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Testing the Assumptions of Stage of Change for Fruit and Vegetable Consumption: A Naturalistic Study

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1. Introduction

Chronic disease now accounts for 7 of every 10 deaths in the United States and 60% of the nation's health expenditures [1]. Poor nutrition is a substantial contributor to the chronic disease burden, accounting for over $33 billion in medical costs and $9 billion in lost productivity per year [1]. Fortunately, many detriments of chronic disease, such as increased risk for heart disease [2-4], stroke [5, 6], diabetes [7, 8], osteoporosis [9], and cancer [10, 11], can be prevented through adoption of a healthy diet. Fruit and vegetables are an integral part of a healthy diet, and they provide many nutrients that may reduce the risk for some types of cancers and chronic disease [12-16]. To achieve this protective effect, disease prevention guidelines recommend that individuals consume at least five servings of fruits and vegetables a day [17, 18]. However, data from the 50 US states indicates that 70-80% of US adults fall short of these recommendations [19].

The substantiated link between poor diet and the epidemic prevalence of chronic disease in America necessitates population-based interventions aimed at increasing fruit and vegetable consumption. Explanatory theories of behavior change, such as the Transtheoretical Model (TTM), can help guide intervention programs in developing the most effective strategies for promoting and sustaining change in a population. Over the past two decades, the central organizing construct of the TTM, the stages of change has experienced widespread use as well as pointed criticisms [20]. The model postulates that people move through a series of five stages of change in their attempts to modify their problem behaviors [21]. As people change stages, they employ mediating processes such as self-efficacy and decisional balance, differentially making each stage unique. Five stages of change have been identified: precontemplation (no intention to change behavior in the foreseeable future, or denial of need to change); contemplation (intention to change within the next 6 months); preparation (serious intention to change in the next 30 days); action (initiation of overt behavioral change); and maintenance (sustaining behavioral change for 6 months or more) [21].

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Although the TTM was originally developed as a framework for smoking cessation, it has gained widespread use over the past two decades as the basis of formalized treatment programs and population-based interventions for over a dozen health-related behaviors. The TTM has been adapted to many areas of behavior change including eating behaviors [22], exercise adoption [23], condom use [24], and several others [25].

With the great popularity of the stages of change construct in particular, careful measurement work has not always been conducted when adapting the construct to a new behavior. Over the past few years, several research papers have examined the cross-sectional relationship between the stages of change for fruit and vegetable intake and other related variables [26-31].

Research on self-change in naturalistic populations is necessary to assess the efficacy of stage of change models. While the vast majority of the literature is cross-sectional, a longitudinal approach is "more in line with the temporal nature of the model" because it can expose processes and patterns of change at the individual level that may be masked by a cross-sectional, population-based design [32].

Weinstein and colleagues (1998) have outlined four properties of a stage theory of health behavior [33]. The first is a classification system to place individuals into discrete stages. The second characteristic is an ordering of the stages. It is assumed here that although people can move both forward and backward between the stages they are most likely to move to adjacent stages in their attempts to change. It is also predicted that on a population level the closer a stage is to action, the more likely those people are to move into action in the future. The final two characteristics of a stage theory are common barriers to change facing people in the same stage and different barriers to change in different stages. For instance, the TTM postulates that experiential processes are important for early stage changes such as precontemplation to contemplation, while behavioral processes are important for later stage changes for example preparation to action [21]. Two alternatives also exist to the interpretation of a stage model: pseudostages created from a continuous variable, for instance motivation (linear pseudostage), and pseudostages created from a general algebraic equation, including interactions and limits on variables (non-linear pseudostage) [33].

Four research designs have been developed for testing the efficacy of stage models [33]. The first and most common design is to examine cross-sectional comparisons of people in different stages. In this approach, an analysis of variance is typically conducted to assess differences across the stages of change for certain variables which are predicted to differ by stage. While the largest body of research is conducted in this area it provides a weak test of stage model which cannot rule out a non-linear pseudostage [33]. The second design for testing the stage of change construct is the examination of stage sequences. This requires longitudinal data and often predicts movement between pre-action stages to action [34]. The prediction is that people who start in stages closer to action will be more likely to move to action over time. Stage transitions across more than two time points can also be examined to assess if changes are more likely to occur to adjacent stages. However, data collection periods can often miss transitions in stage. This also does not rule out either pseudostage. The third design is the longitudinal prediction of stage transitions. This design tests the assumption that different constructs are important for different stage transitions. For instance, behavioral processes are more important for the transition from preparation to action than from the transition from precontemplation to contemplation. This data helps

establish that motivation is not a continuum but that real quantitative differences occur between the stages, supporting the stage model and the non-linear pseudostage model [33]. The final design is an experimental study of matched and mismatched interventions, where participants are randomized to either a stage appropriate intervention or a non-stage appropriate intervention. This method provides the best test of the stage model by formally testing the assumptions that a stage matched intervention is superior to a mismatched intervention [33].

In this study, we will examine three of Weinstein and colleagues (1998) tests of a stage model [33], summarized in Table 1. First, cross-sectional comparisons of people in different stages will be assessed by behavior and related psychosocial variables. Then stage sequences will be examined over three time points. Finally, longitudinal prediction of stage transitions by baseline behaviors and related psychosocial variables will be conducted.

1. Cross-sectional comparisons of people in different stages Supports a stage theory if: a. Attributes of people differ across stages b. The patterns of differences across stages vary from one attribute to another
2. Examination of Stage Sequences Supports a stage theory if: a. Successive stages follow the hypothesized sequence
3. Longitudinal Predictions of Stage Transitions Supports a stage theory if: a. Predictors of stage transition vary from stage to stage

Table 1. Research Designs for Testing Stage Theories

2. Methods

2.1 Data collection

A longitudinal survey using random digit dialing of Hawaii's non-institutionalized adult population was conducted from February to April of 2002 [34]. The person over 18 who had the last birthday was asked to complete the interview to provide randomization within household. Informed consent was obtained over the phone. The survey took approximately 20 minutes to complete. All procedures were approved by the University of Hawaii Committee on Human Subjects. Interviewers were trained on the survey in small group settings for 6 hours in both classroom and live phone settings. Interviewers were assisted by a computer aided telephone interview (CATI) system designed specifically for the survey. Skip patterns and out of range responses were automatically controlled by the system. Follow-up surveys were conducted at 6 and 12 months post-baseline.

During the follow-up, at least five attempts were made to contact the participants. Respondents were also given the option to callback at their convenience. Primary reasons for non-completion included disconnected phone numbers, no longer living at current number, no callback by participants, and no answer.

2.2 Measures

Participants were asked a series of demographic questions, including age, sex, height, weight, education attained, income level, marital status, ethnic identification, language spoke at home, and perceived health. Participants were then asked about behaviors and other variables related to fruit and vegetable consumption.

Fruit and Vegetable Intake was assessed using a short "all day" assessment developed by the National Cancer Institute [35]. This instrument has been shown to have good reliability compared to actual intake and is recommended for population based research [35].

Stage of Change relative to consumption of fruits and vegetables was assessed. The instrument (Figure 1) inquired about participants' fruit and vegetable intake followed by their intentions to consume five or more servings per day. Participants were classified into one of five stages; (1) Precontemplation – Do not eat 5-a-day with no intentions to do so in the next 6 months; (2) Contemplation – Do not eat 5-a-day but intend to do so in the next six months; (3) Preparation – Do not eat 5-a-day but intend to in the next month; (4) Action – Currently eating 5-a-day, but for less than six months; (5) Maintenance - Currently eating 5-a-day for more than six months [36].

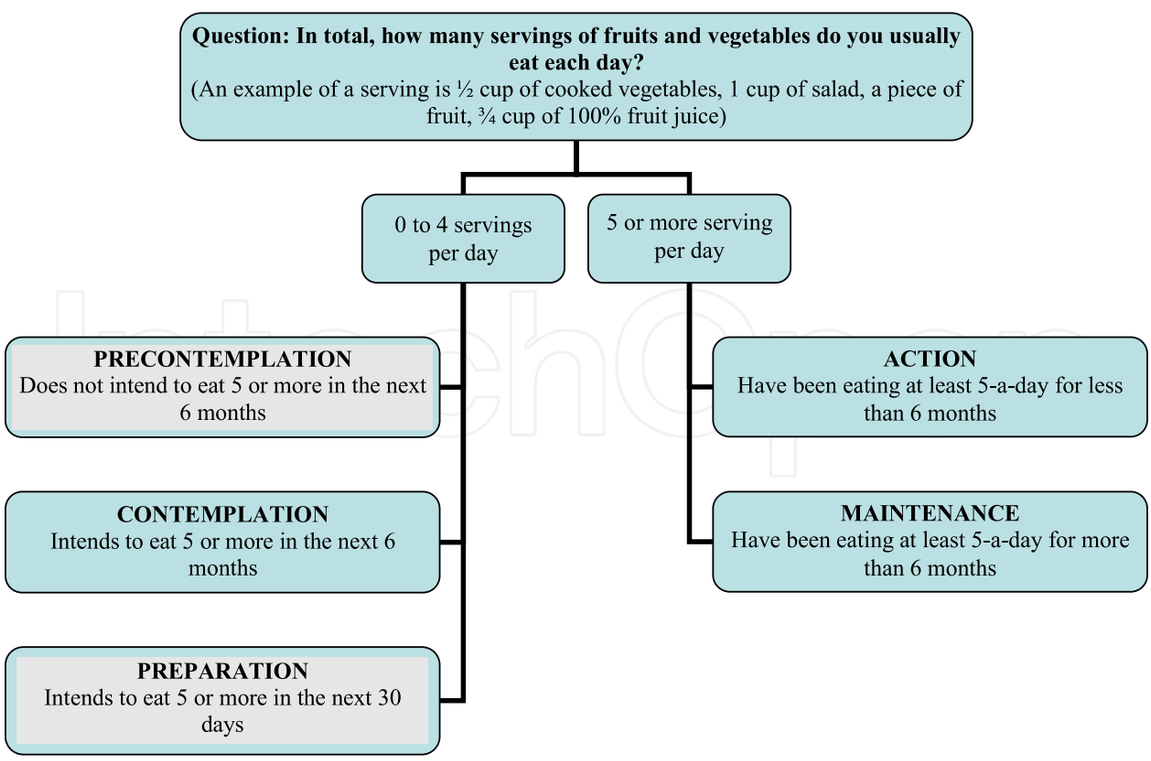

Fig. 1. Stage of Change Instrument

Self-Efficacy for eating 5-a-day was assessed with a 10-point continuous scale from (1) Not at all confident to (10) Very confident; "How confident are you that you can eat 5 or more servings of fruits and vegetables per day?"

Intentions, subjective norm, perceived behavioral control and attitude from the Theory of Planned Behavior were also assessed [37].

Subjective Norm was measured using three continuous 10-point scale items from (1) strongly disagree to (10) strongly agree. Satisfactory alpha levels for this scale were α = .82 and .86 at baseline and 1 year. Questions included: "Most people who are important to me think I should be eating 5-a-day on a regular basis"; "People in general approve of eating 5-a-day"; and "Most people who are important to me would like me to eat 5-a-day".

Perceived Behavioral Control was measured using three continuous 10-point scale items. The higher the score meant the greater the endorsement of the item. Satisfactory alpha levels for this scale were α = .76 and .79 at baseline and 1 year. Questions included: "If I wanted to I could easily eat 5-a-day on a regular basis" (1) strongly disagree to (10) strongly agree; "How much control do you have over the number of times you eat 5-a-day" (1) very little control to (10) complete control; and "For you to eat 5-a-day on a regular basis is……" (1) extremely difficult to (10) extremely easy.

Attitudes were measured using four continuous 10-point scale items. Satisfactory alpha levels for this scale were α = .83 and .84 at baseline and 1 year. One question was asked followed by four different response sets: "Eating 5-a-day regularly is…." (1) harmful to (10) beneficial; (1) foolish to (10) wise; (1) unenjoyable to (10) enjoyable; and (1) unpleasant to (10) pleasant.

2.3 Analysis

The SPSS System for Windows version 11.5.0 was used for all data analyses [38]. For all analyses, only individuals who completed both the baseline and 12 month assessment were included. T-tests and chi-square analyses were used to assess differential dropout between baseline and the 12 month follow-up. Mean differences in behavior, self-efficacy, intentions, subjective norm, perceived behavioral control and attitudes for fruit and vegetable consumption were examined across stages of change at baseline using an analysis of variance (ANOVA). Longitudinal stability of the stages of change was examined using the Cohen's kappa test of inter-rater reliability. Stage transitions were examined descriptively by examining the pattern of stage transition across baseline, 6 months and 12 months. For this analysis, the contemplation and preparation stages were combined as were the action and maintenance stages. This was done due to very small sample sizes in both contemplation and action. Patterns of change were assessed using similar categories to Prochaska and colleagues (1991). They included: 1. Stable – in the same stage all three time points; 2. Progressing – moving forward at least one stage with no setbacks; 3. Relapse – moving backward at least one stage without returning to the original stage; 4. Mixed inverted V pattern – participants first increased and then decreased their stage, for example moving from contemplation to action and then back to contemplation; 5. Mixed V pattern – participants first decreased and then increased their stage, for example moving from action to contemplation and then back to action [39].

Baseline differences in behavior and the related psychosocial variables were examined as possible stage change predictors by looking at each baseline stage of change and assessing which stage the individual moved into at 12 months. One-way ANOVAs with follow-up Tukey tests were used to assess significant differences by baseline stage.

3. Results

3.1 Sample characteristics

A total sample of n=3,519 respondents completed baseline surveys (22.8% response rate), with n=2,390 (67.9%) completing the six month follow-up, and N=1,978 completing the 12 month follow-up (56.2% of baseline). At baseline, the mean age was 46.3 years, with a mean of 14.9 years of education, and a median income of $40,000 to $50,000 per year. A greater percent of females participated in the study (62.0%). The sample was ethnically diverse with 86% of the sample comprised of Caucasian, Japanese, Filipino, Chinese, and Native Hawaiians. A mean of 3.1 fruits and vegetables were consumed per day by participants. All demographic variables are displayed in Table 2.

3.2 Attrition analysis

Differential attrition rates by demographic variables and behavior were analyzed. No significant differences were found across gender and fruit and vegetable consumption. Small but significant differences existed across age, income level, education, and ethnicity, $p < .001$. Those less than 35 years of age, a household income of less than $40,000, and no college education experienced a higher rate of attrition. Those of Japanese ethnicity showed the greatest percent of retention as compared to other ethnicities. The main reason for non-response was an inability to contact the participant (63.3%) after five attempts. Demographic characteristics of participants who completed the study and those who dropped out are presented in Table 2.

3.3 Missing data analysis

Missing data was assessed for all of the variables of interest including stage of change, fruit and vegetable consumption, intentions, self efficacy, attitudes, subjective norms and perceived behavioral control. None of these variables had more than 10% missing data across both baselines, 6 months and 12 months. With the low level of missing data and the large sample size, no corrections were made for missing data and the case was eliminated from the analysis.

3.4 Stage distributions

First, the stage distributions were examined across both time points, individually. Almost identical results were found with 39.2% in precontemplation (38.2% at 12 months), 5.4% in contemplation (4.2% at 12 months), 34.8% in preparation (36.7% at 12 months), 2.2% in action (1.9% at 12 months) and 18.4% in maintenance at baseline (18.9% at 12 months).

	6 Months		12 Months	
Demographics	Dropout (n = 1129)	Retain (n = 2390)	Dropout (n=1541)	Retain (n=1978)
Gender				
% Male	41.4	38.9	41.9	38.0
% Female	58.6	61.1	58.1	62.0
Age				
Mean (SD) in yrs	42.8 (16.4)	**48.0 (16.0)	43.1 (16.4)	**48.8 (15.8)
Ethnicity[1,2]				
% Caucasian	32.5	35.0	33.2	35.0
% Hawaiian / part-Hawaiian	18.7	17.6	19.3	16.9
% Japanese	15.5	20.7	14.9	22.2
% Filipino	10.8	8.7	11.0	8.2
% Other	22.5	18.0	21.7	17.7
Education				
Mean yrs (SD)	14.2 (3.0)	**14.9 (3.1)	14.4 (3.0)	**14.9 (3.2)
Income[1,2]				
< $40,000	49.8	39.3	47.4	39.0
$40,000-$49,999	11.9	11.2	12.2	10.9
> $49,999	38.3	49.5	40.4	50.1
Behavior				
Mean fruit and vegetable intake	3.0 (1.83)	3.1 (1.82)	3.1 (1.9)	3.1 (1.8)

** Significant t-test ($p < .001$)
1 = Significant Chi-Square Test at 6 months ($p < .001$)
2 = Significant Chi-Square Test at 12 months ($p < .001$)

Table 2. Attrition comparison by baseline demographics at 12 months

3.5 Behaviors and related constructs by stages of change

Differences in behavior and related constructs for fruit and vegetable consumption were examined across stages of change at baseline for self-efficacy, intention, subjective norms, perceived behavioral control, and attitude. Significant differences in behavior and all related constructs were observed across stages of change, $p < .001$ (Table 3). The largest effect sizes were found across stages of change for behavior, intentions and self efficacy; $\eta^2 = .624$,

η^2=.310 and η^2=.304 respectively. These three variables showed significant differences across almost all of the stage transitions. Attitudes and subjective norms were important for differentiating between precontemplation and the other stages and perceived behavioral control was significant in differentiating between maintenance and the other stages.

	Behavior N = 1884	**Self-Efficacy** N = 1917	**Attitudes** N = 1890	**Subjective Norm** N = 1791	**Perceived Behavioral Control** N = 1891
Precontemplation	2.09 (1.02)	5.32 (2.92)	8.23 (1.83)	6.45 (2.64)	6.69 (2.30)
Contemplation	2.51 (1.14)	6.65 (2.52)	8.57 (1.68)	7.40 (2.30)	7.22 (2.23)
Preparation	2.73 (1.00)	7.94 (2.00)	9.02 (1.47)	7.82 (2.34)	7.97 (1.86)
Action	5.53 (0.91)	8.19 (1.76)	9.23 (1.08)	8.02 (1.87)	7.91 (2.01)
Maintenance	5.87 (1.44)	9.27 (1.37)	9.55 (0.98)	8.34 (1.95)	9.20 (1.19)
F-value	F(4,1879) = 780.39, p < .000	F(4,1912) = 209.03, p < .000	F(4,1885) = 49.97, p < .000	F(4,1786) = 45.50, p < .000	F(4,1886) = 103.97, p < .000
eta^2	.624	.304	.096	.092	.181
Tukey post-hoc test[1]	PC < All C < A,M P < A,M	PC < All C < P,A,M P,A < M	PC< P,A,M C < M	PC < All C < M P < M	PC< P,A,M C < P,M P,A < M

PC = Precontemplation, C = Contemplation, P = Preparation, A = Action, M = Maintenance.

Table 3. Behavior and mediators by stage of change at baseline

3.6 Examination of progression to action/maintenance

While a high level of stability in stages of change was found cross-sectionally, longitudinal results yielded a small yet significant Cohen's kappa correlation at κ = .246, indicating a low level of stability from baseline to 12 months, p < .001 (Table 4). Less than half of those in maintenance at baseline remained after 12 months. Precontemplators showed the greatest level of stability at 59.2%. Baseline stage of change was a significant predictor of action and

maintenance status at 1 year with only 8.0% of precontemplators reaching action or maintenance compared to 7.9% of contemplators, 22.1% of individuals in preparation, 38.1% of individuals in action and 49.1% of individuals in maintenance ($p < .01$). Table 4 displays the stage transitions from baseline to 12 months.

	Stage at 6 Months n = 2390				
Baseline[1]	PC (%)	C (%)	P (%)	A (%)	M (%)
Precontemplation	**58.8**	4.9	27.4	2.4	6.6
Contemplation	36.0	**16.2**	33.3	3.6	10.8
Preparation	25.3	4.8	**49.6**	2.1	18.2
Action	14.6	2.1	41.7	**2.1**	39.6
Maintenance	15.3	1.1	26.5	4.6	**52.5**
	Stage at 12 months n = 1978				
Baseline[2]	PC (%)	C (%)	P (%)	A (%)	M (%)
Precontemplation	**59.2**	5.1	27.7	0.8	7.2
Contemplation	37.3	**8.8**	46.1	2.0	5.9
Preparation	26.9	3.7	**47.3**	2.6	19.5
Action	14.3	7.1	40.5	**4.8**	33.3
Maintenance	18.4	1.7	30.7	2.3	**46.8**
	Stage at 12 months n = 1831				
6 Months[3]	PC (%)	C (%)	P (%)	A (%)	M (%)
Precontemplation	**66.3**	5.1	22.6	0.2	5.9
Contemplation	34.5	**8.3**	48.8	4.8	3.6
Preparation	26.5	2.7	**54.0**	2.7	14.1
Action	24.5	8.2	32.7	**2.0**	32.7
Maintenance	11.9	3.5	26.8	2.7	**55.1**

1 = Cohen's kappa; $\kappa = .289$, $p < .001$
2 = Cohen's kappa; $\kappa = .246$, $p < .001$
3 = Cohen's kappa; $\kappa = .349$, $p < .001$

Table 4. Longitudinal stability of stage of change for 5-a-day over 6 and 12 months

3.7 Examination of stage sequence

Stage sequence was then assessed across the 3 time points. Stable patterns were the most common for individuals in precontemplation (43.3%) and maintenance (32.5%) at baseline. The contemplation stage was very unstable with only 3.7% of respondents who began in contemplation remaining there for all three time points. Overall, more than a third (34.5%) of participants remained in the same stage over the three time points. Over the 12 month time period, about one-quarter (24.6%) of respondents progressed without relapse through the stages and one-fifth (19.3%) relapsed without progress. Precontemplators (40.4%) and contemplators (34.6%) were the most likely to progress, while maintainers (45.6%) were the most likely to relapse. Mixed patterns of change were also common with 11.7% of respondents showing the mixed inverted V pattern and 9.9 showing the mixed V pattern. Table 5 shows the patterns of stage transitions for all of the stages.

Precontemplation (n = 669)	**N**	%
Stable	290	43.3
Progressing	270	40.4
Relapse	N/A	
Mixed inverted V	109	16.3
Mixed V	N/A	

Contemplation (n = 81)	**N**	%
Stable	3	3.7
Progressing	28	34.6
Relapse	18	22.2
Mixed inverted V	19	23.5
Mixed V	13	16.0
Preparation (n = 597)	**N**	%
Stable	181	30.3
Progressing	115	19.3
Relapse	129	25.0
Mixed inverted V	66	11.1
Mixed V	86	14.4

Action (n = 39)	**N**	%
Stable	0	0
Progressing	9	23.1
Relapse	15	38.5
Mixed inverted V	6	15.4
Mixed V	9	23.1
Maintenance (n = 326)	**N**	%
Stable	116	35.6
Progressing	N/A	
Relapse	149	45.7
Mixed inverted V	N/A	
Mixed V	61	18.7
Overall (n = 1712)	**N**	%
Stable	590	34.5
Progressing	422	24.6
Relapse	331	19.3
Mixed inverted V	200	11.7
Mixed V	169	9.9

Note: 1. Stable – in the same stage all three time points; 2. Progressing – moving forward at least one stage with no setbacks; 3. Relapse – moving backward at least one stage without returning to the original stage; 4. Mixed inverted V pattern – participants first increased and then decreased, for example moving from contemplation to action and then back to contemplation; 5. Mixed V pattern – participants first decreased and then increased, for example moving from action to contemplation and then back to action.

Table 5. Stage sequences across 3 time points

3.8 Longitudinal prediction of stage transitions

Longitudinal prediction of stage transitions was then assessed by stage for behavior and the related psychosocial variables over the 12 month time period. All of the variables significantly predicted change across time except for subjective norms and behavior which did not predict relapse among people in action and maintenance at baseline. Self efficacy was the strongest predictor of relapse. Behavior was the strongest predictor of movement

from contemplation and preparation to action or maintenance. Intention was the strongest predictor of change out of precontemplation. For transitions into stages, attitude and subjective norm predicted change from precontemplation to contemplation/preparation and perceived behavioral control predicted change from preparation to action/maintenance. All of the longitudinal predictors of stage transition are displayed in Tables 6 and 7.

Stage at 6 months					
Baseline	PC	C/P	A/M	F value	η^2
Behavior					
PC	1.99 (0.99)	2.19 (0.99)[1]	2.71 (1.05)[2,3]	F(2,853) = 19.02 p < .001	.045
C/P	2.53 (1.05)	2.59 (1.05)	3.15 (0.87)[2,3]	F(2,888) = 22.93 p < .001	.052
A/M	5.78 (2.00)	5.61 (1.14)	5.99 (1.35)[3]	F(2,485) = 3.45 p < .05	.014
Attitude					
PC	8.03 (1.88)	8.57 (1.67)[1]	8.60 (1.75)[2]	F(2,858) = 9.60 p < .001	.022
C/P	8.61 (1.68)	9.01 (1.36)[1]	9.38 (0.98)[2,3]	F(2,895) = 15.92 p < .001	.036
A/M	9.25 (1.15)	9.48 (0.88)	9.61 (0.99)[2]	F(2,481) = 3.92 p < .05	.016
Subjective Norm					
PC	6.19 (2.70)	6.76 (2.68)[1]	6.47 (2.44)	F(2,814) = 3.96 p < .05	.010
C/P	7.20 (2.47)	7.97 (2.17)[1]	8.07 (2.22)[2]	F(2,859) = 10.26 p < .001	.024
A/M	7.98 (2.04)	8.15 (1.95)	8.44 (1.82)	F(2,438) = 2.07 p = ns	----
Perceived Behavioral Control					
PC	6.41 (2.33)	6.91 (2.28)[1]	7.12 (2.33)[2]	F(2,860) = 5.97 p < .01	.014
C/P	7.33 (2.15)	7.96 (1.82)[1]	8.43 (1.65)[2,3]	F(2,896) = 17.96 p < .001	.040
A/M	8.67 (1.68)	8.85 (1.40)	9.39 (1.01)[2,3]	F(2,481) = 14.10 p < .001	.059
Self Efficacy					
PC	4.83 (2.88)	5.72 (2.66)[1]	5.75 (3.00)[2]	F(2,869) = 10.61 p < .001	.024
C/P	7.43 (2.21)	7.74 (2.08)	8.49 (1.85)[2,3]	F(2,907) = 14.12 p < .001	.031
A/M	8.86 (1.77)	9.04 (1.50)	9.45 (1.11)[2,3]	F(2,484) = 7.74 p < .001	.032

Note: PC = Precontemplation, C = Contemplation, P = Preparation, A = Action, M = Maintenance.
1 = C/P > PC for Tukey post-hoc test ($p < .05$)
2 = A/M > PC for Tukey post-hoc test ($p < .05$)
3 = A/M > C/P for Tukey post-hoc test ($p < .05$)

Table 6. Baseline behavior and mediator score by 12 month stage of change

Stage at 1 Year					
Baseline	PC	C/P	A/M	F value	η^2
Behavior					
PC	1.98 (1.00)	2.18 (1.08)[1]	2.57 (1.06)[2,3]	F(2,719) = 9.83, p < .001	.028
C/P	2.43 (1.04)	2.68 (1.02)[1]	3.18 (0.83)[2,3]	F(2,739) = 26.1, p < .001	.066
A/M	5.70 (1.95)	5.64 (1.04)	6.00 (1.34)	F(2,389) = 2.8, p = .06	----
Attitude					
PC	7.97 (1.87)	8.63 (1.70)[1]	8.56 (1.73)[2]	F(2,721) = 11.5, p < .001	.031
C/P	8.64 (1.82)	9.02 (1.40)[1]	9.32 (1.18)[2]	F(2,746) = 9.8, p < .001	.026
A/M	9.03 (1.28)	9.63 (0.66)[1]	9.61 (1.04)[2]	F(2,384) = 10.2, p < .001	.051
Subjective Norm					
PC	6.19 (2.71)	6.74 (2.52)[1]	6.83 (2.48)	F(2,689) = 3.9, p < .05	.011
C/P	7.30 (2.51)	8.03 (2.24)[1]	7.81 (2.20)	F(2,712) = 6.6, p < .001	.018
A/M	7.97 (2.02)	8.44 (1.77)	8.33 (2.00)	F(2,353) = 1.3, p = ns	----
Perceived Behavioral Control					
PC	6.47 (2.32)	6.80 (2.32)	7.51 (1.98)[2]	F(2,722) = 5.8, p < .01	.016
C/P	7.37 (2.13)	7.95 (1.86)[1]	8.49 (1.59)[2,3]	F(2,746) = 15.7, p < .001	.041
A/M	8.30 (1.95)	9.00 (1.26)[1]	9.40 (0.95)[2,3]	F(2,385) = 19.1, p < .001	.091
Self Efficacy					
PC	4.97 (2.96)	5.75 (2.83)[1]	5.98 (2.64)[2]	F(2,733) = 7.5, p < .001	.020
C/P	7.47 (2.15)	7.72 (2.17)	8.31 (1.84)[2,3]	F(2, 757) = 7.4, p < .01	.019
A/M	8.26 (2.13)	8.98 (1.44)[1]	9.64 (0.83)[2,3]	F(2,388) = 28.1, p < .001	.127

Note: PC = Precontemplation, C = Contemplation, P = Preparation, A = Action, M = Maintenance.
1 = C/P > PC for Tukey post-hoc test (p < .05)
2 = A/M > PC for Tukey post-hoc test (p < .05)
3 = A/M > C/P for Tukey post-hoc test (p < .05)

Table 7. Baseline behavior and mediator score by 12 month stage of change

4. Discussion

This study examines the psychometric properties of the stage of change construct for fruit and vegetable consumption following three of the four research designs for testing stage models outlined by Weinstein and colleagues (1998) [33]. First, stage distribution was

assessed. Over one-third of respondents were in the preparation stage of change. While this is unusual for most proactively recruited samples [25] it is consistent with other fruit and vegetable staging results [40, 27]. Next, cross-sectional comparisons of individuals in different stages showed significant differences for fruit and vegetable consumption and self efficacy as well as related constructs from the Theory of Planned Behavior including attitude, intention, subjective norm and perceived behavioral control. Attitude, self efficacy and intention all varied linearly across the stage of change. Perceived behavioral control showed a non-linear relationship with no increase between preparation and action and a large increase between action and maintenance. Attitude and subjective norms showed significant differences in the early stage with little difference between contemplation, preparation and action. Fruit and vegetable intake increased dramatically between preparation and action due to the definition of action requiring consumption of five servings of fruit and vegetables a day. These findings support the ability of stage to differentiate between related psychosocial constructs among people at different stages and support both a true stage model and the non-linear pseudostage model over the linear pseudostage model.

Stage of change was then examined longitudinally. Stage membership varied greatly over the year with less than half of respondents remaining in the same stage of change. However, the construct did show predictive validity with individuals in preparation almost three times as likely to reach action and maintenance than those in precontemplation at baseline. The preparation stage was also reached by 18% more contemplators than precontemplators at 12 months. Individuals who began the study in maintenance were also the most likely to be in maintenance at the end of the study. Participants in preparation, action and maintenance at baseline were more likely to be in action or maintenance at 12 months than those who started at precontemplation or contemplation. This supports the assumption that the stage of change for fruit and vegetable consumption are temporally ordered, with preparation the closest to action [33].

Next, we looked at patterns of change across the three time points. Stable patterns were the most common for individuals in precontemplation and maintenance. This is consistent with finding with stage of change for smoking [39]. Overall, we saw about one-third of participants remaining stable in their stage, one-quarter linearly progressing, one-fifth linearly regressing and one-fifth showing unstable patterns. With little longitudinal data available of stage transitions for fruits and vegetables it is difficult to compare or contrast these results to other studies. Although Weinstein et al (1998) recommend the examination of stage sequences even they admit that, "labeling a changing pattern of transition probabilities as gradual or abrupt is somewhat subjective, so sequence data may not be very conclusive" [33]. This appears to be the case here, with the stage transition data neither supporting nor refuting the stage model. The six month time point is probably too long for what appears to be a fairly unstable behavior.

Finally, we examined the longitudinal prediction of stage transitions. All of the variables showed some predictive validity, although the effect sizes were small. According to the TTM, cognitive strategies are important for early stage progress, while behavioral processes are important for later stage progress [21]. While this study did not examine the processes of change it does contain both experiential (attitude, subjective norm) and behavioral (perceived behavioral control) psychosocial constructs. We would therefore expect that attitude and subjective norm predict change from precontemplation to

contemplation/preparation and perceived behavioral control predicts change from preparation to action/maintenance. Similar to our cross-sectional findings, the data does appear to support this assumption.

5. Conclusions

Overall, the stage of change measure for fruit and vegetable consumption is well supported by these analyses. The measure differentiates between individuals cross-sectionally, provides prediction for progress to action, and does appear to show properties relevant to an actual stage model over a linear pseudostage model. These analyses do not settle the debate between stage models and a non-linear pseudostage model, since matched and mismatched interventions are needed to examine this difference. They do, however validate the utility of the stage of change measure as an important tool for designing population interventions to increase fruit and vegetable intake. Stage of change is widely used in practice due to its utility in interventions. Stage-based expert system technology has been shown to be an important tool in reaching [41, 42]. However, Weinstein and colleagues (1998) last test of matched and mismatched interventions are still uncommon, with two small studies in physical activity and smoking not supporting improved efficacy of a stage-matched intervention [43, 44].

This study has several limitations. We did not use all of the constructs from the Transtheoretical Model including decisional balance and the processes of change. Instead several constructs from the Theory of Planned Behavior were used. Although this is not entirely consistent with the TTM, since it is a *trans*-theoretical model it is not surprising that the constructs showed similar relationships across stage to the ones postulated by Prochaska and DiClemente (1983) [45]. This approach also follows what other authors have shown, with non-Transtheoretical Model constructs varying by stage of change including attitude and expectancies [46, 47]. Also differential dropout occurred across several demographic categories. However, this appeared to be related to a younger, more mobile population rather than active refusals.

To our knowledge, this is the largest study of the fruit and vegetable staging construct to examine Weinstein and colleagues (1998) first three research designs and one of the only studies for any behavior to examine the longitudinal predictors of stage transition [33]. Several questions still need to be addressed to further improve the stage of change instrument. The most important is probably the 30 day criteria for precontemplation and the 6 month criteria for maintenance. These timeframes have been applied almost universally to every behavior that stage of change has been applied to with little rationale except historical precedence. For fruit and vegetable intake, the preparation stage is endorsed by over 40% of the population yet only 22% of these individuals were in action or maintenance after one year. This might be an area where additional examination is needed since action for an acquisition behavior is very different than from cessation of an addictive behavior. Finally, intervention research testing matched and mismatched groups is needed for fruit and vegetable intake to assess the feasibility of the stage model compared to the non-linear pseudostage model.

6. Competing interests

The authors declare that they have no competing interests.

7. Authors' contributions

JM conceptualized the paper, conducted the study, and wrote a large section of the manuscript. JB conducted the statistical analysis. CM drafted sections of the manuscript. As co-investigator, CN also participated in the conception and design of the study and provided comments on the manuscript.

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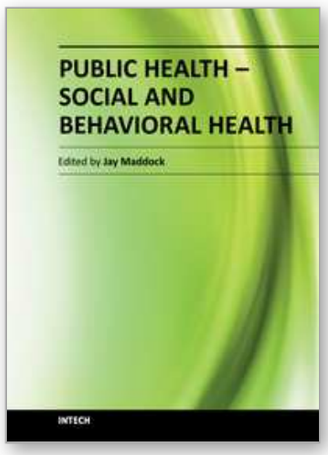

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