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Transtheoretical model as a framework for promoting cardiovascular health through behaviour change: a systematic review

PhD, Ejiofor A. Ezika^{1*}, MBBS, Adaobi Nwankwo-Ezika²

¹School of Health and Life Sciences, University of the West of Scotland.

²Emergency Medicine Department, Southend University Hospital.

ABSTRACT

Introduction: Cardiovascular disease (CVD) remains the single leading cause of death around the globe. The Transtheoretical model (TTM) is a successful framework for guiding behaviour change programmes for several health behaviours, yet there are limited reviews on how TTM has been used to facilitate behaviour change associated with reduced CVD. Therefore, the aims of this systematic review are to determine (i) how TTM has been used in promoting physical activity, fruit and vegetable consumption, and smoking cessation and (ii) gaps in knowledge in the use of stage-based model to improve physical activity, intake of fruit and vegetables, and smoking cessation.

Materials and Methods: The approach to this systematic review was informed by current recommendations known as Preferred Reporting Items for Systematic Reviews and Meta-analysis Approach (PRISMA).

Results: Constructs of TTM were used in the design of studies, facilitation of health behaviour change, monitoring of change in the movement of the participants across the change continuum, and evaluation of the effectiveness of health behaviour programmes. TTM was incorporated with other models, including Health Belief Model (HBM), social-ecological model, and social cognitive theory to facilitate behaviour change. There were limited studies that used all the four constructs of TTM to promote health behaviour change.

*Correspondence to Author:

Dr Ejiofor A. Ezika,
University of the West of Scotland,
High Street, Paisley, UK.

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Conclusion: TTM is a promising tool for designing, facilitating, monitoring, and evaluating behaviour change associated with reduced cardiovascular disease (CVD). TTM may be incorporated with other models, including HBM, social-ecological model, and social cognitive theory to facilitate behaviour change.

Key words: Behaviour change; Transtheoretical model; Systematic review; Cardiovascular health

Introduction: Cardiovascular disease (CVD) remains the single leading cause of death around the globe. A wealth of evidence shows that majority of CVD risk factors, including hypertension, cholesterol, unhealthy diets, obesity, tobacco use, physical inactivity and diabetes can be controlled, treated or modified (Gaal et al., 2006; Mathers and Loncar, 2006). Improvement in the level of physical activity, intake of fruit and vegetables, and smoking cessation have shown to be useful in preventing CVD (Bennett et al., 2012; Li and Siegrist, 2012).

There have been studies that tested the effectiveness of the Transtheoretical model (TTM) in improving the level of physical activity, intake of fruit and vegetables, and smoking cessation worldwide (Robinson and Vail., 2012; De Vet et al., 2006; Marshall and Biddle, 2001). The TTM has four key constructs. The four key constructs are (i) the stages of change, (ii) a series of ten independent variables known as the process of change, (iii) self-efficacy and (iv) decisional balance. The TTM uses the stages of change to integrate the most powerful principles and processes of change from leading theories of counselling and behaviour change (Prochaska and Velicer, 1997). Behaviour change was often construed as an event, such as quitting smoking, drinking, or overeating. But TTM interprets change as a process involving progress via a series of five stages (Lach et al., 2004). The second major component of the TTM is the processes of change. While the Stages of Change indicates when particular shifts in intentions and behaviour occur, the Processes of Change describe how these shifts occur (Prochaska et al., 2013; Velicer et al., 1998). Decisional balance shifts in critical ways as people progress through the Stages of Change.

The TTM is a successful framework for guiding behaviour change programmes for several

health behaviours, yet there are limited reviews on how TTM has been used to facilitate behaviour change associated with reduced CVD. Therefore, the aims of this systematic review are to determine (i) how TTM has been used in promoting physical activity, fruit and vegetable consumption, and smoking cessation and (ii) gaps in knowledge in the use of stage-based model to improve physical activity, intake of fruit and vegetables, and smoking cessation.

Materials and Methods: The approach to this systematic review was informed by current recommendations known as Preferred Reporting Items for Systematic Reviews and Meta-analysis Approach (PRISMA) and the National Institute of Health Quality Assessment Tool for Observational Cohort and Cross-sectional Studies. (NIH, 2017; Hutton et al., 2015; Liberati et al., 2009). PubMed, SAGE, and ScienceDirect databases were used to systematically search the literature. Search terms were used to screen the titles and abstracts indicated in the flowchart of the search strategy (Figure 1). Only articles in the English language with full text were included. Research published between 2004 to 2014 were favoured as they have contemporary evidence-based perspectives as at the time this systematic review was completed.

Inclusion was limited to studies intended to reduce the incidence or risk of CVD through primary or secondary preventions. Specifically, studies that promote physical activity, intake of fruit and vegetables, and smoking cessation that reported clear approaches to the use of TTM and outcome measures are included. An initial screening of titles of the studies was carried out, and those that did not meet the inclusion criteria were excluded. A more detailed review of the remaining abstracts was conducted to ascertain their eligibility. Full texts of potentially eligible studies were obtained and reviewed to determine

if they merited inclusion.

Exclusion criteria included studies that are not relevant to cardiovascular (CV) health, secondary studies as well as studies published in foreign languages. Also excluded from the review are studies that do not incorporate TTM as a tool to facilitate physical activity, intake of fruit and vegetable, and smoking cessation. The selected research articles were read in details, and those that didn't meet inclusion criteria were excluded. A standardised data extraction form was used to

extract study characteristics, including the authors name, year and countries in which the studies were undertaken, participants' mean age or range, study design and duration, risk factors investigated, constructs of TTM reported and comments on how TTM was used. Data extraction and the quality of the studies were initially completed and reviewed by the first reviewer (EAE) and then checked for accuracy by the second reviewer (AN). Disagreement was resolved by discussion.

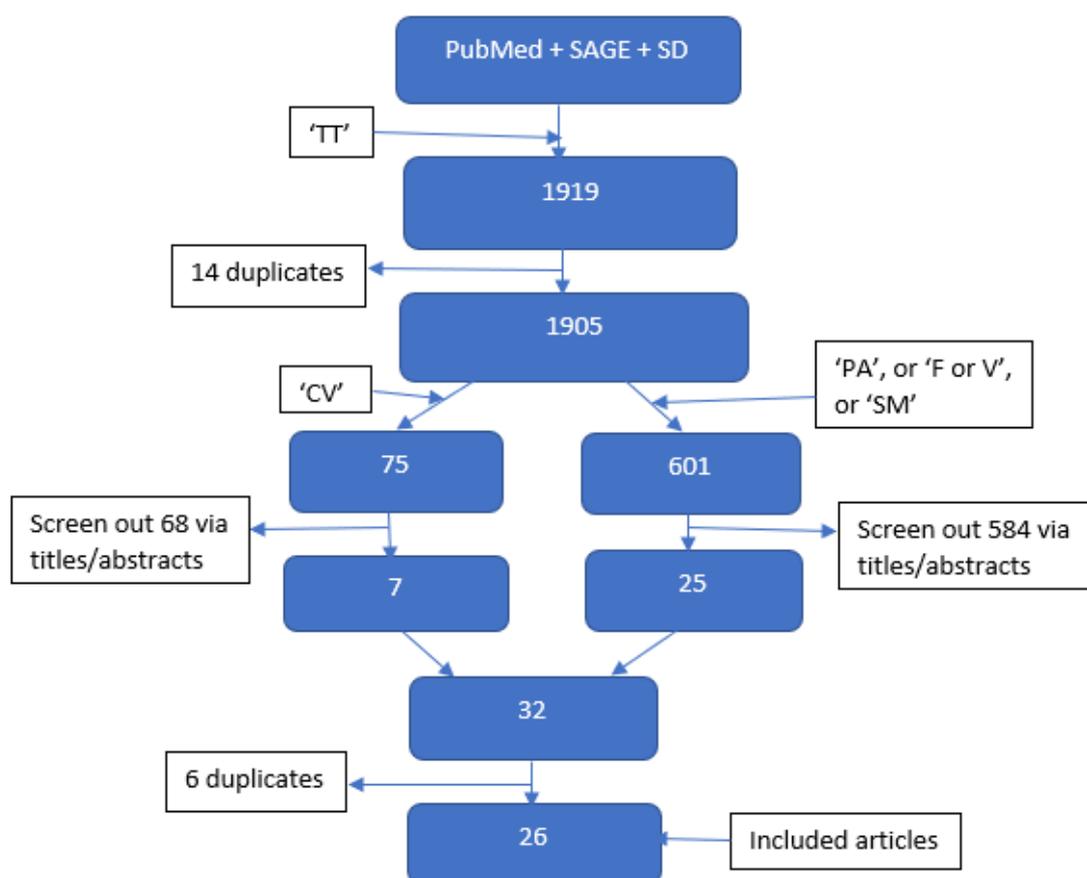


Figure 1. Search strategy. The diagram shows how 26 articles were selected for inclusion in this systematic review. The acronyms SD = ScienceDirect, TT = transtheoretical, CV = cardiovascular, PA = physical activity, SM = smoking, F = fruit, V = vegetable

Results: When the term 'transtheoretical' was used to search PubMed, SAGE, and ScienceDirect, 1919 articles were found, 75 articles also contained the term 'cardiovascular' in the title or abstract and 601 articles included a combinations of the term 'transtheoretical' with 'physical activity', or 'fruit' or 'vegetable', or 'smoking' from the three databases. After screening out duplicates and irrelevant titles and abstracts, 26

articles met criteria and were included for systematic review in this study. There were 16 intervention studies that used TTM to facilitate and/or monitor behaviour change. These included ten randomised controlled trials (RCT) and six quasi-experimental studies and are shown in Table 1. Eight cross-sectional studies and two longitudinal studies are shown in Table 2.

Table 1. Intervention studies:

Published between 2004-2014 that use the Transtheoretical Model to facilitate lifestyle changes associated with reduced cardiovascular risk

Publication: author year country	Participant: number age (mean or range) gender (% female) health	Study design	Duration	Risk factor investigated			Contracts of TTM reported, in addition to Stage of change			Comments
				Physical activity	Nutrition	Smoking	Process of change	Decisional balance	Self- efficacy	
Mochari et al. 2010 USA	n=501 48y 66% female healthy; family of hospitalised CVD patients	RCT	12 months		X					Determined impact of stage of change on effect of dietary intervention. Intervention group less likely to revert to lower levels on the stage continuum
Fahs et al. 2013 USA	n=117 35-65y 100% female healthy	RCT	14 months	X	X	X				Stages of change used in design of a community intervention for CV risk factors. Social-ecological model used to address issues of rurality.
Crabtree et al. 2010 USA	n=19 8-12y 58% girls obese	RCT	3 months	X	X		X			Stages of change of parent and child used in design of case management intervention. Significant effect of intervention on child stage of change.
Abdulla et al. 2005 China	n=952 89% <45y 16% female parent smokers	RCT	6 months			X	X	X	X	Stages of change used in design of telephone counselling intervention. Participant stages of change measured.
Zhu et al. 2014 China	n=196 89% >60y 27% female coronary artery disease	RCT	8 months	X			X	X	X	Study arms matched for stage of change; effect of 8-week education intervention on change stages of change maintained at 6-month follow-up.
Huang et al. 2013 Taiwan	n=355 32y 100% female pregnant or child <3y	RCT	1 month			X	X	X	X	Stages of change used in study design. Significant effect of intervention (educational materials and telephone counselling) on stage of change.
Nakamura et al. 2004 Japan	n=979 44y 2% female smoker + hypertension or hypercholesterolaemia	RCT	6 months			X				Stages of change used to determine individual counselling. Similar effect of counselling intervention regardless of stage of change.
Reusch et al. 2011 Germany	n=753 50y 48% female rehabilitation inpatients	RCT	12 months	X	X					Stages of change used in study design to assign participants to interactive small-group or lecture-based information-only intervention. Trends to more advanced motivation in interactive group.

Table 1. contd.

Publication: author year country	Participant: number age (mean or range) gender (% female) health	Study design	Duration	Risk factor investigated			Constructs of TTM reported, in addition to Stage of change			Comments
				Physical activity	Nutrition	Smoking	Process of change	Decisional balance	Self- efficacy	
Menezes et al. 2014 Brazil	n=118 58y 100% female healthy	RCT	6 months	X	X		X		X	Participant stage of change used in selection and development of group interventions. Stage of change not re-assessed.
Dunton & Robertson 2008 USA	n=156 43y 100% female healthy	RCT	3 months	X			X	X	X	Stages of change used to monitor and tailor website/weekly email intervention activities. TTM in combination with the Health Belief Model. No impact of intervention on stage of change at follow-up.
Topp et al. 2009 USA	n=63 5-10y gender not specified 60% overweight/obese	Quasi- experimental	14 weeks	X	X		X			Stages of change used in design of an intervention. Participant stage of change not measured.
Gillespie & Lenz 2011 USA	n=35 51y 83% females CVD-prone	Quasi- experimental	6 months	X	X	X			X	Stages of change used to determine behaviour change strategies. No difference in stage of change at follow-up.
Dawson et al. 2008 Canada	n=355 45y 67% females healthy	Quasi- experimental	10 weeks	X			X		X	Stages of change used to determine relevant approach to an web-based compared to a group-based educational intervention; in combination with social cognitive theory; impact on self-efficacy.
Huang et al. 2009 Taiwan	n=130 100% females healthy	Quasi- experimental		X				X	X	Stages of change used in study design and to match participants; impact on self-efficacy.
Salehi et al. 2011 Iran	n=400 over 60 y healthy	Quasi- experimental	4 weeks		X			X	X	Stages of change used in study design and in monitoring; weekly face-to-face interviews; impact on self-efficacy and decisional balance
Skaal & Pengpid 2012 South Africa	n=200 81% females healthy hospital staff	Quasi- experimental	4 weeks	X						Stages of change used in design, selection and monitoring impact of four interventions.

Table 2. Cross-sectional and longitudinal studies:

Published between 2004-2014 that use the Transtheoretical Model to facilitate lifestyle changes associated with reduced cardiovascular risk

Publication: author year country	Participant: number age (mean or range) gender (% female) health	Study design	Risk factor investigated			Constructs of TTM reported, in addition to Stage of change			Comments
			Physical activity	Nutrition	Smoking	Process of change	Decisional balance	Self-efficacy	
Di Noia and Thompson 2012 USA	n=549 11-14y 61% females healthy	Cross-sectional		X		X			Stages of Change was used to categorise participants into low consumers of fruit and vegetable (pre-action stages) and high consumers (action and maintenance stages).
DiNoia et al. 2006 USA	n=262 11-14y 65 girls healthy	Cross-sectional		X		X	X	X	Questionnaire was used to determine Stages of Change for fruit and vegetable consumption using one-item staging instrument with a five-choice response options.
Salehi et al. 2010 Iran	n=400 60y and over 75% females healthy	Cross-sectional	X				X	X	Participants were categorised into five Stages of Change. Details of the categorisation was not stated
Charkazi et al. 2012 Iran	n=578 18-49y females excluded smokers and ex-smokers	Cross-sectional			X			X	Dichotomous scale was used to determine Stages of Change of smokers
De Vet et al. 2006 Netherlands	n=2500 35y 65% female online group	Cross-sectional		X		X	X	X	Questionnaire was used to determine Stages of Change for fruit, vegetable and fish consumption using one-item staging instrument with a five-choice response options.
Mao et al. 2014 China	n=81 14y 49% girls healthy	Cross-sectional		X		X	X	X	Dichotomous scale was used to determine Stages of Change of participants for fruit and vegetable consumption
Maruf et al. 2014 Nigeria	n=499 18y and older 80% female healthy	Cross-sectional	X				X	X	Dichotomous scale was used to determine Stages of Change of participants for physical activity
Girma et al. 2010 Ethiopia	n=384 31y 8% female smokers	Cross-sectional			X	X	X	X	Self-report was used to determine Stages of Change of participants for smoking behaviour
Kosma et al. 2012 USA	n=132 50y 77% female neurological disorder	Longitudinal	X			X	X	X	Stages of Change was categorised into four stages (Precontemplation, Contemplation, Preparation and Action). Action Stage reflects a combination of Action and Maintenance Stages.
De Vet et al. 2008 Netherlands	n=735 38y 51% female healthy	Longitudinal		X		X			Stage of change was operationalized by a single-item algorithm by asking participants to select from five statements, each representing a stage of change, the most applicable to their personal situation

Ten research articles used in this systematic review were conducted in North America, making it the continent where the largest number of research articles used in this study was carried out. Out of these ten, nine were conducted in the USA, making it the country with the highest number of studies used in this systematic review. Nine studies were carried out in Asia, three in Europe, three in Africa, and one in South America. A cross-sectional study used TTM to explore the relationships among decisional balance, self-efficacy, and physical activity level in relation to stages of change for physical activity among Nigerian vendors.

All the 26 included studies in this systematic review used Stages of Change construct. 17 studies used Self-efficacy; 15 studies used Process of Change while 13 used Decisional Balance constructs. Some of the approaches integrated with TTM to promote physical activity include distribution of pamphlets about physical activity and health, posters, set fun runs, sports day, a daily radio program, and aerobic classes. Some of the methods that were used in the research articles included in this systematic review to promote smoking cessation include Intervention programmes that consisted of educational materials and phone counselling. In some of the studies, participants were supported in identifying and overcoming barriers to health behaviour change through the provision of practical tips.

TTM was sometimes used in conjunction with other theories and models. One research article integrated TTM with the Health Belief Model (HBM), one research article integrated TTM with social-ecological model while another integrated TTM with social cognitive theory (Fahs et al., 2013; Dawson et al., 2008; Dunton and Robertson, 2008). In the study that integrated TTM and HBM to promote physical activity, TTM was used to identify readiness to change and tailor activities accordingly while HBM was used to reduce barriers to physical activity by providing suggestions for overcoming them (Dunton and Robertson, 2008). The study that integrated TTM with social-ecological model used a web-based health programme in combination with an annual

health fair to promote physical activity, nutrition, and smoking cessation. TTM was used in the identification of stage of change and development of the Stage-Matched Nursing and Community Intervention. A Social-ecological model was used to address issues of rurality in the development of interventions (Fahs et al., 2013). The number of participants that were involved in the included studies varied considerably. A cross-sectional study had the highest number of participants with 1142 people while the RCT of obese children had just 19 participants. The duration of the studies ranged from one month to fourteen months, however, the majority of the research lasted for at least six months and three studies lasting for one year or more. The studies were diverse in terms of types of intervention and outcome measures. Nine of the research studies described complex interventions and outcome assessment involving a combination of varieties of activities, including physical activity, blood lipid and BMI assessment, monitoring of heart rate, medication management, blood pressure monitoring, healthy eating, and smoking cessation programmes. Eight of the studies are specifically on physical activity promotion, five on smoking cessation, and four on promotion of intake of fruit and vegetables. Some studies used a number of instruments and approaches including, pedometer, blood pressure monitor, assessment of lipid and glucose concentrations as part of clinical evaluations to objectively confirm reported behaviour change as well as monitor the impact of public health intervention on health outcomes.

Four studies involved all female participants while none involved all male participants. Four research articles involved child participants with a focus to promote physical activity as a means to tackle childhood obesity. Eight studies involved participants with CVD-prone conditions. These participants have one or a combination of hypertension, dyslipidemia, obesity, diabetes, and smoking behaviour. The primary purpose of these studies was to reduce diastolic and systolic pressure, cholesterol, and Framingham risk scores. All the interventional studies (RCT and

quasi-experimental) suggested an increase in health behaviour for physical activity, fruit and vegetable consumption, and smoking cessation compared with control groups. The authors focused on describing the studies, their approaches and results as well as their limitations rather than meta-analysis because the study designs, participants, interventions, and reported outcome measures varied markedly.

Discussion: TTM was used in the study design, the design of an intervention, assessment of readiness to change or in monitoring behaviour change. In some studies, participants were assigned into different Stages of Change: Pre-contemplation, Contemplation, Preparation, Action and Maintenance (Salehi et al., 2011). These categorisations were carried out at either pre-intervention, or, pre-and-post intervention (Mochari et al., 2010). In some studies, Stages of Change was used in the study design. Cognitive or behavioural intervention was designed based on the participants' Stages of Change. The strategies and techniques used to motivate individual in the Precontemplation or Contemplation stage to change their health behaviour is different for those in Action or Maintenance stage. In Abdulla et al. (2005), for example, stage matched smoking cessation self-help materials were designed to target smokers at different stages of readiness to stop smoking. For the participants who were in the Preparation or Action stage, the self-help materials emphasised the benefits of quitting and provided tips as to how to become a successful quitter. For those in the Pre-contemplation or Contemplation stage, the self-help materials described the harms of smoking and benefits of quitting and provided tips as to how to move through Stages of Change and become a successful quitter. Stages of Change were also used for monitoring the movement of the participants across the change continuum (Gillespie and Lenz, 2011; Dawson et al., 2008). In one of the studies, Stages of Change was dichotomised into Maintenance verses others, because those in Maintenance have already made health behaviour changes for at least six months, and participants in other states have not yet, or are in

the process of making health behaviour changes (Mochari et al 2010).

In one of the studies, participants in Pre-action stages (an indication that intake of fruit and vegetable was < 5 daily servings) were labelled low consumers, and those in Action and Maintenance stages (an indication that intake was ≥ 5 daily servings) were labelled high consumers (Di Noia and Thompson, 2012). A study categorised Stages of Change into four stages (Precontemplation, Contemplation, Preparation and Action). Action Stage reflects a combination of Action and Maintenance Stages (Kosma et al., 2012). In some studies, dichotomous scale was used to determine Stages of Change of participants for smoking behaviour and physical activity (Char-kazi et al., 2012; Mao et al., 2014; Maruf et al., 2014). In other studies, questionnaire was used to determine the participants' Stages of Change for fruit, vegetable and fish consumption using one-item staging instrument with a five and seven-choice response options (De Vet et al., 2006; DiNoia et al., 2006). One of the studies operationalized Stage of Change by a single-item algorithm by asking participants to select from five statements, each representing a stage of change most applicable to each participants' personal situation (De Vet et al., 2008).

The cross-sectional studies focussed on the relationship between the constructs of TTM and health behaviour. The specific Process of Change, Decisional balance, Pros and Self-efficacy ratings were positively correlated with Stages of Change transition (Mao et al., 2008). TTM Processes of Change are associated with consumption of ≥ 5 daily servings of fruit and vegetables (DiNoia et al., 2012). Consciousness raising, Environmental reevaluation, helping relationships and Stimulus control processes were significantly associated with fruit and vegetable consumption and were practised more often by youths who consumed ≥ 5 daily servings of fruit and vegetables relative to those who did not ($p < .05$). Lack of knowledge, low perceived benefits, low self-efficacy, and high perceived barriers towards physical activity could lead to lower levels of physical activity (Salehi et al., 2010).

In a cross-sectional study in the Netherlands, it was found that Stages of Change and changes in fruit, vegetable and fish intake were only weakly associated; Decisional balance and Self-efficacy were more strongly associated (De Vet et al., 2006). Strong Pros predicted progress out of Precontemplation, and low Self-efficacy predicted relapse from Action/ Maintenance for all behaviours. Progress out of Contemplation and out of Preparation showed different patterns for fruit, vegetable and fish intake.

The National Institute of Health Quality Assessment Tool for Observational Cohort and Cross-sectional Studies (NIH, 2017) was used to assess the strengths and the weaknesses of the included studies. One of the strengths of this systematic review is that the research objectives of all the research included in the systematic review were clear and unambiguous. Also, all the participants for the intervention and control groups in each of the intervention studies included in this study were recruited from the same or similar populations and at the same period. Furthermore, the inclusion and exclusion criteria for the participants recruited to each study were prespecified and applied uniformly to the selection of the participants. The loss in participants at follow-up in each intervention studies was less than 20%.

One of the limitations of the studies included in this systematic review is that thirteen out of the twenty-six research studies did not carry out a sample size justification, power description, or variance and effect estimates. However, this flaw is mitigated by the fact that four out of the thirteen studies are cross-sectional studies and two are longitudinal studies which are exploratory and may not require power description, or variance and effect estimates. Another limitation is that a few studies included in this systematic review did not measure discreet categories of exposures that were used, but instead, exposures were measured as continuous variables. For example, a study conducted in Taiwan by Huang et al. (2013) included education and phone counselling as a means to support mothers with young children and pregnant women to

avoid passive smoking. In the study, it was reported that the intervention lasted for one month. It was not clear how often and how long each session of the education and phone counselling lasted. Providing information on the number of exposures would enable investigators to assess trends or dose-response relationships between exposures and outcomes.

Another limitation is that only one RCT was blinded out of the sixteen intervention studies (ten RCT and six quasi-experimental). Some empirical studies had shown that certain methodological characteristics such as poor concealment of treatment allocation or no blinding in studies exaggerate treatments effects (Pildal et al., 2007). The implication of this is that the included studies may have been affected by outcome assessment bias. In the study by Huang et al. (2013), biochemical results (urine or saliva cotinine results) were not included as outcome measures, the significance of results is therefore limited by the nature of self-report. Also, individuals may regress to a lower stage of behaviour change when they encounter new difficulties or barriers in changing health behaviour. Thus, long-term follow-up may be needed to track the maintenance of passive smoking avoidance behaviour.

Despite the limitations, this systematic review indicates that it may indeed be important to include TTM in health-promoting interventions aimed at stage progression for increasing physical activity, fruit and vegetable intake, and smoking cessation. Some studies suggest that for individuals unmotivated to change, interventions should focus on cognitive as well as behavioural strategies, and that motivated people should be exposed to behavioural strategies to help them to action. The effectiveness of these approaches, and the contribution of TTM in particular, will require larger well-controlled prospective studies in which the use of TTM is clearly delineated in the methodology and is compared to other theoretical frameworks. It seems reasonable to conclude, however, that TTM, integrated with other approaches may be used in complex public health interventions to promote

change in public health knowledge, physical activity, consumption of fruit and vegetables, and smoking cessation, tailored to all age groups, including children and older adults. Public health strategies involving TTM may also be used to promote health behaviour change in those with CVD-prone conditions, pregnant women, and women with young children. The relationships among the constructs of TTM requires further exploration in relation to a specific health behaviour.

There are gaps in knowledge that were uncovered in this systematic review. There are limited studies that incorporated TTM to promote health behaviour change associated with reduced CVD in Europe, South America, and Africa, and just one study in Nigeria. This was a cross-sectional study that explored Decisional balance, Self-efficacy, and physical activity level in relation to Stages of Change for physical activity among Nigerian vendors. This fact suggests a gap in knowledge in the use of TTM to promote health behaviour change in the Nigerian context. There are limited studies that used all the four constructs of TTM to promote health behaviour change.

TTM in combination with other strategies is used as a tool to promote health behaviour change associated with reduced CVD. TTM is used to promote secondary prevention in patients with CVD-prone conditions, including diabetes and hypertension. It is also used to promote physical activity, intake of fruit and vegetables, and smoking behaviour in healthy populations as a means to promote primary prevention of CVD. Constructs of TTM may be used in the design of studies, facilitate health behaviour change, monitor change in the movement of the participants across the change continuum, and evaluate the effectiveness of health behaviour programme. TTM may be incorporated with other models, including HBM, social-ecological model, and social cognitive theory to facilitate behaviour change. Stages of Change construct is the most widely used TTM construct followed by Self-efficacy. The studies varied widely in designs, age of participants, duration, and interventions,

therefore, the outcomes cannot be compared. The effectiveness of these approaches, and the contribution of TTM in particular, will require larger well-controlled prospective studies in which the use of TTM is clearly delineated in the methodology and is compared to other theoretical frameworks.

Conflict of interest

No conflict of interest declared

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