to stages of change for a low-fat diet	Non-validated access to healthy foods questionnaire, modified stages-of-change questionnaire <sup>82</sup> , food habits questionnaire, pros and cons instrument for a low-fat diet, temptation scale for low-fat foods, and a low-fat diet process-of-change questionnaire were used	Percentage fat in diet decreased significantly across stages of change, while access to low-fat foods and processes related to a low-fat diet increased across stages. Exercise-related processes also increased significantly across stages. Access to low-fat foods and gender were identified as antecedents of a diet low in fat	Results suggest that access to low-fat foods might be an important aspect of future stages-of-change-based interventions. Stage-appropriate processes are also important to consider
P8 Greene <i>et al.</i> (2004) <sup>23</sup>	What are the differences in demographic and psychological variables related to fruits and vegetables across the stages of change?	Volunteer sample of 1254 community residents (mean age 75.4 years; mean BMI 27.2 kg/m <sup>2</sup> ; 69.8% female; participation rate reported elsewhere)	This was a descriptive study including participants from the SENIOR project	Two validated FFQ, and questionnaires assessing stages of change for fruit and vegetable consumption <sup>81</sup> , decisional balance, processes of change, and self-efficacy were used	15% were in precontemplation, 64% were in maintenance and fewer than 2% were in contemplation or action; fruit and vegetable consumption increased linearly across stages (explaining 15–17% of the variance), with variable increases in decisional balance, processes of change, and self-efficacy	The study results supported the utility of self-assessed number of servings for stage-of-change classification in this population. Authors suggested a focus on perceived benefits of fruit and vegetable consumption in older adults when designing interventions

P9 Gulliver & Horwath (2001) <sup>24</sup>	How does decisional balance relate to stages of change for milk consumption among women in New Zealand?	Random sample of 704 females selected from national electoral rolls (age 25–70 years; participation rate 80%)	Participants were sampled from a larger study investigating application of the TTM and milk consumption. Participants completed mailed surveys related to meeting milk consumption goals (either two servings per d) and a short phone interview for stage assessment	FFQ for Ca intake, stages-of-change <sup>25</sup> decisional balance scale; demographic, health conditions, and height and weight data were collected	27% were in precontemplation, 4% were in contemplation, 4% were in preparation, 4% were in action and 61% were in maintenance. Perceived benefits were positively correlated with Ca intake while perceived barriers were positively associated with weight. Differences existed in perceived benefits across stages and explained 17.6% of the variance. Only a small percentage of the variance was explained by differences in barriers across stages	Results regarding decisional balance suggest a focus on perceived benefits of milk consumption for women in precontemplation, as well as a focus on how to achieve milk consumption goals despite perceived barriers
P10 Gulliver & Horwath (2001) <sup>25</sup>	What is the stage distribution for New Zealand women regarding readiness to meet milk consumption recommendations?	Random sample of 704 females selected from national electoral rolls (age 25–70 years; participation rate 80%)	Participants were sampled from a larger study investigating application of the TTM and milk consumption. Participants completed mailed surveys related to meeting milk consumption goals (either two or four servings per day) and a short phone interview for stage assessment	FFQ, stages of change for milk consumption (used non-validated algorithm based on DiClemente <i>et al.</i> <sup>3</sup> ), demographic, health conditions, and height and weight data were collected	73% of women were in the precontemplation stage for meeting the recommendation of two servings/d. Greater than 80% were in precontemplation for consuming four servings/d. Mean Ca intakes increased significantly across stages	Results demonstrated the feasibility of a stage-of-change assessment tool related to milk product consumption in this population. The assessment tool corresponded with the FFQ results for Ca intake
P11 Hawkins <i>et al.</i> (2001) <sup>26</sup>	Can the stages-of-change model regarding intentions for weight loss be generalised to overweight and obese rural African-American women, and what factors predict stages of change in this population?	Random sample of 200 African-American women aged less than 40 years from a prior study sample (71% overweight or obese; participation rate 76%)	Participants were sampled from the Alliance of Black Churches Health Project. Data were collected in person or over the phone	Stages-of-change questionnaire (non-validated algorithm based on DiClemente <i>et al.</i> <sup>3</sup> ), BMI, demographic information, and social expectations for weight loss were measured	30% were in precontemplation, 15% were in contemplation, 48% were in preparation, 4% were in action, and 3% were in maintenance. Education level, social expectations, BMI and positive aspects of weight loss predicted stages of change	This study demonstrated the applicability of the TTM to weight-loss intentions among African-American women. It also described important predictors of stages of change. This information is useful in further developing interventions to help African-American women progress through stages
P12 Lea <i>et al.</i> (2006) <sup>27</sup>	What is the readiness to change to a plant-based diet in a random sample of Australian adults?	Random sample of 415 Australian adults (59.4% female; participation rate 51%)	This was a descriptive, cross-sectional study to assess stages of change and decisional balance related to a plant-based diet	A mailed questionnaire was used that included newly developed stages-of-change (adapted from Povey <i>et al.</i> <sup>95</sup> ) and decisional-balance assessments, and an eating habits questionnaire was used	58% were in precontemplation, 14% were in contemplation or preparation, and 28% were in action or maintenance; those in higher stages recognised more benefits and fewer barriers than those in lower stages	Stages of change and decisional balance were consistently applied in this Australian sample as they related to a plant-based diet

Table 1. Continued

Study no. and reference	Research question	Sample characteristics	Study design	Measures	Findings	Implications
P13 Logue <i>et al.</i> (2000) <sup>28</sup>	How do stages of change vary for obese primary-care patients regarding fat intake, portion control, vegetable intake, fruit intake, physical activity, and planned exercise, and how do stages relate to anthropometric data?	Volunteer sample of 284 obese primary-care patients from an obesity care centre (mean age 46.5 years; 81 % female; mean BMI 35.9 kg/m <sup>2</sup> ; participation rate not reported)	Researchers gathered girth measurements and assessed readiness to change via a survey	Stages-of-change assessment (non-validated algorithm based on DiClemente <i>et al.</i> 1991 <sup>3</sup> ), girth and BMI were measured	Though preparation stage was the most frequent for numerous health behaviours, stages were variable by subject across behaviours. For five of six health behaviours, stage of change was associated with both waist girth and BMI such that decreases occurred across stage level	Because of the diversity of stage level in obese primary-care patients, treatment for obesity must be highly individualised. The TTM can provide the foundation for tailoring treatment
P14 Lopez-Azpiazu <i>et al.</i> (2000) <sup>29</sup>	What is the stage distribution within Spanish adults regarding healthy eating patterns (age > 15 years)?	Random sample of 1009 Spanish adults (59.7 % male; participation rate 88 %)	This was a cross-sectional study assessing stages of dietary change and behaviours and attitudes toward healthy eating using a published questionnaire	Stages of change questionnaire (developed for this study) administered with established interview protocol, and questions on beliefs about healthy eating and food choice were used	56 % were in precontemplation, 7.9 % were dynamic (or in preparation), 28.3 % were in maintenance and 7.7 % were in relapse (or termination). Generally, younger females were classified in stages beyond precontemplation. Those in preparation or maintenance more often cited 'trying to eat healthy' as an influence on the foods they chose to eat. Most participants in precontemplation and maintenance felt no need to change their diets	The adult Spanish population can successfully be classified by stages of change. Thus, the TTM might be useful in developing more targeted nutritional interventions
P15 Nothwehr <i>et al.</i> (2006) <sup>30</sup>	What is the distribution of behavioural strategies for healthful eating across the stages of change, and do stages predict use of strategies over 1 year?	Volunteer sample of 407 adults in rural IA, USA (56.8 % female; response rate 25 %)	This was a cross-sectional study with a 1-year follow-up to assess dietary behaviour strategies	FFQ, non-validated staging questions and previously developed behavioural strategy assessments were used	Significant increases in use of behavioural strategies for healthful eating were noted across stages. Stages did not consistently predict, however, changes in use of strategies over 1 year	These data are not conclusive as to the predictive strength of stages of change for dietary strategies in the absence of an intervention. That strategies were related to individual stages might suggest useful intervention strategies for future studies
P16 O'Hea <i>et al.</i> (2003) <sup>31</sup>	What are the sex differences among various constructs of the TTM for dietary fat reduction and other health habits?	Volunteer sample of 554 low-income individuals from primary-care clinics (80.7 % female; participation rate not reported)	This was a cross-sectional comparison of sexes across TTM constructs	Stages-of-change questionnaire <sup>82</sup> , self-efficacy questionnaire and decisional-balance questionnaire were used	A NS difference between sexes across measures was found	These data are not consistent with previous findings. Sex differences might not be accurately assessed using these TTM-related assessment tools in relation to fat intake

P17 Pullen & Walker (2002) <sup>32</sup>	What is the stage distribution for older rural women regarding intake of servings from all food groups (of the old Food Guide Pyramid)?	Volunteer sample of 371 older women (87 % rural; mean age 62.6 years; participation rate not reported)	This was a descriptive, correlational study assessing adherence to the Dietary Guidelines and the Food Guide Pyramid using a convenience sample	Behavioural risk factor surveillance system survey assessment of eating behaviours, stage of eating adherence questionnaire (developed in this study, in relation to fat intake, fruit and vegetable intake, and grain intake), and stage of exercise adherence questionnaire were used	For fat intake, 46.1 % were in maintenance. For fruit and vegetable intake, 53.1 % were in maintenance, and for grain intake, 37.5 % were in maintenance	Significant differences existed among stages for each food group. Thus, TTM-based targeted materials should be used for interventions
P18 Tassell & Flett (2005) <sup>33</sup>	How do social physique anxiety, self-efficacy, common barriers to dietary change, and food security compare across stages of change for dietary fat reduction and increasing fruit and vegetable consumption?	Volunteer sample of 111 Maori women from New Zealand (mean age 36 years; participation rate not reported)	Cross-sectional descriptive study comparing variables across stages of change	Food habits questionnaire for dietary fat assessment, stages-of-change questionnaire for fruit and vegetable consumption and dietary fat modification <sup>81</sup> , the Barriers to Dietary Change questionnaire, a social physique anxiety scale, food security questionnaire, and demographic information were collected	Dietary fat intake and barriers to fruit intake were significantly lower, and self-efficacy for maintaining a healthy diet was significantly higher, across stages for fruit and vegetable consumption. Similar results were found across stages for reducing fat intake	Dietary self-efficacy increases across stages of change for dietary goals and thus should be considered in future interventions. Barriers, such as lack of convenience and taste issues, should also be considered in planning effective interventions using the stages-of-change construct
P19 Vallis <i>et al.</i> (2003) <sup>34</sup>	What is the stage distribution for overweight diabetic individuals in relation to demographics and eating-related factors, among other variables?	Random sample of 768 overweight patients with type 1 or type 2 diabetes from a prior study sample (51.1 % female; mean age 47.5 years; mean BMI 32.8 kg/m <sup>2</sup> ; participation rate reported elsewhere)	Participants from the Diabetes Stages of Change trial were assessed for stages of change for healthy low-fat eating, eating-related factors, and demographics	FFQ and stage-of-change questionnaire for dietary fat reduction <sup>82</sup> were used	For stage of readiness to change regarding healthy eating, 10.2 % were in precontemplation, 25.0 % were in contemplation, 27.2 % were in preparation, 5.8 % were in action, and 31.8 % were in maintenance. Generally, for type 1 diabetics, those in action and maintenance had the lowest percentage energy from fat as well as the highest number of servings of vegetables. For type 2 diabetics, women and married participants were more often in later stages than men or single participants	Healthy eating increased across stages for participants, suggesting the staging done in this study was reflective of behaviour
P20 Van Duyn <i>et al.</i> (2001) <sup>35</sup>	What is the stage distribution for a representative sample of the US adult population regarding a diet high in fruits and vegetables?	Random sample of 2605 US adults from a random digit dial survey (52 % female; response rate 44.5 %)	A phone survey was conducted to gather demographic data and to assess fruit and vegetable consumption and stages of change	Stages-of-change questionnaire for fruit and vegetable consumption <sup>96</sup> and a 'five a day' FFQ were used	47 % were in action. Significant differences existed across stages for total consumption of fruits and vegetables with about one serving increases from contemplation or preparation to action and from action to maintenance. However, stages of change alone accounted for variance in consumption	Stages of change are related to fruit and vegetable consumption, and a variety of constructs probably are important for movement across stages



Table 1. Continued

Study no. and reference	Research question	Sample characteristics	Study design	Measures	Findings	Implications
P21 Wee <i>et al.</i> (2004) <sup>36</sup>	What factors are associated with advanced stages of change for weight loss, and dietary and exercise improvement in primary-care patients?	Random sample of 365 primary-care patients (aged 18 years or older; 65% female; response rate 60%)	A phone survey was conducted to gather all data for this cross-sectional study, including stages of change, demographics, weight-related perceptions, and quality of life	Stages of change for losing weight and increasing exercise and fruit and vegetable intake <sup>28</sup> ; items assessing physical activity, and items assessing perceptions of weight and weight loss	Nearly half of this primary-care patient sample was in preparation, action or maintenance stages concurrently for weight loss, increasing activity, and increasing fruit and vegetable intake. Those perceiving weight as a health risk were at advanced stages of readiness to lose weight and increase exercise and fruit and vegetable intake. Mental and physical functioning were not strongly related to stages of change	Awareness of weight as a risk factor was related to advanced stages, suggesting the importance of increasing such awareness to maximise weight-loss efforts

on nutrients rather than foods. In the body of literature reviewed in the present review, the focus was on foods, which might explain the improved consistency in staging algorithms. In fact, of the twenty-one studies reviewed, only two (study numbers P15 and P16) elicited data that either did not support the TTM as a useful descriptive tool or were inconclusive. It is interesting to note that both studies included stages-of-change assessment of nutrient intake (i.e. fat) alone, or along with, stages-of-change assessment for fruit and vegetable intake. Also, stages of change might not, according to one study, be effective in identifying differences between sexes; however, the results of this study were not reflective of results of previous studies in which sex differences have been successfully measured.

Even though the majority of studies successfully utilised the TTM and its constructs in describing various populations, studies employed different techniques for assessment of dietary intake, nutrition-related perceptions, or stages-of-change determination. A total of eighteen different algorithms for a variety of health behaviours were used among the population studies in Table 1. Seven of the reviewed studies included novel staging mechanisms. The staging algorithms used most often included one developed by Laforge *et al.*<sup>81</sup> for fruit and vegetable intake and one developed by Greene & Rossi<sup>82</sup> for low-fat diets. Of those studies that included dietary intake or habits assessments, eight utilised some form of a FFQ (study numbers P2, P3, P9, P10, P15, P17, P19 and P20), two used a 3 d food record (study numbers P4 and P5), two used a 24 h recall (study numbers P1 and P8) and four included assessments of dietary habits or behaviours (study numbers P6, P7, P12 and P18).

#### Intervention studies

A summary of the twenty-five intervention studies is presented in Table 2. The earliest study was published in 2000 and the most recent in 2006. Of the twenty-five studies, fifteen used experimental designs, four were quasi-experimental and six used non-experimental designs. All but one of the nineteen experimental or quasi-experimental studies had an internal validity rating of good or fair. Populations included low-income adults (*n* 4), primary-care patients (*n* 8), African-Americans (*n* 2), native Hawaiians (*n* 1), Canadian adults (*n* 1), British adults (*n* 1), German adults (*n* 1), Dutch adults (*n* 3), Hispanic mothers (largely migrant farm workers) (*n* 1), denture-wearers (*n* 1), patients on cholesterol-lowering drugs (*n* 1), type 2 diabetics (*n* 4), overweight adults (*n* 3), middle-school students (*n* 1), parents (*n* 2) and undergraduate students (*n* 2). In assessing TTM constructs, twenty-four studies focused primarily on stage of change and one focused primarily on processes of change.

Studies varied according to the dietary habits they attempted to change and measure. It is important to note that dietary behaviour is not one behaviour, but a collection of many specific behaviours. All but one study focused on one or more specific behaviours, often using multiple staging algorithms, each designed to measure a specific dietary behaviour. Fifteen studies measured reductions in dietary fat, seven studies assessed fruit and vegetable intake, two

**Table 2.** Summary of intervention studies of the transtheoretical model (TTM) as applied to dietary behaviour

Study no. and reference	Research question	Sample characteristics	Intervention	Measures	Findings	Implications
11 Armitage (2006) <sup>37</sup> Experimental study Fair rating	Does an intervention using implementation intentions promote stage progression and prevent relapse for eating a low-fat diet?	British employees ( <i>n</i> 729; 72% female; 378 in intervention group; 351 in control group; retention rate 59%)	Implementation intentions are different from behavioural intentions, as they identify specific conditions under which a new behaviour will be performed. They may or may not be stage-matched. The intervention group was asked to independently create their own criteria for when, how and where they would eat low-fat foods instead of high-fat foods. The control group was not asked to do this	Baseline and 1-month surveys assessed stage of change <sup>3</sup> , behavioural intention, attitude, perceived control, subjective norm, and dietary intake using a FFQ	In 1 month, 20.6% of all participants moved forward by one or more stages, 14.7% regressed and 64.6% stayed in the same stage. Those in the intervention group were significantly more likely to progress forward in stage; however, stage regression rates were similar for both control and intervention groups	Interventions using implementation intentions require no direction from professionals and are less expensive to offer. It is difficult to say whether or not this was a stage-matched intervention, as the participants themselves designed their own interventions and the researchers did not review their plans. An interesting question for further research is whether or not participants set behavioural criteria for themselves that are matched to their stages
12 Auslander <i>et al.</i> (2002) <sup>38</sup> Experimental study Good rating	Can a culturally sensitive, peer-led programme reduce the risk of type 2 diabetes among low-income African-American women?	Overweight African-American women ( <i>n</i> 294; age 25–55 years; 138 in intervention group; 156 in control group; retention rate 73.7%)	Eat Well, Live Well Nutrition Program is stage-matched. Intervention subjects participated in six group sessions and six individual sessions with a lay peer educator. Control subjects received a self-help workbook	Baseline and 3-month post-programme interviews assessed behaviour, knowledge, attitudes, fat consumption and body weight. The staging of eating patterns assessment <sup>97</sup> and a FFQ were also used	Intervention participants significantly reduced their fat intake, increased their intake of low-fat foods, and showed higher levels of skill, knowledge and more positive attitudes than did control group participants. No significant differences were found in BMI or weight loss between the two groups	A stage-based intervention was effective in reducing behavioural risks related to diabetes among African-American women. It also resulted in significant stage transitions from pre-action to action stages. It did not result in significant changes in body weight, although this was not its intention
13 Bradbury <i>et al.</i> (2006) <sup>39</sup> Experimental study Fair rating	Does a counselling-based intervention offered in dental offices lead to an increase in fruit and vegetable consumption among denture-wearers?	Patients who wear dentures ( <i>n</i> 58; age 45–88 years; thirty in intervention group; twenty-eight in control group; retention rate 87%)	Intervention participants received two stage-matched counselling sessions as part of dental visits. Control group participants received usual care	Participants were assessed at baseline and 6 weeks. Measures included stage of change <sup>98</sup> , dietary intake and chewing ability	Intervention participants were significantly more likely to move into action or maintenance than were control participants. Chewing ability improved for both groups, though	Wearing dentures poses unique obstacles to eating foods that are more difficult to chew, including fruits and vegetables. This intervention was useful in helping denture wearers to move into action for fruit and vegetable consumption
14 Calfas <i>et al.</i> (2002) <sup>40</sup> Experimental study Fair rating	Can a computerised assessment programme plus brief counselling improve nutrition and exercise behaviour among primary-care patients?	Adult primary-care patients ( <i>n</i> 173; forty-five in intervention group 1; forty-one in intervention group 2; forty-one in intervention group 3; forty-six in control group; 69% female; 71% white; average age 37 years; 21% ( <i>n</i> 49) lost to follow-up)	PACE + is stage-matched. Computerised assessment is supplemented by mail and/or telephone counselling	Baseline and 4-month post-programme interviews assessed the following: stage of change (for physical activity only), overeating behaviour, block simplified fat screener (fat intake), and fruit and vegetable intake	Participants improved both exercise and dietary behaviour over the study period. The more intensive interventions were not more effective than the less intensive one, though	Given that stage of change was only assessed for exercise behaviour and only assessed at baseline, it is impossible to know the effect of the intervention on stage movement

Table 2. Continued

Study no. and reference	Research question	Sample characteristics	Intervention	Measures	Findings	Implications
15 Clark <i>et al.</i> (2004) <sup>41</sup> Experimental study Good rating	Do brief, tailored lifestyle self-management interventions improve the process of lifestyle behaviour change for diet and physical activity with patients who have type 2 diabetes?	Diabetic patients ( <i>n</i> 100; forty-eight in intervention group; forty-six in control group; retention rate 94%)	Intervention group received brief tailored intervention, including follow-up telephone calls. Control group received care as usual	Both questionnaire and physiological assessments were given at baseline, 3 months and 1 year. They assessed stages of change for dietary fat reduction <sup>99</sup> , stage of change for exercise, self-efficacy and barriers to change	Participants in the intervention group perceived themselves to have changed from contemplation to action for dietary fat reduction and lifestyle physical activity levels due to decreased barriers but not increased self-efficacy. Results provide further evidence of the effectiveness of tailored interventions for lifestyle change	There is an increase in understanding the change processes over time for multiple behaviours, allowing behavioural and preventive medicine to have a more significant impact when targeting behaviour change in individuals with multiple risks. These findings may help in developing more effective and efficient interventions
16 Cookson <i>et al.</i> (2000) <sup>42</sup> Non-experimental study	Can a mailed self-help intervention package affect nutrition behaviour changes in parents and their children?	Canadian parents of children aged 6–12 years ( <i>n</i> 300; 21% of initial sample completed post-programme survey)	The HeartSmart Family Fun Pack is a mailed self-help package of materials for parents and children aged 6–12 years to promote healthful diets, exercise and non-smoking	Baseline and 3-month post-programme written survey assessed intention to change (using three-stage tool developed by the authors), dietary behaviour, exercise behaviour, and smoking behaviour	Of parents, 38% said they improved the diets of their children; 28% of parents said they increased the physical activity of their children	More than two-thirds of the parents surveyed indicated that they had made at least one positive health-related change in response to receiving the intervention. The lack of comparison group and small follow-up response rate limit the conclusions that may be drawn
17 Finckenor <i>et al.</i> (2000) <sup>43</sup> Quasi-experimental study Good rating	Can an intervention focusing on cognitive processes of change lead to dietary changes among pre-action staged participants?	Undergraduate students ( <i>n</i> 110; age 17–55 years; 76–83% female; 74–87% white; thirty-eight in intervention group; thirty in control group 1; forty-two in control group 2; retention rate 67–68% at 1 year)	Students participated in eleven 15 min sessions offered once per week. Lessons incorporated a group-oriented dietary fat reduction intervention using the cognitive processes of change	Baseline, 14-week post-programme assessment and 1-year post-programme assessment were conducted. The stages-of-change algorithm for dietary fat reduction <sup>100</sup> and the eating choices food questionnaire were used	Students receiving the intervention showed significant forward stage progression that was maintained at 1 year. Students in the control group who received pre- and post-surveys also showed forward stage progression, but not for 1 year	It is noteworthy that intervention participants maintained dietary changes for 1 year after the programme. This may have been a highly motivated group, though, as all participants were enrolled in a college nutrition course at the start. Focusing on cognitive processes of change for pre-action participants appeared to be effective
18 Frenn <i>et al.</i> (2003) <sup>44</sup> Quasi-experimental study Good rating	Can a school-based intervention lead to diet and exercise changes among middle-school students?	Low-income middle-school students ( <i>n</i> 117; 52% female; 50% African-American; sixty in intervention group; fifty-seven in control group; 91% response rate)	Students in intervention classes received four stage-based classroom lessons. Intervention group students who were in preparation, action or maintenance also participated in four small group sessions. Students in the control group did not receive any type of nutrition intervention	Baseline and post-programme surveys assessed stage of change (modified Greene & Rossi Scale <sup>82</sup> ), self-efficacy, dietary behaviour, exercise behaviour, and benefits and barriers	Intervention students reported consuming significantly less dietary fat than did those in the control group. Among all students, self-efficacy was higher for those in later stages, and dietary fat intake was lower for those in later stages	The TTM appears to fit this population for dietary fat consumption. A stage-based intervention to reduce dietary fat was effective in helping students progress forward in stage

19 Greene <i>et al.</i> (2003) <sup>45</sup> Non-experimental study	Can a home-based intervention lead to diet and exercise changes among obese adults?	Obese adults referred to the programme by a primary physician ( <i>n</i> 31; 71% female; 100% white; average age 45 years). Twenty participants completed the programme; sixteen completed final follow-up survey	Participants received twelve action-oriented weekly mailings addressing exercise, dietary fat reduction, portion control, fruit and vegetable consumption and behaviour change	Baseline, post-programme (3-month) and 6-month follow-up surveys were used. Data were collected via physical examination and written survey. TTM measures included stage of change for exercise and stage of change for dietary fat reduction <sup>82</sup>	Mean weight loss for participants was 46 kg at 6 months. Participants also showed significant improvements in dietary fat reduction, fruit and vegetable consumption, and an increase in aerobic capacity	The findings of this small, preliminary programme evaluation demonstrate that home-based programmes can be practical, low-cost and effective
110 Johnson <i>et al.</i> (2006) <sup>46</sup> Experimental study Fair rating	Can a computerised 'expert system' intervention lead to forward stage movement for dietary fat reduction among patients taking lipid-lowering medication?	Patients on lipid-lowering medication ( <i>n</i> 404; 50% male; age 21–85 years; 202 in intervention group; 202 in control group; 65% response rate at 18 months)	Intervention participants completed the Pro-Change Program for Cholesterol Medication. They interacted with the computer-generated program and received individualised, stage-matched feedback at three time points. Control participants received usual care	Participants were assessed at baseline, 6 months, 12 months and 18 months post-programme for stage of change (unspecified for dietary fat), dietary fat intake and exercise	Intervention participants were more likely than control group participants to move into action or maintenance and remain there for the duration of the study, regardless of their stage at baseline. Among intervention participants, 21% were in action or maintenance for dietary fat reduction by the end of the programme	This study offers clear support for the use of a stage-matched intervention to reduce dietary fat intake among patients with high blood lipid profiles
111 Jones <i>et al.</i> (2003) <sup>47</sup> Experimental study Good rating	Does an integrated, multi-component intervention programme increase readiness to change, self-care and diabetes control?	Subjects with type 1 and type 2 diabetes ( <i>n</i> 1029; 260 in intervention group 1; 250 in intervention group 2; 269 in control group 1; 250 in control group 2; retention rate 78–81%). Intention to treat analysis was performed	An expert system was customised to the individual based on stage of change using phone counselling and newsletters provided for 12 months. Control subjects received treatment as usual. This included regular medical examinations and general diabetes education	Baseline, 3, 6, 9 and 12 months for intervention participants. No contact was permitted for the control group until the end of the 12-month study. Questions on intention to change and current behaviour assessed stage of change (developed and tested as part of this study)	Intervention participants were significantly more likely than those who received usual care to move forward to action for critical diabetes self-care behaviours. The intervention has the possibility to positively affect the health of diverse populations diagnosed with diabetes who are ready to change	Interventions that are integrated and multi-component can be effective by helping large groups of patients with diabetes. This time-efficient programme can redirect efforts to diabetes care and education tactics that result in a positive effect on hindering long-term diabetes conditions and lowering healthcare costs

Table 2. Continued

Study no. and reference	Research question	Sample characteristics	Intervention	Measures	Findings	Implications
I12 Keller <i>et al.</i> (2000) <sup>48</sup> Experimental study Poor rating	Can training primary-care physicians in counselling skills based on the TTM lead to motivational and behavioural changes in their patients?	German primary-care patients ( <i>n</i> 592; 274 in intervention group; 318 in control group; retention rate 50%)	Physicians in the intervention group participated in a workshop focusing on the TTM and general counselling strategies for behaviour modification. They then provided stage-based counselling to their patients, who volunteered to complete the programme assessments. Physicians in the control group did not receive training or the brochures. They were asked to continue usual care treatment	Baseline and after 12 months assessments were conducted. The stages of change for diet, exercise, smoking and stress management were determined through short staging algorithms <sup>101</sup>	After 12 months, patients in the intervention group did not show significant movement through stages of change for diet, exercise, smoking and stress management than did patients with control physicians. There were no differences between groups in counselling frequency, counselling intensity or patient satisfaction with counselling	Limitations of this study were due to the low recruitment rate and high dropout rate in the sample size. The need for improving motivational counselling skills of primary-care physicians is due to the high numbers of patients in the early stages of change and minimal improvement over time. Future research should focus on ways to improve the process of education for physicians on implementing counselling strategies in primary-care settings
I13 Mau <i>et al.</i> (2001) <sup>49</sup> Quasi-experimental study Good rating	Does a lifestyle intervention show greater changes in TTM measures for diet and exercise behaviour than a standard intervention?	Native Hawaiians with or at risk for type 2 diabetes ( <i>n</i> 147; seventy-two in intervention group; seventy-five in control group; retention rate 90%)	Intervention participants received a culturally specific programme. They were asked to choose a support person to attend programme activities with them and were given instructions on how to ask his or her support person for help in overcoming challenges in changing lifestyle behaviours. The control group received a culturally competent programme	A 3–4 h research examination consisting of questionnaires and interviews were given on site at baseline, 6 months and at 1 year to assess dietary stages of change for fat and fibre intake <sup>102</sup> and stage of change for exercise	Stage of change for fat and fibre intake was significantly associated with positive dietary and exercise behaviours. Participants receiving support intervention were more likely to move forward from pre-action to action or maintenance and showed more improvement in those stages than did the control group	Support intervention had positive results in stage advancement and social support roles; however, it was not effective in maintaining individuals at the action or maintenance stage. Encouraging behaviour change in individuals with the help from mediators may aid in the development of more effective and efficient interventions
I14 Prochaska <i>et al.</i> (2005) <sup>50</sup> Experimental study Good rating	Can stage-based expert systems lead primary-care patients through stages of change for multiple risk behaviours, including dietary fat reduction?	Primary-care patients from seventy-nine physician practices ( <i>n</i> 5407; 69% recruitment rate; 2667 in intervention group; 2740 in control group; retention rate 75%)	Stage-based expert systems were used. The intervention group was mailed stage-matched material. The control group completed stages-of-change and behavioural outcomes survey. Follow-up assessments at 12 and 24 months were conducted on participants in both groups	Baseline, 6 and 12 months assessed stage of change for dietary fat reduction <sup>82</sup> and other health behaviours	Effects of intervention were significant for treatment participants in each of the four behaviours, with 28.8% in action for dietary fat reduction	Stage-matched expert systems can have a relatively high impact on a population with multiple risk behaviours for cancer and other chronic diseases. Further research is needed to determine if both efficacy and participation rates can be increased by having primary-care physicians begin multiple behaviour-change processes

<p>115 Prochaska <i>et al.</i> (2004)<sup>51</sup> Experimental study Good rating</p>	<p>Do multiple risk expert system interventions significantly improve readiness for change in an at-risk population for high-fat diets and other health behaviours?</p>	<p>Parents of teenagers (<i>n</i> 2460; 84% recruitment rate; 1209 in intervention group; 1251 in control group; retention rate ranged 65–85%)</p>	<p>A stage-based expert system was used. Stage-matched self-help manuals for each at-risk behaviour and progress questionnaires were mailed to participants. Phone surveys were also used to generate progress reports. The control group received stages of change and behaviour outcomes for the three behaviours</p>	<p>Computer reports were created for each at-risk behaviour at baseline, 6 and 12 months. Stage of change for dietary fat reduction<sup>102</sup> was assessed</p>	<p>In 24 months, 34% of participants reached the action or maintenance stages for dietary fat reduction. Those in the intervention group were more likely to move forward in stage than the control group</p>	<p>Interventions that are stage-matched expert systems can significantly increase multiple behaviour changes in at-risk populations where the majority of participants are not prepared to change. Further research is needed for this expert system to determine if staged-based multiple behaviour change programmes are effective with different populations</p>
<p>116 Proper <i>et al.</i> (2003)<sup>52</sup> Experimental study Good rating</p>	<p>Does personalised feedback on fitness and health status affect an individual's subjective appraisal of their stage-of-change behaviour?</p>	<p>Dutch adults (<i>n</i> 299; 131 in intervention group; 168 in control group; 66% male; retention rate 95%)</p>	<p>The intervention was the stage-matched PACE+. PACE assessment forms were completed after testing and again after feedback. The intervention group also had the option of additional measurements for 9 months. The control group received the health and fitness test without feedback. PACE assessment forms were completed before testing and again after testing</p>	<p>Health and fitness tests were given to both groups at the start of the study. Two PACE assessment forms were given to both groups. The time interval between completion of the assessments was 1 h. Stage of change was measured using the stage model for exercise and nutrition (PACE)</p>	<p>There was no significant change at the behaviour change level for nutrition. There was a significant change in the intervention group; 12% reported a relapse on PACE scores for energy intake and weight management, men more so than women. After feedback, 23% of the intervention group relapsed on their PACE scores of which 53% moved from action or maintenance to contemplation or preparation</p>	<p>Personalised feedback does not immediately induce a change at the level of behaviour stage, but can induce changes in PACE scores and realistic appraisal of participants of their stage of change. Giving feedback at baseline on measurements in an intervention study can influence PACE scores and can be considered a small but important gain</p>
<p>117 Resnikow <i>et al.</i> (2003)<sup>53</sup> Quasi-experimental study Fair rating</p>	<p>Will precontemplators respond differently than preparers to an intervention designed to increase fruit and vegetable consumption?</p>	<p>African-American adults recruited through fourteen black churches (<i>n</i> 1011; six churches in intervention group 1; four churches in intervention group 2; four churches in control group; 62% in preparation at baseline; 21% in maintenance at baseline; retention rate 85% (<i>n</i> 861 at 1 year))</p>	<p>All intervention participants received self-help materials tailored to pre-action stages. Those in group 1 received one phone call based on motivational interviewing; those in group 2 received four calls. Control group participants received non-tailored nutrition information</p>	<p>Baseline and 1-year surveys included: stage of change<sup>81</sup>, FFQ, self-efficacy, barriers to fruit and vegetable intake, outcome expectations and portion size knowledge</p>	<p>Participants in pre-contemplation showed the same degree of change as those in preparation for all major study outcomes. This was true for intervention and control group participants. 85% of precontemplators and 33% of preparers moved forward at least one stage</p>	<p>This study does not support the application of the stage-of-change concept to this study population. The authors note that participants may not have been representative of the larger population. They also note that more frequent assessments (i.e. at 3 and 6 months) may have yielded different results</p>

Table 2. Continued

Study no. and reference	Research question	Sample characteristics	Intervention	Measures	Findings	Implications
I18 Riebe <i>et al.</i> (2005) <sup>54</sup> Non-experimental study	Can a clinic-based intervention to improve diet and exercise habits lead to long-term changes in body weight and lifestyle habits among participants?	Moderately overweight adults ( <i>n</i> 144; 78 % female; 97 % Caucasian; average age 50 years; retention rate 76 %)	Stage-matched intervention focused on lifestyle change and not weight loss specifically. Initially met twice per week for exercise and lifestyle counselling; gradually tapered to fewer meetings	6-month and 24-month post-intervention assessments included BMI, self-reported dietary intake and exercise, and TTM processes of change. (Note: this is a follow-up analysis of the Riebe <i>et al.</i> <sup>55</sup> study also reported in this table as study I19)	Regular exercise and maintenance of a healthy diet were associated with greater use of processes of change. Exercise was also associated with higher confidence. Healthy diet was also associated with lower temptation scores	This study lends evidence of the long-term benefits of an intensive, stage-based intervention aimed at permanent lifestyle change and not simply weight loss. It supports the use of a stage-based intervention
I19 Riebe <i>et al.</i> (2003) <sup>55</sup> Non-experimental study	Can an intensive, stage-based weight-loss intervention based on diet, exercise and behaviour modification lead to positive health changes?	Moderately overweight adults ( <i>n</i> 144; 78 % female; 97 % Caucasian; average age 50 years; retention rate 76 %)	Stage-matched intervention focused on lifestyle change and not weight loss specifically. Initially met twice per week for exercise and lifestyle counselling; gradually tapered to fewer meetings	Baseline, 3-month and 6-month assessments included BMI, lipid profile, exercise testing, assessment of dietary logs. Baseline-only assessment of TTM measures for exercise and dietary fat intake <sup>62</sup>	Most subjects were within recommended levels at baseline for dietary fat and fruit and vegetable intake, but were not meeting exercise guidelines. At 6 months, LDL-cholesterol and energy intake decreased, and aerobic fitness increased	Although intervention was stage-based, stage transitions and use of processes of change were not measured
I20 Soweid <i>et al.</i> (2003) <sup>56</sup> Non-experimental study	Can a health-awareness course change health-related attitudes and self-reported behaviours, including fruit and vegetable intake, of undergraduate students enrolled in the class?	Undergraduate students ( <i>n</i> 32; retention rate 50 %)	The intervention was an undergraduate health awareness course taken by college juniors and seniors of various majors	The comprehensive health assessment inventory was used to assess attitude and self-report behaviour of students	Results showed improvement of at least 20 % from pretest score in four out of eleven health topics and 10–20 % in additional five topical areas. Forward stage movement was seen for several behaviours, including fruit and vegetable intake	The study indicated support for the impact of a health-awareness class on knowledge, attitude and behaviour of undergraduate students. Future research should include a large sample size and control group
I21 Steptoe <i>et al.</i> (2003) <sup>57</sup> Experimental study Good rating	Can a brief physician-delivered intervention improve fruit and vegetable consumption among patients?	Primary-care adult patients from a low-income, inner-city area in the UK ( <i>n</i> 271; 61 % female; average age 43 years; 136 in intervention group; 135 in control group; 81 % response rate at 12 months)	Intervention participants received two 15 min, stage-based nurse-delivered counselling sessions during office visits. Control participants received general nutrition counselling during two office visits	Baseline and 12-month self-reported number of vegetables and fruits eaten daily; biochemical measures of nutrients found in urinalysis, and stage of change (algorithm developed by authors) were assessed	Patients receiving stage-based counselling reported higher intakes of fruit and vegetables than did patients in the control group	While the generic nutrition counselling was also effective in promoting change, the stage-specific counselling promoted greater increases in fruit and vegetable consumption

<p>122 Steptoe <i>et al.</i> (2001)<sup>58</sup> Experimental study Fair rating</p>	<p>Can a brief, physician-delivered intervention lead to positive changes in dietary fat intake, exercise and smoking behaviour among patients at risk for heart disease?</p>	<p>Primary-care patients in the UK from twenty physician practices (<i>n</i> 883; 316 in intervention group; 567 in control group; 96% white; 54% female; 79% elevated BMI; retention rate 54–62%)</p>	<p>The Change of Heart Program is a stage-based intervention delivered by trained nurses during patient examinations. Intervention participants received two to three counselling sessions beyond the initial physician visit. Control participants received non-tailored advice during the physician visit only</p>	<p>Baseline, 4-month and 12-month assessments of: stage of change<sup>3</sup>, FFQ, and the UK National Fitness Survey</p>	<p>Intervention participants were significantly more likely than control participants to advance to action or maintenance at both assessment times; however, control participants also showed forward stage progression at both assessments. The intervention was most effective for those in pre-contemplation or contemplation</p>	<p>Stage-matched primary-care counselling of patients at risk for high-fat diets is supported by this study, particularly for patients who are in pre-contemplation and contemplation. Those in preparation or action did not appear to significantly benefit from the intervention</p>
<p>123 Taylor <i>et al.</i> (2000)<sup>59</sup> Non-experimental study</p>	<p>Can a culturally sensitive, stage-based programme for low-income Hispanic mothers lead to changes in dietary knowledge, attitudes and behaviours?</p>	<p>Hispanic mothers, low-income and/or migrant farm workers (<i>n</i> 337; response rate 24% at 6-month follow-up)</p>	<p>Stage-based, community intervention trained the grandmothers to deliver a face-to-face intervention to mothers of young children in five educational meetings</p>	<p>Immediate and 6-month post-programme surveys measured: stage of change (algorithm not specified) for seven specific dietary habits (i.e. fibre, Na, sugar, and label-reading); nutrition knowledge, attitudes and behaviour</p>	<p>For all of the nutrition behaviours assessed, most subjects were in either preparation or maintenance at baseline, post-programme and follow-up assessments. While knowledge and attitudes appeared to increase, behaviour was more difficult to assess</p>	<p>There appear to be significant cultural and educational barriers to applying the stage-of-change construct to this population. Despite the use of appropriate, well-trained peer educators, many participants did not want to be tested or measured and may have given 'desirable', rather than accurate, responses</p>
<p>124 Van Der Veen <i>et al.</i> (2002)<sup>60</sup> Experimental study Good rating</p>	<p>Does stage-matched nutrition counselling by family physicians have an effect on dietary fat intake and serum lipid levels?</p>	<p>Dutch primary-care patients at risk for heart disease (<i>n</i> 143; seventy-one in intervention group; seventy-two in control group; retention rate 90%)</p>	<p>The intervention group received TTM-based nutrition counselling by family physicians with selective referral to a dietitian. The control group received care as usual</p>	<p>At baseline, 6 and 12 months patients were presented with a self-administered questionnaire on demographics, medical history and food frequency<sup>103</sup>. A four-item algorithm<sup>104</sup> assessed stages of change for reduction of fat intake</p>	<p>Total fat and saturated fat intake at 6 months decreased significantly more in the intervention group (–5.7%) than the control group (–2.6%); at 12 months being decreased more in the intervention group (–3.6%) than the control group (–1.7%). There were only significant differences in body weight at 6 months and no significant changes in serum lipids at 12 months between the two groups</p>	<p>This intervention led to the reduction in short- and long-term dietary fat intake and short-term weight loss among patients receiving the counselling. Emphasis on future research should be testing new methods to maintain dietary behaviour changes, particularly among low socio-economic status patients</p>



Table 2. Continued

Study no. and reference	Research question	Sample characteristics	Intervention	Measures	Findings	Implications
I25 Verheijden <i>et al.</i> (2004) <sup>61</sup> Experimental study Good rating	Are stage-matched nutrition counselling interventions effective in promoting forward stage progression for dietary fat intake?	Dutch adult patients at risk for heart disease ( <i>n</i> 209; age 40–70 years; 143 in intervention group; sixty-six in control group; retention rate 90%)	The intervention group received three 10 min nutrition counselling sessions based on stage for total fat intake from their family physician. The control group received care as usual from their family physician	A four-item algorithm <sup>104</sup> was used to classify patients into one of the stages of change for fat reduction. Intake of energy, total fat and cholesterol was assessed by a self-administered FFQ <sup>103</sup>	After 6 months, 31 % of participants in the intervention group moved from pre-action to post-preparation as a result of stage-matched nutrition counselling, compared with the 14 % in the control group. The difference in distribution did not remain significant after 12 months. Decreases in fat intake were higher in the intervention group than the control group	The results of this study are not conclusive but suggest that stage-matched nutrition counselling promotes movement through stages of change resulting in a reduced fat intake. More research needs to be conducted to focus on possible ways to keep patients in the post-preparation stages

Fair rating, one threat to internal validity; good rating, no significant threats to internal validity; PACE<sub>+</sub>, Patient-Centered Assessment and Counselling on Exercise plus Nutrition; poor rating, two or more threats to internal validity; PACE<sub>-</sub>, Patient-Centered Assessment and Counselling on Exercise.

studies assessed portion control, two studies assessed fibre intake, and one study assessed both Na intake and sugar intake. None had weight loss as a primary study goal or programme focus.

Sixteen studies used staging algorithms that had been previously validated for use with a specific nutrition behaviour. In two studies, authors adapted the tobacco staging algorithm. In three other studies, the staging algorithm used was either unspecified or described in terms too general to determine the specific algorithm used. Finally, one study used a non-validated algorithm developed by the authors of that study.

Of the twenty-five studies, nineteen supported the use of stage-based dietary interventions. These included twelve studies with experimental designs (study numbers I2, I3, I5, I10, I11, I14–16, I21, I22, I24 and I25), three studies with quasi-experimental designs (study numbers I7, I8 and I13) and four programme evaluations using non-experimental designs (study numbers I6, I9, I18 and I23). These studies included populations of primary-care patients, patients at risk for heart disease, patients on cholesterol-lowering drugs, type 2 diabetics, denture-wearers, parents, Canadian adults, English adults, Dutch adults, native Hawaiians, two of the four low-income populations, and students.

Two studies clearly did not support the use of stage-based dietary interventions. One of these was a well-designed, quasi-experimental study of African-American church members, many of whom were low income (study number I17). In this study, participants in precontemplation performed as well as those in preparation in terms of changing and maintaining healthful dietary habits. The second study was a non-experimental programme evaluation of a dietary intervention designed for and delivered to mothers in migrant farm working families (study number I23). The authors identified several significant barriers to reaching this population and concluded that the method of evaluation of stage of change for this population needs to be culturally sensitive and specific to them. In another study (number I1), it was unclear whether the intervention was stage-matched or not, as each participant designed his or her own intervention, and the interventions were not reviewed by the researchers. Among native Hawaiians, the stage-matched intervention was effective in promoting stage progression in earlier stages, but not in enabling those in later stages to maintain their changes (study number I13). While Keller *et al.*<sup>48</sup> (study number I12) did not find support for the use of TTM-based counselling among physicians with their patients, it is important to note that the study suffered from several flaws, including low recruitment and retention rates. The final two studies (study numbers I4 and I18) did not provide follow-up measures of TTM constructs; however, a follow-up study of the Riebe *et al.*<sup>55</sup> (study number I19) sample demonstrated support for the TTM.

Compared with the three intervention studies included in the Horwath<sup>4</sup> literature review, the twenty-five intervention studies in the present paper add considerable evidence to support the effectiveness of stage-based interventions for dietary behaviour. Of the three interventions included in the Horwath review, only one was stage-matched, meaning that the intervention was tailored to the stage of each participant. In the present study, nineteen were stage-matched, including

**Table 3.** Summary of validation studies of the transtheoretical model (TTM) as applied to dietary behaviour

Study no. and reference	Research purpose	Sample characteristics	Study design and measures	Type of analysis	Findings	Implications
V1 De Oliveira <i>et al.</i> (2005) <sup>62</sup> Descriptive study	Create and validate a measure for assessing processes of change for fruit and vegetable consumption	Volunteer sample of 250 male college students: white American ( <i>n</i> 105); Latino ( <i>n</i> 53); Asian ( <i>n</i> 92)	Cross-sectional, written survey assessed: processes of change (created in this study), stage of change <sup>105</sup> , fruit intake, and vegetable intake	Principal-components analysis, analysis of covariance, two-way ANOVA and $\chi^2$ analysis were used	The authors created a valid and reliable processes-of-change survey instrument. Participants differed in their use of processes based on culture, with Asians using more processes than the other two groups. All participants used more cognitive processes than behavioural ones. Those in pre-action stages used fewer processes	Participants in pre-action stages used fewer processes than those in preparation, action or maintenance, as predicted by the TTM. The use of cognitive processes in lieu of behavioural ones is not predicted by the TTM. TTM-based interventions should be culturally specific
V2 De Vet <i>et al.</i> (2005) <sup>63</sup> Multiple time series study	Determine if stage of change, decisional balance and self-efficacy change in expected directions between precontemplation and contemplation for fruit intake	Random sample of 735 Dutch adults in precontemplation for fruit consumption (51 % female; response rate was 78 % at time 3)	Longitudinal, internet-based survey assessed: stage of change <sup>106</sup> , decisional balance, self-efficacy, and fruit intake. Measures assessed at baseline, 53 d and 106 d	Logistic regression was used; compared longitudinal and cross-sectional analysis of data	Pros predicted forward stage progression from both precontemplation and contemplation; cons predicted neither. Self-efficacy predicted forward stage movement from precontemplation. Fruit intake increased from precontemplation to contemplation	The TTM appears to accurately predict increases in fruit intake in early stages
V3 De Vet <i>et al.</i> (2005) <sup>64</sup> Multiple time series study	Predictability and stability of stage of change for fruit intake across all stages	Random sample of 735 Dutch adults (51 % female; average age 37 years; 61 % response rate)	Longitudinal, internet-based surveys assessed measures six times over 4 months using the following assessments: stage of change <sup>81</sup> and fruit intake	MANOVA for repeated measures and one-way ANOVA were used	Precontemplation and maintenance were the most stable stages; preparation was least stable. Stage stability was higher for shorter time durations than for longer ones. Subjects moved through the stages in a sequential, predictable pattern in most cases	Stage of change appears to be predictable and stable as adults move through the stages of fruit intake, although there was some variability in the patterns. In a small number of cases, participants reported moving through stages in theoretically impossible patterns, raising questions about the accuracy of staging for fruit intake

Table 3. Continued

Study no. and reference	Research purpose	Sample characteristics	Study design and measures	Type of analysis	Findings	Implications
V4 Di Noia <i>et al.</i> (2006) <sup>65</sup> Descriptive study	Develop scales for measuring processes of change, decisional balance and self-efficacy for fruit and vegetable consumption	Volunteer sample of 319 low-income African-American adolescents in New York City (age range 11–14 years; 65 % female; fifty-seven served in focus groups and pilot testing; 262 completed the survey)	Initially, a smaller focus group was used to generate items and develop the scales. The larger group was then used to test the scales via a written survey. Measures included: stage of change <sup>105</sup> , decisional balance, self-efficacy and the processes of change	Principal-components analysis, ANOVA and <i>t</i> tests were used to analyse the data	Adolescents who were in action or maintenance had lower cons and higher pros than did those in pre-action stages. They also used the processes of change more frequently. There was no differentiation between the use of cognitive and behavioural processes of change, though	TTM-based interventions for this population seem to be warranted. It is not clear from these results, though, which processes would be most useful for each stage. This is one of the first applications of a TTM-based fruit and vegetable intervention with this population
V5 Hargreaves <i>et al.</i> (1999) <sup>66</sup> Descriptive studies	Create a stage-of-change algorithm for assessing dietary fat intake	Two volunteer samples of 174 adult African-American females (average age 44 years) and 208 adult African-American females (average age 40 years); response rates not given	Two separate studies were conducted, measuring stage of change (created for this study), dietary fat intake, and dietary fibre intake	MANOVA, ANOVA, Pearson's correlation and hierarchical cluster analysis were used	Authors used data from study 1 to develop the eating styles questionnaire, which appeared to accurately place study 2 subjects into different stages	The eating styles questionnaire is useful for staging African-American women according to dietary fat intake
V6 Jordan <i>et al.</i> (2003) <sup>67</sup> Descriptive study	Create a stage-of-change algorithm to assess recovery from anorexia nervosa	Volunteer sample of 278 individuals in treatment for anorexia nervosa (70 % response rate)	Cross-sectional survey measured the following: readiness to change (i.e. stage of change), pros and cons (decisional balance), visual analogue recovery scale, and EAT-26	MANOVA, ANOVA, and discriminant function analysis were used	An algorithm that differentiated stages according to the subjects' readiness to stop bingeing and purging and to stop restricting foods appeared to accurately place subjects into correct stages	This algorithm can be useful for practitioners as they work with anorexic patients to achieve recovery. It can help them better understand, and therefore more effectively treat, these patients
V7 Kasila <i>et al.</i> (2003) <sup>68</sup> Descriptive study	Can stage distribution of patients with type 2 diabetes or impaired glucose tolerance regarding a variety of dietary behaviours be determined through open-ended dialogue during a counselling session?	Volunteer sample of sixteen Finnish patients recently diagnosed with type 2 diabetes or impaired glucose tolerance (sex not reported; all who were eligible participated)	Two trained nurses conducted two interviews each with sixteen patients. Deductive content analysis was used to analyse the thirty-two recorded counselling sessions	A non-validated rubric for analysis of counselling conversations was used	Readiness to change was variable among dietary behaviours assessed and was difficult to measure. Frequently, patients were in different stages for different dietary behaviours	Application of the TTM through counselling conversations is inconsistent, although the authors believe that it holds promise for effective counselling by nurses
V8 Lamb <i>et al.</i> (2004) <sup>69</sup> Descriptive study	Comparison of a previously published staging algorithm to a new algorithm to more accurately stage individuals for dietary fat intake	Volunteer sample of 375 employed adults in the UK (100 % white; 64 % male; average age 37 years; 57 % response rate)	Cross-sectional survey used the following measures: stage of change (Curry <i>et al.</i> <sup>104</sup> ), stage of change (Lamb <i>et al.</i> <sup>99</sup> ) and 24 h dietary recall	ANOVA and $\chi^2$ were used	The staging algorithm created in this study placed more subjects in pre-action stages	The staging algorithm in this study appears to correct for deficiencies in the standard algorithm by more specifically defining preparation as an 'inconsistently active' stage rather than an 'inactive' stage

V9 Ling & Horwath (2001) <sup>70</sup> Descriptive study	Create and validate a decisional-balance scale for fruit and vegetable intake	Random sample of 796 Chinese adults (52 % female; average age 39 years; 71 % response rate)	Cross-sectional survey using both mail and telephone assessed stage of change <sup>3</sup> , decisional balance, fruit intake and vegetable intake	Principal-components analysis, factor analysis and ANOVA were used	Forward stage movement predicted a large increase in pros and a smaller decrease in cons, which is consistent with the application of decisional balance to other behaviours. In this culture, taste and price considerations are not among the most important in choosing foods, unlike Western cultures	The decisional-balance scale appears to describe this population well. In early stages, it is most beneficial to emphasise the pros, or benefits, of changing. In later stages, reducing cons may be most helpful
V10 Ling & Horwath (2000) <sup>71</sup> Descriptive study	Is stage classification more accurate with use of an objective assessment of dietary behaviour?	Volunteer sample of 101 Chinese Singaporeans (51 % male; mean age 38.7 years; participation rate reported elsewhere)	Researchers tested the validity and predictive ability of two algorithms designed to classify individuals by stage of change for dietary goals	Validated, sixteen-item FFQ, telephone interviews for stage assessment (developed for this study) and three 24 h diet recalls were used	Grains, and fruits and vegetable servings increased variably across stage distribution. Stages of change explained 41 and 50 % of the variance in mean number of grains and total fruits and vegetable servings, respectively. Validity measures were adequate	Application of the TTM to food-based, rather than nutrient-based, goals might allow for more accurate staging of individuals
V11 Logue <i>et al.</i> (2004) <sup>72</sup> Multiple time series study	To determine if overweight patients who spend more time in the action and maintenance stages for dietary and exercise behaviours exhibit more weight loss than those who spend more time in pre-action stages	Random sample of 329 overweight adults in a primary-care setting (28 % African-American; age 40–69 years; 89 % retention rate)	Measures were taken at baseline and at 6, 12, 18 and 24 months. They included stage of change (unspecified), dietary fat intake, fruit and vegetable intake, exercise and body weight	Ordinal logistic regression analysis and $\chi^2$ were used to analyse the data	There was a direct positive relationship between spending more time in action or maintenance and increased weight loss. Of the behaviours studied, controlling portion sizes had the largest effect on weight loss	This is one of the first prospective random studies to analyse the relationship between time spent in action and maintenance, weight-loss behaviours and weight loss
V12 Ma <i>et al.</i> (2002) <sup>73</sup> Descriptive study	Examine the validity of stage of change, decisional balance and self-efficacy in describing fruit and vegetable intake	Random sample of 1545 young adults (61 % female; 90 % white; 55 % response rate)	Cross-sectional design employed an initial telephone interview, followed by mailed survey. It assessed stage of change <sup>81</sup> , decisional balance, self-efficacy, fruit intake, and vegetable intake	Principal-components analysis, cluster analysis and ANOVA were used	Self-efficacy and fruit and vegetable intake increased in a linear pattern from precontemplation to maintenance. Pros increased and cons decreased across the five stages in a predictable manner	The TTM appears to accurately describe young adults for fruit and vegetable intake
V13 Ma <i>et al.</i> (2001) <sup>74</sup> Descriptive study	Create a staging algorithm for fruit and vegetable intake	Volunteer sample (used quota sampling procedures) of 301 young adults (61 % female; 74 % white; 70 % response rate)	Cross-sectional, mailed survey measured stage of change <sup>82</sup> , fruit intake and vegetable intake	ANOVA, Pearson's correlation, factor analysis and cluster analysis were used	Three distinct stages emerged: precontemplation, preparation and maintenance. Separate analyses identified seven clusters that were slightly different for fruit v. vegetable consumption	This study supports the application of a staging algorithm to young adults for fruit and vegetable intake. However, research with a randomly selected sample is warranted for validation of the algorithm

Table 3. Continued

Study no. and reference	Research purpose	Sample characteristics	Study design and measures	Type of analysis	Findings	Implications
V14 Padula <i>et al.</i> (2003) <sup>75</sup> Descriptive study	Use focus groups to identify key concepts to incorporate in the development of instruments to assess TTM concepts related to fruit and vegetable intake	Volunteer sample of 105 adults (aged 60 years or over; 87% white; average age 75 years; response rate not given)	Adults were divided into low and high consumers of fruits and vegetables. Separate focus groups were conducted with each group. The 90 min sessions were tape-recorded	A series of open-ended questions, based on TTM concepts of decisional balance, process use and self-efficacy, were developed and used with the focus groups. Two independent researchers analysed and interpreted the data	Pros of eating fruits and vegetables that emerged included: weight control, better health, taste, nutritional value, reducing constipation and physician recommendation. Cons included cost, preparation difficulty, spoilage and chewing difficulty. Participants overwhelmingly reported preferring written self-help interventions	This study demonstrated the effective use of focus groups for TTM instrument development. Researchers were able to develop items for decisional balance, processes of change and self-efficacy that can be tested for validity
V15 Rossi <i>et al.</i> (2001) <sup>76</sup> Descriptive study	Validation of two instruments: decisional balance questionnaire for adolescent dietary fat reduction and the situational temptations questionnaire for adolescents	Volunteer sample of 2639 ninth grade students from twelve Rhode Island high schools (89% response rate)	Students completed an assessment of stage of change <sup>82</sup> , decisional balance (authors designed an assessment for this population) and situational temptations (authors designed an assessment for this population)	Structural equation modelling ANOVA and MANOVA were used to analyse the data	Pros were higher and cons were lower for subjects in contemplation and preparation, as compared with those in precontemplation. Students in different stages identified different situational temptations. This fits the TTM as predicted	Both measures appeared to be valid when used with an adolescent population
V16 Simmons & Mesui (1999) <sup>77</sup> Descriptive study	Develop a decisional-balance questionnaire and validate a readiness to change questionnaire to assess dietary fat reduction, weight control-related behaviours and exercise	First study volunteer sample of 105 Pacific islanders of New Zealand (67% female; age 17–80 years). Second study sample of 195 Pacific islanders of New Zealand (53% female; age 17–70 years). Participation rates (based on the size the invited population) not specified	The first study sample ( <i>n</i> 105) completed open-ended questionnaires which were used to develop a closed-ended decisional-balance scale. The second study sample ( <i>n</i> 195) completed the decisional-balance questionnaire and a previously-developed readiness to change questionnaire	Validation of the decisional-balance scale was conducted using both a binary and rank order method. The data from two randomly selected subsets of the second sample were analysed separately; however, few differences existed between the groups	The most frequent pros to changing each of the three behaviours were being healthier, avoiding disease and being more fit. The most frequent cons to changing each behaviour were losing too much weight, having to give up favourite high-fat foods and taking too much time to exercise. Women identified more pros than did men; less educated participants identified more cons than did those with college educations	Pacific island culture is unique compared with other cultures worldwide and diverse among the subgroups within it, making validation research particularly challenging. Given the epidemic levels of type 2 diabetes among Pacific islanders, the evidence for the validity of applying decisional balance and stage of change for dietary and exercise behaviour to this population is encouraging
V17 Snelling <i>et al.</i> (2006) <sup>78</sup> Descriptive study	Develop and validate a staging algorithm for Ca intake	Random sample of 180 male college students (92% response rate)	Measures included stage of change <sup>105</sup> and a FFQ	One-way ANOVA with <i>post hoc</i> comparisons were used to analyse the data	Participants in the pre-action stages consumed significantly less Ca than did those in action or maintenance. Of the college males, 46% were assigned to either action or maintenance with this algorithm. Self-efficacy scores increased with stage	The stage-of-change algorithm appears to accurately classify male college students for Ca intake

<p>V18 Sutton <i>et al.</i> (2003)<sup>79</sup> Descriptive study</p>	<p>To create a more accurate staging mechanism for weight-loss behaviour by identifying multiple weight-loss behaviours within the algorithm</p>	<p>Random selection of 329 participants in a weight-management programme (70% female; average age 52 years; response rate not given)</p>	<p>Measures included stage of change (authors developed algorithm for this study), dietary intake and self-reported exercise behaviour</p>	<p>Correlation, McNemar's tests and logistic regression were used to analyse the data</p>	<p>The multi-item algorithm placed half as many subjects in action or maintenance as did the single-item algorithm</p>	<p>The multi-item algorithm appeared to more accurately stage participants, avoiding the tendency of single-item algorithms to over-place participants into later stages</p>
<p>V19 Tucker <i>et al.</i> (2002)<sup>80</sup> Descriptive study</p>	<p>Develop a valid staging mechanism for Ca intake</p>	<p>Random sample of 344 college females (age 18–24 years; 91% response rate)</p>	<p>Self-reported Ca intake was assessed using a written food intake questionnaire. Stage of change (developed by the authors) and self-efficacy were assessed</p>	<p>A one-way ANOVA was used to analyse the data</p>	<p>Of the respondents, 40% were classified as being in action or maintenance for Ca intake. Significant differences were found between participants in each stage of change. Self-efficacy was higher for those in action and maintenance</p>	<p>This appears to be a valid and useful mechanism for assessing stage of change for Ca intake with a female college population</p>

MANOVA, multivariate ANOVA.

all of the studies using experimental and quasi-experimental designs.

### Validation studies

Of the nineteen validation studies summarised in Table 3, thirteen focused on the development and/or validation of a stage-of-change algorithm. These included one for each of the following behaviours or situations: fruit and vegetable intake (study number V8), dietary fat reduction (study numbers V5 and V16), readiness for recovery from anorexia nervosa (study number V6) and weight-loss behaviours (study numbers V16 and V18). In two studies, an algorithm was created for Ca intake (study numbers V17 and V19). Six studies included the development and testing of other TTM measures with specific populations. In four of these studies, decisional-balance measures for fruit and vegetable intake were created for Chinese adults (study number V9), senior citizens (study number V14), low-income African-American adolescents (study number V4) and middle-class adolescents (study number V15). One study featured the development of a decisional-balance scale to assess fruit and vegetable intake for culturally diverse male college students (study number V1). A second study featured the development of a decisional-balance scale to assess dietary fat reduction and other weight-loss behaviours among Pacific islanders (study number V16). Padula *et al.*<sup>75</sup> (study number V14) also tested the application of self-efficacy to fruit and vegetable intake with a senior citizen population. Di Noia *et al.*<sup>65</sup> (study number V4) developed both a processes-of-change scale and a self-efficacy assessment tool for low-income African-American adolescents to assess fruit and vegetable intake. Rossi *et al.*<sup>76</sup> (study number V15) also tested an instrument to measure situational temptations with the fruit and vegetable intake of adolescents.

Of the nineteen studies, only three used a prospective design and were designated as 'multiple time series' in Table 3. Eight studies randomly selected participants and eleven used convenience sampling methods. The populations of these studies varied widely, and included Dutch adults, British adults, Pacific islanders, Finnish diabetic patients, young adults, senior citizens, overweight females, African-American females, low-income African-American adolescents, middle-class adolescents, females with anorexia nervosa, female college students and culturally diverse male college students.

Of the three categories of studies in the present review (validation, population and intervention), the category studied in greatest depth in the Horwath<sup>4</sup> review was the group of validation studies. In her analysis of twenty-five studies attempting to validate one or more constructs of the TTM as related to dietary behaviour, Horwath<sup>4</sup> drew several important conclusions. The first was that it is much more complicated to stage individuals for dietary behaviour than for smoking behaviour. Many of the staging algorithms in her review tended to place individuals in action or maintenance, when in reality they were not yet in action for a specific nutrition behaviour. Another staging concern among staging nutrition behaviour is that some behaviours, such as consuming 30% or less energy from fat, are harder for consumers to measure than others, such as eating five

servings of fruit or vegetables per d. Horwath<sup>4</sup> suggested that future studies needed to offer simpler and more specific goals that consumers can easily assess within a short time frame. In the present review, two studies successfully addressed the issue of inaccurately identifying pre-action participants as being in action or maintenance through the development of new staging algorithms for fruit and vegetable intake (study number V8) and for multiple weight-loss behaviours (study number V18). No studies specifically attempted to identify dietary behaviours that were easy for participants to measure, and the most common behaviours measured were fruit and vegetable consumption and the reduction of dietary fat.

The second important finding of Horwath<sup>4</sup> was that the processes of change for dietary behaviour were minimally studied and validated, except for a few studies related to dietary fat reduction. In the present review, two studies (numbers V4 and V14) included the development of a tool to assess the use of the processes of change for fruit and vegetable consumption among low-income African-American middle-school students and diverse, male college students.

Horwath<sup>4</sup> identified a stronger body of studies linking self-efficacy with dietary behaviour, most notably dietary fat reduction and increases in fruit and vegetable consumption. As expected, individuals in pre-action stages had lower self-efficacy scores than did those in action and maintenance. One study in the present review included the application of self-efficacy to senior citizens for fruit and vegetable consumption (study number V14), although the authors did not specify how it applied to the study findings. Di Noia *et al.*<sup>65</sup> (study number V4) created a process-of-change scale for low-income African-American middle-school students and found that those in action or maintenance were more likely than their peers in pre-action stages to report using a greater number of the processes, although they did not report using the behavioural processes more frequently than the cognitive ones. (The TTM postulates that individuals are more likely to use the cognitive processes in pre-action stages and the behavioural processes in action and maintenance.)

Decisional balance also appeared to relate predictably with stage of change for dietary fat reduction, fruit and vegetable intake and increased consumption of milk products<sup>4</sup>, although two of the seven studies cited in Horwath's review were of unpublished results. Four studies in the present review included the development of a decisional balance instrument for a specific population. Ling & Horwath<sup>70</sup> (study number V9) found that a culturally specific decisional-balance scale to assess fruit and vegetable consumption among Chinese adults followed the same pattern as it does for other populations, with pros increasing in contemplation and cons decreasing in preparation, action and maintenance. A focus group method was used to identify pros and cons of fruit and vegetable consumption among senior citizens (study number V14). Di Noia *et al.*<sup>65</sup> (study number V4) found that decisional balance applied in predicted ways to a low-income African-American middle-school sample, with pros rated higher than the cons by the action stage. Simmons & Mesui<sup>77</sup> (study number V16) found that Pacific islanders identified

pros and cons that were culturally specific, yet also found support for the use of the decisional-balance construct with this population. Finally, a decisional-balance questionnaire was successfully developed to assess fruit and vegetable consumption among ninth-graders (study number V15).

## Conclusions

In this section of the review, we answer the three research questions on which the present review is based. We also evaluate the evidence for using stage-matched dietary behaviour interventions, using the criteria presented earlier in the paper. We begin by answering the three research questions in order.

*How has the transtheoretical model been used to describe the dietary behaviours and nutrition goals of populations?  
Have researchers been able to accurately classify participants according to stage for various dietary behaviours and nutritional goals?*

In the body of literature reviewed, the TTM has been applied mainly to describe fruit and vegetable intake or dietary fat intake, with very few studies focusing on other food groups or nutrients. Researchers have been able to classify participants accurately, and this success has been most consistently related to use of FFQ. Success in staging based on other food groups was demonstrated, but studies are too few to be able to identify scientific consensus. Inconsistency in staging occurred mainly when the focus was on nutrient intake rather than food intake, similar to what has been noted by Horwath<sup>4</sup>.

*What is the evidence for using stage-based interventions with populations to achieve positive nutritional goals and behaviours?*

Using the criteria established by Anderson & O'Donnell<sup>15</sup>, we rated the evidence as indicative for dietary fat reduction and suggestive for other dietary behaviours. While there are a growing number of studies supporting the use of stage-matched interventions for fruit and vegetable consumption, there are few, if any, studies which provide evidence for stage-matched interventions for other dietary behaviours. While nineteen studies supported the use of stage-matched interventions, two did not. These two studies both utilised non-white, low-income populations, suggesting that the interventions themselves and the algorithms used to assess stage of change may not apply equally to all socio-economic and cultural groups. Of the nineteen interventions using experimental or quasi-experimental designs, all were well designed with one or no threats to internal validity, adding to the evidence for the use of stage-matched interventions for dietary fat reduction and fruit and vegetable consumption.

In a recent review of thirty-seven TTM-based interventions employing a randomised control trial design<sup>83</sup>, the authors raised several important concerns with the quality of these studies and the inferences which can and should be drawn from them. This review, which included trials of interventions for dietary behaviour, smoking cessation, exercise, screening mammography, mental health treatment,

tobacco or alcohol prevention, and multiple lifestyle changes, demonstrated a lack of evidence for TTM-based interventions. One of the critical issues raised was the potential for poorly designed TTM-based interventions due to limited application of the model in assessing participants and creating interventions for them. Bridle *et al.*<sup>83</sup> found that, in many cases, interventions were vaguely described and staging mechanisms lacked evidence for validity. They attributed this to a limitation of the TTM itself in clearly discerning discrete stages and specifically identifying the processes of change that should be used in each stage. They also pointed out that, in many of these studies, the intensity of the TTM-based intervention was potentially greater than that of the comparison intervention, which could explain its apparent effectiveness in these studies. One potential limitation of drawing inferences from the Bridle *et al.*<sup>83</sup> review specific to dietary behaviour is that only five diet-related interventions met the review criteria and were included. These included three published articles in peer-reviewed journals, one doctoral dissertation and one conference proceedings abstract.

In the present review, we found some improvement among the intervention studies in two of the three problem areas identified by Bridle *et al.*<sup>83</sup>. In our judgment, ten of the nineteen experimental or quasi-experimental intervention studies provided sufficient detail about the interventions to allow other practitioners to replicate them. Four studies utilised the 'expert systems' approach<sup>46,47,50,51</sup>. Two studies used the Patient-Centered Assessment and Counseling for Exercise plus Nutrition<sup>40,52</sup>. Auslander *et al.*<sup>38</sup> clearly referenced the Eat Well, Live Well programme, Clark *et al.*<sup>41</sup> clearly cited the sources of the assessments used in patient counselling and Steptoe *et al.*<sup>58</sup> provided references for the Changes of Heart Program. In each of these studies, the authors specified the name of the intervention and referred to another source in which the intervention was described in detail. In addition, Resnikow *et al.*<sup>53</sup> both described within the article and referenced the Motivational Interviewing techniques used in this intervention. Of this same group of nineteen experimental or quasi-experimental intervention studies, only four included assessments of TTM measures other than stage of change. Prochaska *et al.*<sup>50,51</sup> also assessed processes of change and decisional balance in two studies. Finckenor *et al.*<sup>43</sup> used the processes of change to create stage-matched interventions for college students. Johnson *et al.*<sup>46</sup> also assessed processes of change and decisional balance in their expert system intervention for patients using cholesterol-lowering medications. While self-efficacy was measured in several other interventions, the additional presence of this measure alone was not considered evidence of using multiple TTM constructs, given that many behaviour-change theories incorporate self-efficacy. Finally, we fully concur with Bridle *et al.*<sup>83</sup> on the lack of intensity of interventions provided to participants in control or comparison groups. Almost all of the intervention studies in this review compared a stage-matched intervention to 'usual care' or to no intervention at all. It is no surprise that a TTM-based intervention would yield significantly better results than no intervention at all; this would be true for most interventions based on many of the existing health-behaviour theories. The more important

question is whether a TTM-based intervention is more effective than other types of interventions, particularly if other interventions require fewer resources to implement. We recommend that future research compare multiple interventions to determine which are the most effective and efficient.

It would be useful to see future research compare stage-matched to stage-mismatched dietary interventions. These types of studies have been conducted for tobacco<sup>84–88</sup> and physical activity<sup>89,90</sup>. It is important to note that these seven interventions varied in methodology and overall quality of design, yet all but one of the studies raise doubts as to the superiority of the stage-matched intervention over the stage-mismatched intervention.

*Do valid and reliable measures exist to describe the nutritional status and behaviours of populations using the transtheoretical model constructs? Do they still only exist for stage of change, or have measures been developed for processes of change, situational temptation, decisional balance and self-efficacy?*

Progress has clearly been made in developing valid and reliable stage-of-change algorithms for dietary behaviour, although more validation research is needed. Since the Horwath review in 1999<sup>4</sup>, the bulk of published validation literature has focused on the development of stage-of-change algorithms for specific populations. This is an important step forward, since staging algorithms appear to be culturally and demographically specific. Few researchers have sought to refine and improve existing algorithms to correct for the problem of placing pre-action individuals into action and maintenance, although more have developed algorithms for dietary behaviours that are easier for the average consumer to measure. It is encouraging that four published studies since the Horwath review have attempted to develop and validate measures for decisional balance, processes of change, situational temptations, and self-efficacy, but more studies on these constructs are needed.

Based on this body of literature, it was apparent that there is little consensus on the best algorithm to use for each dietary behaviour, although the existence of multiple validated algorithms add to the validity of the stage-of-change construct. Twenty-four different staging algorithms were used in these studies (including the eighteen identified among the population studies) and another four studies employed staging algorithms that were not identified at all (noted as 'unspecified' in Tables 1, 2 and 3). We estimate that approximately fifteen of these algorithms have been tested for validity and reliability, although it is difficult to discern this in a few studies. Some studies used algorithms that are specific to one behaviour, such as fruit and vegetable consumption or dietary fat reduction, while others used a form of the algorithm that was initially developed for smoking and simply adapted it for a nutrition behaviour or status. The most frequently used algorithms were for fruit and vegetable consumption<sup>81</sup>, dietary fat reduction<sup>82</sup>, and an adapted form of the algorithm created for smoking behaviour<sup>3</sup>.

The findings of the present review are limited in that we used a subjective method to categorise and evaluate each



study individually, as well as evaluate the body of literature as a whole. While we strove to use a systematic approach and clear criteria for the assessment of this literature, it remains a qualitative process that relies upon human judgment. While we tried to include all of the relevant literature, it is also possible that an appropriate study was inadvertently omitted from the present review.

We make the following recommendations for future research in the application of the TTM to dietary behaviour:

- (1) The use of previously tested and validated forms of a staging algorithm is desirable when possible, as well as the clear identification of the staging algorithm used. Correctly staging individuals is the cornerstone of all TTM applications. It would enhance the validity of the application of the TTM to dietary behaviour if consensus could be reached for the staging algorithm used with each dietary behaviour. This would be particularly useful for fruit and vegetable consumption and dietary fat reduction, as they appear to be the most often-studied behaviours.
- (2) The application of the entire TTM is important in designing and evaluating interventions, rather than just the stage-of-change construct. For example, it would be very useful to know which processes of change facilitate forward stage movement for each dietary behaviour, and how these vary between populations. Similarly, understanding how decisional balance, situational temptations and self-efficacy affect stage progression would also be useful in designing effective interventions.
- (3) More experimental studies are needed to determine if TTM-based dietary interventions are more effective than other kinds of interventions. The current evidence suggests that they are effective for dietary fat reduction and may be for fruit and vegetable consumption, but a larger body of evidence is needed to state this conclusively. Experimental studies are completely lacking for TTM-based interventions related to other dietary behaviours, and these are also warranted.

The progress that has been made in the body of research on the application of the TTM to dietary behaviour is encouraging. Several of Horwath's<sup>4</sup> concerns and recommendations for future research have been addressed; however, more research is needed to determine with confidence if employing the TTM to describe dietary behaviour and plan dietary interventions is the most effective way to promote healthier dietary intake for many populations.

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