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Title: Comparative efficacy of simultaneous versus sequential multiple health behavior change interventions among adults: a systematic review of randomized trials

Running title: simultaneous versus sequential systematic review

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25 **ABSTRACT** (words=244)

26 **Background:** Growing evidence points to the benefits of addressing multiple health behaviors rather than
27 single behaviors.

28 **Purpose:** This review evaluates the relative effectiveness of simultaneous and sequentially delivered
29 multiple health behavior change (MHBC) interventions. Secondary aims were to identify: a) the most
30 effective spacing of sequentially delivered components; b) differences in efficacy of MHBC interventions
31 for adoption/cessation behaviors and lifestyle/addictive behaviors, and; c) differences in trial retention
32 between simultaneously and sequentially delivered interventions.

33 **Methods:** MHBC intervention trials published up to October 2015 were identified through a systematic
34 search. Eligible trials were randomised controlled trials that directly compared simultaneous and
35 sequential delivery of a MHBC intervention. A narrative synthesis was undertaken.

36 **Results:** Six trials met the inclusion criteria and across these trials the behaviors targeted were smoking,
37 diet, physical activity, and alcohol consumption. Three trials reported a difference in intervention effect
38 between a sequential and simultaneous approach in at least one behavioral outcome. Of these, two trials
39 favoured a sequential approach on smoking. One trial favouring a simultaneous approach on fat intake.
40 There was no difference in retention between sequential and simultaneous approaches.

41 **Conclusions:** There is limited evidence regarding the relative effectiveness of sequential and simultaneous
42 approaches. Given only three of the six trials observed a difference in intervention effectiveness for one
43 health behavior outcome, and the relatively consistent finding that the sequential and simultaneous
44 approaches were more effective than a usual/minimal care control condition, it appears that both
45 approaches should be considered equally efficacious.

46 **Key words:** multiple health behavior change, preventive care, simultaneous, sequential, effectiveness

47 **PROSPERO registration number:** CRD42015027876

48

49 **Introduction (count = 4431)**

50 The presence of multiple health risk behaviors has a synergistic negative influence on health [1-4],
51 resulting in higher rates of premature mortality, increased morbidity [2], and an increased healthcare
52 burden [5]. It is plausible that multiple health behavior change (MHBC) interventions [6]; that is,
53 interventions that target two or more health behaviors [6], could increase health benefits and reduce
54 healthcare costs [6]. As such, they have been identified as a strategic priority by governments in the US,
55 the UK and Australia [7-9].

56

57 Previous reviews of the effectiveness of MHBC interventions are mixed [4, 10-15]. Three reviews that
58 focused on cardiovascular disease and its behavioral risk factors [10, 11, 15], concluded that MHBC
59 programmes were effective in decreasing cardiovascular risk factors [10, 11] and have a small but
60 potentially important effect on mortality and cardiac events [10, 11, 15]. In contrast, a 2011 review of
61 MHBC interventions for primary prevention ([4]; 150 trials) reported conflicting outcomes for
62 interventions targeting diet and physical activity; that treating an addictive behavior alongside smoking
63 resulted in greater sobriety from alcohol and illicit drugs compared to treatment that excluded smoking
64 cessation care, and; effects were more consistent for cancer prevention compared to cardiovascular
65 disease prevention interventions [4].

66

67 Whilst MHBC interventions appear promising, major questions remain unanswered about how best to
68 accomplish MHBC; including whether to intervene simultaneously or sequentially [16-18]. The
69 simultaneous approach is suggested to be time and cost-effective [4]. However, it may also be more
70 overwhelming and place too many demands on a person's inherent ability to change their behavior. The
71 theory of **cross-behavior regulation** (the regulation of at least two health behaviors) suggests that
72 performing multiple health behaviors requires much effort [19]. Similarly, **self-control strength model**
73 [20] and **ego-depletion** [21] suggests that efforts in one domain can have implications for one's capacity
74 to self-regulate in other domains. This could cause individuals to feel over-burdened and prematurely

75 drop out of the intervention program [12, 22]. In addition, simultaneous interventions may also fail to
76 address any behavior in sufficient depth, reducing the potential for an intervention effect [17, 23, 24].
77 Delivering interventions sequentially may overcome many of these limitations and be better suited for
78 developing stronger habits [25]. If individuals successfully meet one behavior (eg. exercise), self-
79 regulatory resources occupied by one behavior (e.g. exercise-specific demands) become vacant and can
80 be invested in other behavior tasks (eg. planning healthy diet) [26]. Analogous is the concept of **spillover**
81 **effects** (a.k.a. transfer or gateway effects) where success in one domain results in increased self-efficacy
82 to tackle a second behavior [27]. However, a potential complication are **compensatory health beliefs** [28],
83 which suggest that efficacy of a sequentially delivered intervention is likely to negatively impact on other
84 current behaviors. Additionally, a sequential approach often requires delivery of the interventions over a
85 longer time, potentially increasing cost and reducing participant adherence [6, 29]. Further, the most
86 appropriate spacing to address each targeted behavior when implementing a sequential MHBC
87 intervention is unknown [16].

88
89 It is also unclear whether some behaviors are (more) amenable to simultaneous intervention than others.
90 Behaviors influencing health include health-enhancing (exercise and eating healthily), protective (condom
91 use or participating in screening), and harm avoidance (avoiding smoking or drug taking) behaviors [30].
92 There may also be psychological differences in habit formation and behavior change for cessation
93 behaviors (e.g. consuming less fat) compared to adoptive behaviors (e.g. consuming more vegetables) [6].
94 In addition, interventions may address addictive behaviors (e.g. smoking) that have a physiological
95 withdrawal associated with cessation that is not necessarily experienced when addressing lifestyle
96 behaviors (e.g. physical inactivity). More research is required to evaluate optimal approaches for different
97 risk factor combinations [6].

98
99 To date, one review has described the relative effectiveness of simultaneous and sequential approaches
100 to MHBC [4]. Prochaska et al identified four randomised controlled trials (RCTs), and concluded that there

101 was little variance in outcomes between a simultaneous versus a sequential approach. However, the
102 review only included studies published up to 2009, did not compare the effectiveness of the spacing of
103 sequential interventions or when intervening with adoptive/cessation or addictive/lifestyle behaviors, did
104 not report retention rates by approach, and did not include an examination of the risk of bias of included
105 studies. Accordingly, the primary aim of this systematic review was to evaluate the relative efficacy of
106 simultaneous and sequential interventions for addressing multiple health risk behaviors. Secondary aims
107 were to identify i) the most effective spacing for the delivery of each behavior change component when
108 delivered sequentially, ii) if there were differences in efficacy of the MHBC interventions for
109 adoptive/cessation or addictive/lifestyle behaviors, and iii) any differences in retention between
110 simultaneous and sequentially delivered interventions.

111

112 **METHOD**

113 The '*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*' (PRISMA) statement was
114 followed [31].

115

116 **Trial selection criteria**

117 Eligible RCTs were those that directly compared simultaneous with sequential delivery of a MHBC
118 intervention. As per previous reviews of MHBC interventions [6, 14, 32], interventions that targeted
119 multiple behaviors within a singular behavioral domain (e.g. a nutrition intervention that targeted fruits
120 and vegetables and dietary fat consumption) were not included. There were no limits on behaviors
121 targeted. Trials were excluded if they i) described a MHBC intervention that was implemented via
122 sequential and simultaneous approaches but only compared those approaches to a usual care control
123 condition or an intervention with a single health behavior outcome, or ii) if the change in the targeted
124 behaviors over time was not described.

125

126 **Search strategy and data sources**

127 Trials were identified through an electronic database search of all publication years (until 18th October
128 2015) in Embase, Medline, CINAHL, PsycInfo, Scopus and Web of Science. The following search terms were
129 used: consecutive (or continual or continuous or following or in a row or proceeding or sequential or single
130 or straight or succeeding or successive or uninterrupted) or coexisting (or coinciding or concomitant or
131 concurrent or contemporaneous or contemporary or parallel or separate or simultaneous or
132 synchronised) and multiple risk factors (or health behavior/behavior). The search was limited to title and
133 abstract, adults (18 years or older), English language, and RCTs (Table 1).

134

135 Second, reference lists of identified MHBC reviews [4, 10-15, 33], were scanned for trials not identified in
136 the above search. Third, seven journals that published a large number of MHBC change articles
137 (Translational Behavioral Medicine, Preventive Medicine, Annals of Behavioral Medicine, Health
138 Education Research, International Journal of Behavioral Nutrition and Physical Activity, Patient Education
139 and Counseling, and Health Psychology) were hand searched for trials from 1995 to October 2015. Last,
140 the reference list of all included trials were scanned.

141

142 Initially, articles were assessed for eligibility by a single reviewer (AB) based on the title and abstract. Trial
143 abstracts and full texts were subsequently assessed independently by two reviewers (EJ, AB), and
144 disagreements resolved by consensus.

145

146 **Data extraction**

147 A paper-based data extraction tool informed by the Cochrane Handbook [34] was developed. The data
148 extracted was checked by two reviewers (MF, FS) and included: the country, the size, age, gender and
149 source of the trial setting, population, if the participants were at risk for each behavior examined,
150 eligibility criteria, trial design, comparison group, the outcome measures, measurement tools, the follow-
151 up period/s, prevalence of participant drop-out, and if power calculations were undertaken.

152

153 **Table 1: MEDLINE Search Strategy 1946 to October 2015**
 154

#	Searches	Results
1	(concurrent* or separate or simultaneous* or synchroni* or parallel or coexisting or co-existing or contemporaneous* or concomitant* or contemporary or coinciding).tw.	958636
2	(sequential* or successive* or consecutive* or succeeding or following or "in a row" or uninterrupted or continual* or continuous* or straight or proceeding or single).tw.	2754290
3	1 or 2	3482392
4	Health Behavior/	37990
5	health behavior?r*.tw.	12858
6	(multiple adj2 risk factor*).tw.	4814
7	4 or 5 or 6	49074
8	randomized controlled trial.pt.	413900
9	controlled clinical trial.pt.	91907
10	random*.tw.	721799
11	trial.tw.	377859
12	groups.tw.	1386150
13	8 or 9 or 10 or 11 or 12	2172062
14	3 and 7 and 13	2327
15	limit 14 to (english language and "all adult (19 plus years)")	1555

155

156 Extracted outcome data describing the targeted health behaviors included the: prevalence of a risk
 157 behavior; prevalence of ceasing a risk behavior; prevalence of participants meeting a specified risk
 158 behavior guideline, mean consumption or activity; and a measure of overall behavior change (e.g.
 159 standardized score). The timing of sequential treatment spacing and the intervention format, content and
 160 length was also extracted. Behavior change techniques (BCTs) [35] of each intervention were also
 161 extracted.

162

163 Data regarding methodological quality was extracted and assessed independently by two reviewers (AB,
 164 EJ) using the McMaster Quality Assessment Tool for Quantitative Studies [36]. The methodological quality
 165 of each trial was determined to be strong, moderate or weak for eight criteria and an overall rating for
 166 each trial was also determined (Table 3). 'Strong' methodological quality equates to low risk of bias.

167

168 **Analysis**

169 Based on the findings of a previous review [4], it was anticipated that the included trials would be too
170 heterogeneous to allow a meta-analytic approach. As such a narrative synthesis was undertaken [4].
171 Outcomes were described separately for trials that included a usual or minimal intervention control arm
172 and for trials that compared sequential and simultaneous approaches only. As the follow-up period after
173 intervention delivery varied for each health risk behavior between trials, the effect at the first follow-up
174 period after which all intervention components had been delivered was described. Outcomes at any later
175 time-points were also described. Where there was a control arm, the effectiveness of the sequential and
176 simultaneous approaches versus the control condition was noted. Intervention effectiveness was also
177 compared according to sequential intervention spacing and adoptive/cessation and addictive/lifestyle
178 behaviors. Retention was recorded for the trial overall and by study group where available.

179

180 **RESULTS**

181 The initial search of the databases yielded 6372 publications. An additional 21 papers were sourced from
182 the electronic journal specific search and reference list checking. After removal of duplicates, 4437 title
183 and abstracts were screened, and 33 full text manuscripts were assessed for eligibility. Six trials (reported
184 in 12 papers) met the inclusion criteria [37-48] (Figure 1).

185

186 **Trial characteristics**

187 Trials were published between 2001 and 2014. Four of the trials compared the sequential and
188 simultaneous approaches to a control condition as well as to each other [38, 42, 43, 47]. The remaining
189 two trials compared the sequential and simultaneous approaches only [40, 41]. Four of the six trials were
190 undertaken in the US [38, 39, 41, 42], one in Belgium [47], and one in the Netherlands [43] (Table 2). Three
191 trials recruited participants from the general public [42, 43], two recruited from substance use clinics [39,
192 41, 47], and one from primary care clinics [38]. One trial recruited males only [41]. Baseline sample sizes

193 ranged from 36 [41] to 5,055 participants [43]. Power calculations were undertaken for four trials [38, 39,
194 42, 44], but only two included calculations for a comparison of intervention effect between the sequential
195 and simultaneous approaches [38, 39].

196

197

Figure 1: PRISMA flow diagram summarising selection process

224 The targeted behaviors were smoking in four trials [38, 39, 41, 43], diet in four trials [38, 42, 43, 47],
225 physical activity in four trials [38, 42, 43, 47], and alcohol consumption in three trials [39, 41, 43]. Four
226 trials examined two behaviors [39, 41, 42, 47], one trial examined three behaviors [38, 47], and one trial
227 examined four behaviors [43]. Two trials examined smoking and alcohol in combination [39, 41], two trials
228 examined physical activity and dietary behaviors (fat and/or fruit and vegetable intake) [42, 47], one trial
229 examined physical activity, diet (sodium intake) and smoking [38], and one trial examined smoking,
230 alcohol, diet (fruit and vegetable intake) and physical activity [44]. All six trials reported behavior change
231 for each individual behavior examined, and four trials also included a measure of overall multiple behavior
232 change (e.g. adherent to all behavior recommendations) [38, 42, 43, 47].

233

234 In terms of the intervention design, four trials included a face-to-face visit [38, 39, 41, 42] and three of
235 the four were supplemented by telephone calls [38, 39, 42] and printed resources [38, 41]. Two trials
236 evaluated tailored web-based interventions [43], one of which was supplemented by printed resources
237 [47]. Four of the trials stated that the design of the intervention was guided by the Transtheoretical stage
238 of change model [38, 39, 42, 47]. Of the two remaining studies, one was theoretically based on the I-
239 Change model [44], while the other did not state a theoretical basis [41]. Intervention session length
240 ranged from 15 minutes [38] to one hour [39], the number of intervention contacts from one [47] to 16
241 [42], and the length of the intervention period from one day [47] to two years [43]. For sequential
242 interventions, the spacing between delivery of the interventions for each behavior ranged from four
243 weeks [41] to one year [43]. The individual BCTs [35] are reported in Appendix Table A.1.

244 **Table 2: Summary of trial design, intervention characteristics and results**

Study author (year/s) Country	Participants, risk status, age, gender, sample size (baseline), drop out (%), power calculation	Target Behaviors (TB), Outcome Measure (OM), Tool (T)	Design: number of arms, sequential treatment spacing, sequence, follow-up period	Intervention format (F), content (C), length (L)	Outcome	Conclusions.
Kalman (2001) US [41]	<p>Inpatients of a 21 day substance abuse treatment clinic</p> <p>Alcohol dependent, smoked ≥ 10 cigs/day, interested in making a smoking quit attempt</p> <p>Age: not stated</p> <p>Gender: male</p> <p>N=36</p> <p>Drop outs: 19.4% overall (not reported by study group)</p> <p>No power calculation</p>	<p>No primary outcome stated</p> <p>TB: Smoking OM: Seven-day point prevalent abstinence, mean cigs/ day T: Self-report validated by expired carbon monoxide.</p> <p>TB: Alcohol consumption OM: alcohol relapse T: The Time-Line Follow-Back interview</p>	<p>RCT: Two arm trial 4 weeks sequential spacing</p> <p>Sequential: Routine substance use treatment with smoking intervention introduced 3 weeks after discharge.</p> <p>Simultaneous: Routine substance use with smoking intervention introduced 2 weeks after admission</p> <p>Follow-up: Smoking-sequential week 20, simultaneous week 16. Alcohol- week 20 (both groups)</p>	<p>F: individual counseling sessions, booklet, relaxation tape.</p> <p>C: <i>Smoking</i>: based on the Quit Smart program, nicotine replacement therapy (patches) <i>Alcohol</i>- 21 day inpatient substance abuse treatment, alcohol specific treatment not stated</p> <p>L: three 45 minute sessions over 4 weeks, nicotine replacement 22mg for six weeks and 11mg for 2 weeks.</p>	<p><i>Smoking</i> No significant difference between sequential and simultaneous in smoking abstinence (8% vs 19%) or mean cigs/day (14.8 vs 13.2) (<i>p</i> values not provided).</p> <p><i>Alcohol</i> No difference in relapse rates between sequential and simultaneous (55% vs 20%, <i>p</i>=0.07)</p>	<p>Timing of smoking intervention had no impact on smoking outcomes. A non-significant trend for more participants in the sequential vs simultaneous treatment condition to relapse to alcohol was found</p>
Joseph et al. (2003, 2004) US [39, 40]	<p>Attending substance use disorder clinics (inpatient and outpatient), first 3-5 weeks of treatment</p> <p>Alcohol dependent, smoked ≥ 5 cigs/day for more than a year, ready to make a smoking quit attempt</p> <p>Age: 21-75, mean 39 years</p>	<p>Primary outcomes: smoking 7 day point prevalent smoking abstinence at and 6 mth duration of alcohol abstinence</p> <p>TB: Smoking OM: Seven-day point prevalence abstinence, mean reduction in no. of cigs smoked/day</p>	<p>RCT: Two arm trial 6 month sequential spacing</p> <p>Sequential: Routine intensive treatment for alcohol dependence, then smoking cessation intervention introduced</p> <p>Simultaneous: Routine intensive treatment for alcohol dependence and</p>	<p>F: <i>Smoking</i>- Individual face-to-face, and telephone <i>Alcohol</i>- group counseling</p> <p>C: <i>Smoking</i>- Behavioral and pharmacological (nicotine replacement therapy), based on transtheoretical stage of change model <i>Alcohol</i>- Intensive dependence treatment followed by less intensive via group counseling and</p>	<p><i>Smoking</i> No difference in point prevalence abstinence between sequential and simultaneous at 12 or 18mths.</p> <p>At 18 mths the prolonged abstinence rates did not differ between sequential and simultaneous (8.9% vs 8.8%, <i>p</i>=0.97)</p> <p>In non-abstinent participants, no difference mean cigs/day between sequential and simultaneous at 12 or 18mths.</p>	<p>These findings suggest that smoking cessation interventions should be provided to patients after intensive alcohol treatment. Drinking outcomes are worse with concurrent tobacco treatment.</p>

Study author (year/s) Country	Participants, risk status, age, gender, sample size (baseline), drop out (%), power calculation	Target Behaviors (TB), Outcome Measure (OM), Tool (T)	Design: number of arms, sequential treatment spacing, sequence, follow-up period	Intervention format (F), content (C), length (L)	Outcome	Conclusions.
	<p>69% male</p> <p>N=499</p> <p>Drop outs: 19.8% overall, 22.7% simultaneous, 17.3% sequential</p> <p>Power calculations: 90% for 8-10% difference sequential vs simultaneous in smoking outcomes</p> <p>90% for a 15% difference sequential vs simultaneous in the alcohol outcome</p>	<p>T: Self-report, validated by expired carbon monoxide.</p> <p>TB: Alcohol consumption OM: 6-month prolonged abstinence, 30 day alcohol abstinence T: The Time-Line Follow-Back interview, validated by breath alcohol concentration.</p>	<p>smoking cessation intervention within 1 week of study enrolment.</p> <p>Follow-up: 12 and 18 months after recruitment. Primary outcome follow-up was 18mths</p>	<p>education, and based on 12 Steps of Alcoholics Anonymous.</p> <p>L: <i>Smoking</i>- 1 hr face to face and up to 3 calls; available every 3 month for 1 year <i>Alcohol</i>- intensive treatment 3-5 weeks, aftercare 1-20 weeks</p>	<p><i>Alcohol</i> No difference in prolonged abstinence at 12 or 18 mths.</p> <p>30 day alcohol abstinence was lower in the simultaneous compared to the sequential group at 18 mths (48% vs 60%, $p=0.01$) but not at 12 mths (46% vs 53%, $p=0.11$)</p>	
Vandelanotte (2005, 2007, 2008) Belgium [46-48]	<p>Community based, recruited via local media, posters and email</p> <p>No 'at risk' requirements</p> <p>Age: 20-60</p> <p>64.5% female</p> <p>N=1023</p> <p>Drop outs: 24.6% overall at 6 months (not reported by study group)</p> <p>No power calculation</p>	<p>Primary outcome not stated</p> <p>TB: Physical activity (PA) OM: minutes of any activity per week, minutes moderate/high intensity per week. Goal was to do 30 mins of moderate PA every day.</p> <p>T: International Physical Activity Questionnaire</p> <p>TB: Fat intake</p>	<p>RCT: Four arm trial</p> <p>3 month sequential spacing</p> <p>Sequential arm a: PA at baseline & fat intake at 3 months.</p> <p>Sequential arm b: fat intake at baseline & PA at 3 months.</p> <p>Simultaneous: both PA and fat intake at baseline.</p> <p>Control arm: wait list control received both PA and fat intake after 6 mth follow -up.</p>	<p>F: interactive on screen computer delivered with take home printed advice.</p> <p>C: personally tailored content to a range of demographic and psychosocial correlates, as well as the stages of change. Included general introduction, normative feedback and suggestions to increase PA or decrease fat intake. Based on theory of planned behavior and transtheoretical stage of change model</p>	<p><i>Physical activity</i> No difference between sequential and simultaneous at 6 or 24 mths. At 6 mths. All intervention arms increased any PA compared to the control arm but not moderate/vigorous per week (no control comparison at 24mths).</p> <p>Subgroup analysis: at 6 months for those meeting PA guidelines at baseline, sequential more effective than simultaneous (+210 mins vs +40 mins any per week, and +72 mins vs -57 mins moderate/high per week). At 6 mths, sequential arms (but not simultaneous increased any PA and compared to control. At 24 mths, the sequential arm was more effective for mins moderate/high per week</p>	<p>At 6 months, for the fat intake intervention, and for the participants who did not meet recommendations for physical activity, the simultaneous approach worked better than the sequential mode.</p> <p>At 24 mths, the sequential intervention mode was overall slightly more effective than</p>

Study author (year/s) Country	Participants, risk status, age, gender, sample size (baseline), drop out (%), power calculation	Target Behaviors (TB), Outcome Measure (OM), Tool (T)	Design: number of arms, sequential treatment spacing, sequence, follow-up period	Intervention format (F), content (C), length (L)	Outcome	Conclusions.
		<p>OM: fat intake per day, and consume less than 30% energy from total fat. T: 48-item food frequency questionnaire</p> <p>TB: PA and fat intake OM: increase of ≥ 60 mins moderate /vigorous PA and/or reduction of $\geq 30\%$ energy derived from fat T: as for individual behaviors</p>	Follow-up: 1 st study 6mths after baseline. 2 nd study 24 mths after baseline and did not include control data	L: 50 min for each for PA and fat intake	<p>Those not meeting guidelines at baseline, simultaneous more effective (+189 mins vs +116 mins moderate/high per week). Simultaneous and sequential increased any PA compared to control. No difference at 24mths.</p> <p><i>Fat intake</i> At 6 months, fat intake and energy from fat decreased more in the simultaneous than the sequential group (-33 vs -25 per day, and 11.5% vs -8.6% for energy from fat), not sustained at 24 mths.</p> <p>At 6 mths, both the sequential and simultaneous arms decreased total fat intake and energy from fat compared to the control.</p> <p>Subgroup analysis: At 6 mths, those not meeting guidelines, simultaneous more effective (-45 vs -36 per day, and -15.6% vs -12.0% for energy from fat),not sustained at 24 mths. At 6 mths, simultaneous and sequential decreased total fat intake and energy from fat compared to the control.</p> <p>No difference for those meeting guidelines at baseline at 6 or 24 mths.</p> <p><i>Physical activity and fat intake</i> At 6 mths, no difference between sequential and simultaneous in successful change of none, one or 2 behaviors (no comparison to control).</p>	the simultaneous mode in maintaining intervention effects.
Hyman (2007, 2008) US [37, 38]	African Americans attending 2 primary care clinics	Primary outcome: % of patients adherent to ≥ 2 targeted behaviors	RCT: Three arm trial 6 month sequential spacing	F: brief in-clinic session with health educator; home-based, self-help, instructional materials	<p><i>Adherence to 2 or more behaviors</i> No difference between sequential and simultaneous. No difference between</p>	This study provides strong evidence that addressing multiple behaviors

Study author (year/s) Country	Participants, risk status, age, gender, sample size (baseline), drop out (%), power calculation	Target Behaviors (TB), Outcome Measure (OM), Tool (T)	Design: number of arms, sequential treatment spacing, sequence, follow-up period	Intervention format (F), content (C), length (L)	Outcome	Conclusions.
	<p>Hypertensive and non-adherent for smoking, sodium intake, and physical activity</p> <p>Age: 45 – 64 Mean age 53 years</p> <p>67.3% female</p> <p>N= 281</p> <p>Dropouts: 17.1% overall, 19.8% sequential, 19.6% simultaneous, 15.1% control</p> <p>Power calculation: 70% power to detect a 20% difference sequential vs simultaneous</p> <p>99% power to detect a 15% difference between sequential and control</p> <p>82% power to detect a 35% difference between simultaneous and control</p>	<p>Secondary outcomes: % of patients adherent to each targeted behavior</p> <p>TB: Physical activity OM: at least 10,000 steps per week higher than baseline PA level T: Pedometers</p> <p>TB: Sodium intake OM: Dietary sodium level less than 100 mEq/L per day T: 24-hour urine sodium</p> <p>TB: Smoking OM: Absence of urinary cotinine T: Urine cotinine</p>	<p>Sequential arm: Target behaviors introduced 1 at a time (order of introduction randomised).</p> <p>Simultaneous arm: all 3 target behaviors delivered at the same time.</p> <p>Usual care arm: educational materials regarding the 3 target behaviors</p> <p>Follow-up: 18 mths</p>	<p>(written manual and videotape), telephone counselling sessions</p> <p>C: assessment of stage of change, motivational interviewing, postcards, compared current behavior with behavioral goals. Based on transtheoretical stage of change model</p> <p>L: Over 18 mths- in clinic visit every 6 months, telephone sessions (15 mins each) at 2, 4, 6, 8, 12, 16, and 20 weeks following clinic visit.</p>	<p>sequential or simultaneous and control at any time point.</p> <p><i>Physical activity</i> No difference between sequential and simultaneous. No difference between sequential or simultaneous compared to control point.</p> <p><i>Sodium intake</i> No difference between sequential and simultaneous. No difference between sequential or simultaneous and control at any time point.</p> <p><i>Smoking</i> No difference between sequential and simultaneous at any time point. No difference between sequential or simultaneous compared to control at any time point.</p>	<p>sequentially is not superior, and may be inferior, to a simultaneous approach.</p> <p>NB: non-significant results demonstrated a trend in favour of the effectiveness of the simultaneous over the sequential intervention.</p>
Schulz (2011, 2012, 2014) Netherlands [43-45]	<p>Respondents to a community Dutch adult health monitoring survey</p> <p>No 'at risk' requirements</p> <p>Age: 18-65 (mean 44.15)</p>	<p>Primary outcome: risk factor score (ranged from 0: adhering to all guidelines to 5: adhering to no guidelines)</p>	<p>RCT: Three arm trial</p> <p>1 year sequential spacing</p> <p>Sequential: received interventions one at a time for their health risk</p>	<p>F: web-based, tailored computer program + option to print tailored advice</p> <p>C: personalised advice based on psychosocial</p>	<p><i>Adherence to all risk behavior guidelines</i> At 24 mths, no difference between sequential and simultaneous. Simultaneous arm (but not sequential) more effective than control at 24mths ($p=0.048$)</p> <p><i>Smoking</i></p>	<p>Evidence was found for the effectiveness of both programs. No simple conclusive finding could be drawn</p>

Study author (year/s) Country	Participants, risk status, age, gender, sample size (baseline), drop out (%), power calculation	Target Behaviors (TB), Outcome Measure (OM), Tool (T)	Design: number of arms, sequential treatment spacing, sequence, follow-up period	Intervention format (F), content (C), length (L)	Outcome	Conclusions.
	<p>47.36% female</p> <p>N=5390</p> <p>Drop outs: 73.0% overall, 75.1% sequential, 74.5% simultaneous, 69.1% control</p> <p>Power calculation: 80% power to detect an effect size of 0.2 on the risk factor score between conditions</p> <p>80% power to detect a 10% difference in individual risk behaviors between conditions</p>	<p>Secondary outcomes: % of patients adherent to each targeted behavior</p> <p>TB: Smoking OM: Cessation of smoking T: self-report survey items.</p> <p>TB: Alcohol intake OM: ≤ 1 (women) or 2 (men) glasses alcohol/day T: Alcohol - 5-item Dutch Quantity-Frequency-Variability questionnaire</p> <p>TB: Fruit consumption OM: eating 2 pieces fruit/ day. T: 4-item food frequency Questionnaire</p> <p>TB: Vegetable consumption OM: eat 200gm vegetables/day T: 4 item Food Frequency Questionnaires</p> <p>TB: Physical activity</p>	<p>behaviors. Respondents could choose a second behavior after 1 year.</p> <p>Simultaneous: received intervention on all their risk behaviors at the same time. At random, half of the respondents started preventive health behaviors (i.e., physical activity, vegetable consumption, fruit consumption), the other half started with addiction behaviors (i.e., alcohol intake, smoking)</p> <p>Control group: Completed health risk appraisal online. Note: those in the sequential group could only receive intervention for a maximum of 2 risk behaviors given the 1 year sequential spacing</p> <p>Follow-up: 24 months</p>	<p>constructs: attitude, social influence, preparatory plans, and self-efficacy and coping. Based on I-change model.</p> <p>L: Over 2 years- multisession program, participants encouraged to revisit the website on an unlimited basis.</p>	<p>At 24 mths, sequential was more effective than simultaneous ($p=.0004$). No difference between sequential or simultaneous and control at 24 mths.</p> <p><i>Alcohol intake</i> No difference between sequential and simultaneous. The sequential arm was more effective compared to control ($p=0.048$) at 24mths.</p> <p><i>Fruit consumption</i> No difference between sequential and simultaneous. No difference between sequential or simultaneous and control at 24 mths.</p> <p><i>Vegetable consumption</i> No difference between sequential and simultaneous. No difference between sequential or simultaneous and control at 24 mths.</p> <p><i>Physical activity</i> No difference between sequential and simultaneous. No difference between sequential or simultaneous and control at 24 mths.</p>	<p>about which intervention mode was more effective. The best kind of intervention may depend on the behavior that is targeted or on personal preferences and motivation.</p>

Study author (year/s) Country	Participants, risk status, age, gender, sample size (baseline), drop out (%), power calculation	Target Behaviors (TB), Outcome Measure (OM), Tool (T)	Design: number of arms, sequential treatment spacing, sequence, follow-up period	Intervention format (F), content (C), length (L)	Outcome	Conclusions.
		OM: moderately active 30 minutes 5 days/week T: Short Questionnaire to Assess Health-enhancing physical activity.				
King (2013) US [42]	<p>Community based, recruited via mass mailings, media, and informal family care giving organisations</p> <p>Not meeting currently guidelines for physical activity and diet (fruit and veg, daily calories from saturated fat), and reporting stress & time management complaints.</p> <p>>44 years (46.0-54.2% female) Mean age 55 years.</p> <p>N=200</p> <p>Drop outs: 7% overall, 4-8% sequential, 4% simultaneous, 12% control</p> <p>Power calculation: 80% power to detect a difference of 30min/week MVPA, 1.5%</p>	<p>TB: Physical activity 150 mins MVPA most days of the week. OM: Average minutes/week moderate-vigorous physical activity, % meeting guidelines, T: Combined the Stanford 7-Day Physical Activity Recall and The Community Healthy Activities Model Program for Seniors measures</p> <p>TB: Diet (decreased total saturated fat and increase fruit and veg intake to 5-9 servings/day) OM: daily serves of fruit and vegetable, % meeting guidelines, and daily percentage of calorie intake from saturated fats. T: Block98 Food Frequency</p>	<p>RCT: Four arm trial</p> <p>4 month sequential spacing</p> <p>Sequential (exercise first): exercise advice then nutrition advice added.</p> <p>Sequential (diet first): nutrition advice first, then exercise advice added.</p> <p>Simultaneous: exercise plus nutrition advice.</p> <p>Control: stress management attention control arm (telephone counseling)</p> <p>Follow-up: 12 months</p>	<p>F: individual face to face and telephone delivered by trained health educators C: face to face introductory session, phone sessions facilitating mastery, structuring realistic outcomes, learning cognitive and behavioral processes of change, and enacting active problem solving. Participants tracked behaviors using pedometer and paper calendar. Based on social cognitive theory and transtheoretical stage of change model</p> <p>L: 12 months; 1 face to face followed by 15 telephone contacts. Sequential groups received 21 calls, and 15 calls in simultaneous and control. <i>Sequential-</i> First four months: 15–20 min per call, last eight months 30-40 min per call when including both physical activity and diet, plus 6</p>	<p><i>Physical activity</i> At 12 mths, exercise first, diet first and simultaneous did not differ from each other. Exercise first ($p<0.01$) and simultaneous ($p<0.05$) were more effective than the control in increasing mins of PA</p> <p>At 12 mths, more subjects in the exercise first group (48%) met the guidelines compared to the control (22%, $p=0.01$). No differences between the other arms.</p> <p><i>Diet</i> Fruit and vegetable serves At 12 mths all 3 experimental arms did not differ from one another but had higher serves of fruit and veg compared to the control ($p<0.0001$)</p> <p>- % meeting guidelines At 12 mths, a greater % in diet first group (78%) achieved recommended intake compared to exercise first (54%, $p=0.02$). No difference between either exercise first or diet first and simultaneous.</p> <p>At 12 mths, a greater % in diet first, exercise first and simultaneous achieved recommended</p>	In the current population, delivering physical activity and dietary interventions simultaneously may result in the most positive sustained outcomes across these 2 health behaviors. A possible behavioral suppression effect of early dietary intervention on physical activity deserves further evaluation.

Study author (year/s) Country	Participants, risk status, age, gender, sample size (baseline), drop out (%), power calculation	Target Behaviors (TB), Outcome Measure (OM), Tool (T)	Design: number of arms, sequential treatment spacing, sequence, follow-up period	Intervention format (F), content (C), length (L)	Outcome	Conclusions.
	percent of daily calories from fat, and one daily fruit or vegetable consumed between conditions	questionnaire, and the Health Habits and History questionnaire. TB: multiple health behavior change OM: change index scores T: based on single risk behavior outcome measures		booster calls for second behavior. <i>Simultaneous</i> -30-40 min per call	intake compared to control ($p<0.0001$, $p=0.05$, and $p=0.02$) % daily calories from saturated fat At 12mths, the 3 experimental arms did not differ from each other, but the diet first and simultaneous had lower % of daily calories from fat compared to the control ($p<0.0001$) At 12 mths, a greater % in diet first (57%) and simultaneous groups (57%) achieved recommended fat intake compared to control (31%, $p=0.02$). No difference between either exercise first, diet first and simultaneous. <i>Multiple health behavior change</i> At 12 months, no difference between any of the 3 experimental groups (ie exercise first, diet first or simultaneous). All 3 experimental arms indicated higher index score relative to the control ($p<0.001$)	

245

246

247

248 **Appendix Table 1: Behavior change techniques [35] reported in each trial**

249

BCT Taxonomy (v1)[35]	Joseph 2003; 2004. Smoking (S), alcohol.	Hyman 2007. Smoking, sodium, PA.	Vandelanotte 2005; 2007; 2008. PA, fat.	Schulz 2011; 2014; 2012. Smoking, alcohol, fruit, vege, PA.	Kalman 2001. Smoking (S), alcohol.	King 2013. PA, diet (D).
1. Goals and planning						
1.1. Goal setting (behavior)	S	Y		Y	S	PA, D
1.2. Problem solving			Y	Y	S	Y
1.3. Action planning		Y		Y		PA
1.4. Review behavior goal(s)				Y		
2. Feedback and monitoring						
2.2 Feedback on behavior		Y	Y	Y		
2.3 Self-monitoring of behavior						PA, D
3. Social support						
3.1 social support (unspecified)	S		Y	Y	S	Y
3.2 Social support (practical)			Y			
3.3 Social support (emotional)		Y				
5. Natural consequences						
5.1 Information about health consequences	S		Y	Y		
5.2 Salience of consequences						
5.3 Information about social and environmental consequences	S	Y	Y	Y	S	
5.5 Anticipated regret	S					
5.6 Information about emotional consequences			Y	Y		
7. Associations						
7.3 Reduce prompts/cues					S	
7.4 Remove access to the reward	S					
8. Repetition and substitution						
8.6 Generalisation of target behavior					S	
9. Comparison of outcomes						
9.1 Credible source	S				S	
9.2 Pros and cons	S	Y		Y	S	
11. Regulation						
11.1 Pharmacological support	S	Y- S			S	
13. Identity						
13.1 Identification of self as role model				Y		

250 “Y” means that the Behavior Change Technique (BCT) was reported to be in the intervention, but it was not associated with a
251 specific behavior. If there is “S”, this means the BCT was mentioned specifically in relation to smoking. “PA” means the BCT was
252 used in relation to physical activity. “D” means the BCT was mentioned specifically in relation to diet. All trials targeted >1
253 behavior, if only one behavior is coded this indicates insufficient detail was provided in the published paper to allow
254 identification of BCTs for every behavior.

255

256 **Risk of bias**

257 Overall, the methodological quality was classified as strong (ie. low risk of bias) for three trials [38, 39,
258 47], moderate for two trials [13, 44] and weak for one [41] (Table 3). In terms of individual methodological
259 quality criteria, two trials were determined to be weak regarding selection bias as only 14% and 21% of
260 selected individuals agreed to participate, respectively [41, 42]. Two trials were rated as weak regarding

261 withdrawals and drop outs; one trial did not provide information regarding withdrawals or the proportion
 262 of participants that completed the trial [41], whilst the other trial did not provide reasons for drop outs
 263 and only 28% of those at baseline participated in follow-up data collection [44].

264

265 **Table 3: Risk of bias (quality assessment) of included trials***

266

Component Rating	Kalman	Joseph	Vandelanotte	Hyman	Schulz	King
Selection Bias	Weak	Moderate	Strong	Strong	Strong	Weak
Trial Design	Strong	Strong	Strong	Strong	Strong	Strong
Confounders	Strong	Strong	Strong	Strong	Strong	Strong
Blinding	Strong	Moderate	Moderate	Moderate	Moderate	Moderate
Data Collection methods	Strong	Strong	Strong	Strong	Strong	Strong
Withdrawals and drop outs	Weak	Strong	Moderate	Strong	Weak	Strong
OVERALL SCORE	Weak	Strong	Strong	Strong	Moderate	Moderate

267 *Assessed using the McMaster Quality Assessment Tool for Quantitative Studies [36]. A classification of strong methodological
 268 quality equates to low risk of bias.

269

270 **Effectiveness of sequential and simultaneous approaches compared to a control condition**

271 The four trials that included a control arm recruited participants from the community and/or the primary
 272 care setting [38, 42, 44, 47]. Three of the four trials reported the sequential and/or simultaneous approach
 273 were more effective than the control arm for at least one behavior [42, 43, 47]. Vandelanotte et al found
 274 both the sequential and simultaneous approaches were more effective than the control condition
 275 regarding minutes of physical activity (but not for moderate/vigorous activity), total fat intake and
 276 percentage of energy from fat [47]. Schulz et al found the simultaneous approach was more effective than
 277 the control regarding the proportion of participants who were adherent to all risk behavior guidelines
 278 [44]. Regarding individual behaviors, they found that the sequential approach was more effective than
 279 the control for alcohol intake, but no difference was found for smoking, fruit or vegetable consumption
 280 and physical activity. King et al found the sequential approach (exercise or nutrition first) and the
 281 simultaneous approach to be more effective than the control condition in improving multiple behavior

change index scores [42]. Regarding individual behaviors (physical activity, fruit and vegetable consumption, fat intake), one or both of the sequential arms and the simultaneous approach were more effective than the control arm with the exception of one of two measures of fat intake (adherence to guidelines). In the fourth trial, Hyman et al found no difference between the sequential or simultaneous approaches and the control condition for adherence to all behavior goals, or for the individual behaviors examined (physical activity, sodium intake and smoking) [38].

288

Effectiveness of sequential compared to simultaneous approaches

Trials comparing sequential versus simultaneous approaches only (no control condition)

Of the two trials that compared the sequential and simultaneous approaches but did not include a usual care or minimal intervention control condition [39, 41], both were undertaken or initiated in substance use settings and involved the addition of smoking cessation care to usual care substance use treatment. One trial found an effect in favour of the sequential approach and the other found no difference between approaches. In a two arm trial, Joseph et al (2004) found 30 day alcohol abstinence was worse for participants in the simultaneous condition compared to those in the sequential condition at 18 month follow-up [39]. However, the same study found no difference between sequential and simultaneous conditions for the other behaviors targeted (including prolonged alcohol abstinence, smoking cessation or reduction in cigarettes per day). In the other two arm trial, Kalman et al found no difference between sequential and simultaneous conditions for any behavioral outcome including smoking abstinence, mean number of cigarettes per day and alcohol relapse [41].

302

Trials that compared sequential versus simultaneous approaches and included a control condition

Of the three studies that found the sequential and simultaneous approaches to be more effective than the control condition [42, 43, 47], two found a significant difference between the sequential or simultaneous intervention approaches. However, significant effects were found for only one behavioral outcome out of the multiple behavioral outcomes reported in each of the two trials. One trial [47]

308 favoured a simultaneous approach and the other [44] favoured a sequential approach. For the trial that
309 found an effect in favour of the simultaneous approach, the outcomes of a four-armed study were
310 described in terms of short (6 month) and long term follow-up (24 month) in separate papers [46-48]. At
311 the six-month follow-up, Vandelanotte et al (2005, 2007) found the simultaneous approach was more
312 effective than a sequential approach in reducing fat (not sustained at 24 months). No differences between
313 the sequential and simultaneous approaches were found for physical activity at six or 24 months [46, 47].
314 In the three arm trial that found an effect in favour of the sequential approach, Schulz et al (2012),
315 reported that the prevalence of smoking cessation (one of five secondary outcomes) at the 24 month
316 follow-up was greater among participants in the sequential condition compared to those in the
317 simultaneous condition [43]. However, as previously noted, there was no difference between both the
318 sequential or simultaneous approaches and the control condition for smoking cessation. There were no
319 differences between the sequential and simultaneous conditions regarding the primary outcome
320 (adherence to all risk behavior guidelines) or for the other four secondary behavioral outcomes (alcohol,
321 fruit and vegetable intake, and physical activity).

322

323 Although finding that the sequential and simultaneous approaches were more effective than the control
324 condition, King et al (2013) found, in a four arm trial (sequential exercise first, sequential nutrition first,
325 simultaneous, control), no difference between the sequential and simultaneous arms for any of the seven
326 outcomes describing three behaviors (physical activity, fruit and vegetable intake, fat intake) [42]. Hyman
327 et al (2007) found no difference between the sequential or simultaneous approaches compared to the
328 control condition and also found no difference between the sequential and simultaneous approaches
329 regarding the primary outcome (adherence to two or more of three behaviors) or for the three secondary
330 outcomes (physical activity, smoking, sodium intake) at 18 months [38].

331

332 **Spacing of sequential interventions**

333 Of the two trials that found one outcome in favour of a sequential approach, one was conducted in a
334 substance abuse setting [39] and the other recruited participants from the general community [44]. In a
335 two arm trial, Joseph et al (2004) included a six month spacing between substance use treatment and the
336 introduction of smoking cessation care [39]. In a three arm trial, Schulz et al included one year spacing
337 between the introduction of a subsequent behavioral intervention [44]. The one trial that found one
338 outcome in favour of a simultaneous approach included an intervention delivery spacing of three months
339 in the sequential arm [47]. Of the three trials that found no difference between a sequential and
340 simultaneous approach, all included a spacing of intervention delivery of four months or less [38, 41, 42].

341

342 **Adoptive/cessation and addictive/lifestyle behaviors**

343 Two trials targeted cessation behaviors only [39, 41] and both were undertaken in the substance abuse
344 setting. Both studies provided outcomes for addictive behaviors only (smoking and alcohol). One of these
345 studies favoured the sequential approach for one of the four cessation behavior outcomes reported [39].
346 The remaining four trials targeted both cessation and adoptive behaviors and were undertaken with
347 participants from the general community or primary care setting. All four trials included a measure of
348 overall MHBC, and all four studies found no difference between the sequential and simultaneous
349 approaches regarding overall MHBC. In regards to individual behavior change outcomes, two of the four
350 studies found a differential effect between the sequential and simultaneous approaches for one lifestyle
351 cessation behavior (reduced salt intake) and no adoptive lifestyle behaviors [44, 47]. One study favoured
352 the simultaneous approach for fat intake (but not for physical activity) [47], and the other favoured the
353 sequential approach for smoking (but not for alcohol, fruit or vegetable intake or physical activity) [44].

354 **Impact of sequential and simultaneous delivery on participant drop-out**

355 Drop-out ranged from 4.0% to 75.1% for sequential arms, 4% to 74.5% for simultaneous arms and 12% to
356 69.1% for control arms. Two trials [41, 47] only provided a drop-out rate for the trial overall (19.4% and
357 24.6%).

358

359 **DISCUSSION**

360 This review identified six trials that compared sequential and simultaneous approaches to MHBC. When
361 compared to a usual care/control condition, most demonstrated that the MHBC intervention was
362 efficacious. Three of the trials reported a difference between a sequential and simultaneous approach in
363 their effectiveness in improving one of the MHBC outcomes measured in each trial. Of the trials favouring
364 a sequential approach, both included intervention spacing of six months or more, and found a differential
365 effect for addictive cessation behaviors (smoking and alcohol use). The trial favouring a simultaneous
366 approach was also found for a cessation behavior (fat intake). Simultaneous or sequential delivery did not
367 impact retention. The small number of trials and the heterogeneity between studies in terms of the
368 behavior combinations targeted, the intervention length and content, the participant types, and the time
369 between sequential interventions make it difficult to draw firm conclusions regarding the relative
370 effectiveness of the sequential and simultaneous approaches, but a number of observations are worthy
371 of comment.

372 First, although three of the six included studies observed an impact on intervention effectiveness for one
373 health behavior outcome, no such effect was demonstrated for the other health behavior outcomes
374 reported within each study. Given this, and the relatively consistent finding that the sequential and
375 simultaneous approaches were more effective than a usual/minimal care control condition, the
376 conclusions drawn by Prochaska et al in their 2011 review and other observational studies [49] that both
377 approaches can be effective is largely supported [4]. In line with patient-centred care and shared decision-
378 making [50], service providers should consider patient preference when considering sequential or
379 simultaneous delivery.

380

381 Second, a difference in the effectiveness of a sequential or simultaneous approach was found for
382 cessation behaviors only; none of the adoptive behaviors (e.g. increased physical activity) were influenced
383 by the approach. It has been suggested that people differ in their 'readiness to change' for various
384 behaviors [24, 51, 52] and that health behaviors are 'domain specific' [17]. The intervention strategies

385 targeting cessation behaviors may not affect adoptive behaviors if they do not address a common
386 stimulus, provide explicit links between behaviors, or teach a common coping mechanism [4]. Further, for
387 the two studies [39, 44] where the sequential approach favoured a cessation behavior, the cessation
388 behavior was an addictive behavior and the spacing of intervention in the sequential arm was six months
389 or one year. The precise mechanisms underlying the benefits of sequential versus simultaneous treatment
390 of addictive behaviors are still unclear. Traditionally, addictive disorders are treated using a sequential
391 approach, focused on the primary drug of concern, and clinicians often report anecdotal evidence that
392 multiple treatment targets over-burden poly-substance using clients [53]. More recent research on co-
393 occurring addiction and mental health problems, for example, contradict this notion, and demonstrate
394 the added benefits of addressing multiple addictive behaviors simultaneously in integrated interventions
395 that not only provide strategies for addressing MHBC, but incorporate a motivational approach to
396 encourage change, and teach clients to examine the ways in which their multiple health behaviors interact
397 and relate to each other [54].

398

399 Third, there was variation in reporting MHBC outcomes and hence the authors' interpretation of
400 effectiveness. For example, Schulz et al nominated adherence to all risk behavior guidelines as the primary
401 outcome, and reported the outcomes for each behavior individually as secondary outcomes [44]. The
402 remaining five studies did not nominate a primary outcome and reported each behavior separately, with
403 three of these studies also describing intervention effects across behaviors. Reporting for each behavior
404 individually is the traditional approach when reporting effectiveness of MHBC intervention research [55-
405 57], while more recently a simple summative index has been used [56-58]. Both approaches have
406 limitations and researchers have now begun to examine alternate methods of analysis, such as the
407 creation of a combined change score and modelling an optimal linear combination of multiple risk factors
408 [57, 59]. Consensus regarding some form of standardised reporting is required to inform reporting in
409 research trials and to allow future reviews to more clearly synthesise the literature [57]. BCTs were

410 inadequately described in the included trials, as only two trials were published since the first published
411 version of the taxonomy in 2008 [60].

412

413 Last, the evidence regarding the comparative effectiveness of sequential and simultaneous approaches is
414 limited. Despite the explosion in MHBC interventions in the past five years [33], only three additional trials
415 were identified in the current review to supplement those identified in the 2011 review [4]. One of the
416 trials included in the Prochaska et al study was excluded from the current review as it did not directly
417 compare a sequential and simultaneous approach [18]. Although the methodological quality of five of the
418 six studies included in the current review were determined to be of strong or moderate quality, only two
419 [38, 39] of the six studies provided a power calculation for the sequential versus simultaneous
420 comparison. As such, it is unclear if all included trials were of a sufficient sample size to detect a difference
421 between all intervention conditions. Further, one of the studies [38] was powered to be able detect a
422 large difference (20%) between the sequential and simultaneous approaches and so a smaller effect size
423 may have been missed. Finally, we could find limited evidence about intervening on more than two health
424 behaviors, sequentially or simultaneously. It is possible that intervening simultaneously on three or more
425 health behaviors does indeed create an overload of information in participants, as suggested by several
426 authors [61, 62], but this remains to be studied.

427

428 The findings of this review should be considered in light of its strengths and limitations. Trials with null
429 findings may not have been reported and as such the current review may have been susceptible to
430 publication bias. Further, the literature search only included trials published in English and the search did
431 not include the grey literature, and so some relevant trials may have been overlooked. However, the
432 literature search was extended by hand searching relevant journals and by searching the reference list of
433 included trials. A further strength of the review was its inclusion of a methodological quality assessment
434 which has been excluded in previous reviews examining aspects of MHBC [4, 11, 14, 33].

435

436 **CONCLUSION**

437 The limited number and heterogeneity of the included studies constrains the conclusion that can be
438 drawn from the review. Compared to usual care/control conditions, both simultaneous and sequentially
439 delivered interventions appear efficacious in changing behavior. However, when comparing simultaneous
440 and sequential arms directly, there seemed to be little difference in effectiveness between the two
441 approaches when implementing a MHBC intervention. Further research is required to understand how to
442 intervene successfully with adoptive/cessation and addictive/lifestyle behaviors in the context of MHBC,
443 the ideal spacing for sequentially delivered interventions, and analysis approaches that capture change
444 across multiple behaviors.

445

446

447 **Conflict of Interest Statement**

448 The authors declare that there are no conflicts of interest.

449

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457

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