James, Erica; Freund, Megan; Booth, Angela; Duncan, Mitch J.; Johnson, Natalie; Short, Camille E.; Wolfenden, Luke; Stacey, Fiona G.; Kay-Lambkin, Frances; Vandelanotte, Corneel “Comparative efficacy of simultaneous versus sequential multiple health behavior change interventions among adults: a systematic review of randomised trials”. Published in Preventive Medicine Vol. 89, Issue August 2016, p. 211-223 (2016)

**Available from:** http://dx.doi.org/10.1016/j.ypmed.2016.06.012

© 2016. This manuscript version is made available under the CC-BY-NC-ND 4.0 license
http://creativecommons.org/licenses/by-nc-nd/4.0/

**Accessed from:** http://hdl.handle.net/1959.13/1326518
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

Authors: Erica James¹,²,³,⁴ *, Megan Freund¹,²,⁴, Angela Booth³,⁴, Mitch J Duncan¹,³,⁴, Natalie Johnson¹,²,⁴, Camille E Short⁵, Luke Wolfenden¹,²,⁴, Fiona G Stacey¹,²,⁴, Frances Kay-Lambkin⁷, Corneel Vandelanotte⁸

Affiliations
1. School of Medicine and Public Health, The University of Newcastle, Callaghan NSW Australia
2. Priority Research Centre for Health Behaviour, The University of Newcastle, Callaghan NSW Australia
3. Priority Research Centre in Physical Activity and Nutrition, The University of Newcastle, Callaghan NSW Australia
4. Hunter Medical Research Institute, New Lambton Heights NSW Australia
5. Freemasons Foundation Centre for Men's Health, School of Medicine, University of Adelaide, Adelaide SA, Australia
7. National Drug and Alcohol Research Centre, University of New South Wales, Sydney NSW, Australia
8. Physical Activity Research Group, the Central Queensland University, North Rockhampton QLD, NSW

* correspondence

Erica James: erica.james@newcastle.edu.au
ABSTRACT (words=244)

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

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

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

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

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

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

PROSPERO registration number: CRD42015027876
Introduction (count = 4431)

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

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

Whilst MHBC interventions appear promising, major questions remain unanswered about how best to accomplish MHBC; including whether to intervene simultaneously or sequentially [16-18]. The simultaneous approach is suggested to be time and cost-effective [4]. However, it may also be more overwhelming and place too many demands on a person’s inherent ability to change their behavior. The theory of cross-behavior regulation (the regulation of at least two health behaviors) suggests that performing multiple health behaviors requires much effort [19]. Similarly, self-control strength model [20] and ego-depletion [21] suggests that efforts in one domain can have implications for one’s capacity to self-regulate in other domains. This could cause individuals to feel over-burdened and prematurely
drop out of the intervention program [12, 22]. In addition, simultaneous interventions may also fail to
address any behavior in sufficient depth, reducing the potential for an intervention effect [17, 23, 24].
Delivering interventions sequentially may overcome many of these limitations and be better suited for
developing stronger habits [25]. If individuals successfully meet one behavior (e.g. exercise), self-
regulatory resources occupied by one behavior (e.g. exercise-specific demands) become vacant and can
be invested in other behavior tasks (e.g. planning healthy diet) [26]. Analogous is the concept of spillover
effects (a.k.a. transfer or gateway effects) where success in one domain results in increased self-efficacy
to tackle a second behavior [27]. However, a potential complication are compensatory health beliefs [28],
which suggest that efficacy of a sequentially delivered intervention is likely to negatively impact on other
current behaviors. Additionally, a sequential approach often requires delivery of the interventions over a
longer time, potentially increasing cost and reducing participant adherence [6, 29]. Further, the most
appropriate spacing to address each targeted behavior when implementing a sequential MHBC
intervention is unknown [16].

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

To date, one review has described the relative effectiveness of simultaneous and sequential approaches
to MHBC [4]. Prochaska et al identified four randomised controlled trials (RCTs), and concluded that there
was little variance in outcomes between a simultaneous versus a sequential approach. However, the review only included studies published up to 2009, did not compare the effectiveness of the spacing of sequential interventions or when intervening with adoptive/cessation or addictive/lifestyle behaviors, did not report retention rates by approach, and did not include an examination of the risk of bias of included studies. Accordingly, the primary aim of this systematic review was to evaluate the relative efficacy of simultaneous and sequential interventions for addressing multiple health risk behaviors. Secondary aims were to identify i) the most effective spacing for the delivery of each behavior change component when delivered sequentially, ii) if there were differences in efficacy of the MHBC interventions for adoptive/cessation or addictive/lifestyle behaviors, and iii) any differences in retention between simultaneous and sequentially delivered interventions.

METHOD

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

Trial selection criteria

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

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

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

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

**Data extraction**

A paper-based data extraction tool informed by the Cochrane Handbook [34] was developed. The data extracted was checked by two reviewers (MF, FS) and included: the country, the size, age, gender and source of the trial setting, population, if the participants were at risk for each behavior examined, eligibility criteria, trial design, comparison group, the outcome measures, measurement tools, the follow-up period/s, prevalence of participant drop-out, and if power calculations were undertaken.
Table 1: MEDLINE Search Strategy 1946 to October 2015

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

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

Data regarding methodological quality was extracted and assessed independently by two reviewers (AB, EJ) using the McMaster Quality Assessment Tool for Quantitative Studies [36]. The methodological quality of each trial was determined to be strong, moderate or weak for eight criteria and an overall rating for each trial was also determined (Table 3). ‘Strong’ methodological quality equates to low risk of bias.
Based on the findings of a previous review [4], it was anticipated that the included trials would be too heterogeneous to allow a meta-analytic approach. As such a narrative synthesis was undertaken [4]. Outcomes were described separately for trials that included a usual or minimal intervention control arm and for trials that compared sequential and simultaneous approaches only. As the follow-up period after intervention delivery varied for each health risk behavior between trials, the effect at the first follow-up period after which all intervention components had been delivered was described. Outcomes at any later time-points were also described. Where there was a control arm, the effectiveness of the sequential and simultaneous approaches versus the control condition was noted. Intervention effectiveness was also compared according to sequential intervention spacing and adoptive/cessation and addictive/lifestyle behaviors. Retention was recorded for the trial overall and by study group where available.

RESULTS

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

Trial characteristics

Trials were published between 2001 and 2014. Four of the trials compared the sequential and simultaneous approaches to a control condition as well as to each other [38, 42, 43, 47]. The remaining two trials compared the sequential and simultaneous approaches only [40, 41]. Four of the six trials were undertaken in the US [38, 39, 41, 42], one in Belgium [47], and one in the Netherlands [43] (Table 2). Three trials recruited participants from the general public [42, 43], two recruited from substance use clinics [39, 41, 47], and one from primary care clinics [38]. One trial recruited males only [41]. Baseline sample sizes
ranged from 36 [41] to 5,055 participants [43]. Power calculations were undertaken for four trials [38, 39, 42, 44], but only two included calculations for a comparison of intervention effect between the sequential and simultaneous approaches [38, 39].
Figure 1: PRISMA flow diagram summarising selection process

Records identified through database searching (n = 6372)

Additional records identified through other sources (n = 21)

Total number of records identified (n = 6393)

Records excluded (n = 1956)

Records after duplicates removed (n = 4437)

Records screened (n = 4437)

Records excluded (n = 4404)

Full-text articles assessed for eligibility (n = 41)

Full-text articles excluded (n = 29)

Full-text articles included (n = 12)

Described n=6 trials

Reasons excluded

- Did not compare sequential and simultaneous intervention delivery (n=25)
- Did not report outcome behaviours (n=1)
- Was not an RCT (n=1)
- Theoretical analysis (n=1)
- Not adult participants (n=1)
The targeted behaviors were smoking in four trials [38, 39, 41, 43], diet in four trials [38, 42, 43, 47], physical activity in four trials [38, 42, 43, 47], and alcohol consumption in three trials [39, 41, 43]. Four trials examined two behaviors [39, 41, 42, 47], one trial examined three behaviors [38, 47], and one trial examined four behaviors [43]. Two trials examined smoking and alcohol in combination [39, 41], two trials examined physical activity and dietary behaviors (fat and/or fruit and vegetable intake) [42, 47], one trial examined physical activity, diet (sodium intake) and smoking [38], and one trial examined smoking, alcohol, diet (fruit and vegetable intake) and physical activity [44]. All six trials reported behavior change for each individual behavior examined, and four trials also included a measure of overall multiple behavior change (e.g. adherent to all behavior recommendations) [38, 42, 43, 47].

In terms of the intervention design, four trials included a face-to-face visit [38, 39, 41, 42] and three of the four were supplemented by telephone calls [38, 39, 42] and printed resources [38, 41]. Two trials evaluated tailored web-based interventions [43], one of which was supplemented by printed resources [47]. Four of the trials stated that the design of the intervention was guided by the Transtheoretical stage of change model [38, 39, 42, 47]. Of the two remaining studies, one was theoretically based on the I-Change model [44], while the other did not state a theoretical basis [41]. Intervention session length ranged from 15 minutes [38] to one hour [39], the number of intervention contacts from one [47] to 16 [42], and the length of the intervention period from one day [47] to two years [43]. For sequential interventions, the spacing between delivery of the interventions for each behavior ranged from four weeks [41] to one year [43]. The individual BCTs [35] are reported in Appendix Table A.1.
Table 2: Summary of trial design, intervention characteristics and results

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

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.
<table>
<thead>
<tr>
<th>Study author (year/s) Country</th>
<th>Participants, risk status, age, gender, sample size (baseline), drop out (%), power calculation</th>
<th>Target Behaviors (TB), Outcome Measure (OM), Tool (T)</th>
<th>Design: number of arms, sequential treatment spacing, sequence, follow-up period</th>
<th>Intervention format (F), content (C), length (L)</th>
<th>Outcome</th>
<th>Conclusions.</th>
</tr>
</thead>
</table>
N=499  
Drop outs: 19.8% overall, 22.7% simultaneous, 17.3% sequential  
Power calculations: 90% for 8-10% difference sequential vs simultaneous in smoking outcomes  
90% for a 15% difference sequential vs simultaneous in the alcohol outcome | T: Self-report, validated by expired carbon monoxide.  
TB: Alcohol consumption  
OM: 6-month prolonged abstinence, 30 day alcohol abstinence  
T: The Time-Line Follow-Back interview, validated by breath alcohol concentration. | smoking cessation intervention within 1 week of study enrolment.  
Follow-up: 12 and 18 months after recruitment. Primary outcome follow-up was 18mths | education, and based on 12 Steps of Alcoholics Anonymous.  
L: Smoking- 1 hr face to face and up to 3 calls; available every 3 month for 1 year Alcohol- intensive treatment 3-5 weeks, aftercare 1-20 weeks | Alcohol  
No difference in prolonged abstinence at 12 or 18 mths.  
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) |

| | | | | | |
| | Community based, recruited via local media, posters and email  
No ‘at risk’ requirements  
**Age:** 20-60  
64.5% female  
N=1023  
Drop outs: 24.6% overall at 6 months (not reported by study group)  
No power calculation | Primary outcome not stated  
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.  
T: International Physical Activity Questionnaire  
TB: Fat intake | RCT: Four arm trial  
3 month sequential spacing  
Sequential arm a: PA at baseline & fat intake at 3 months.  
Sequential arm b: fat intake at baseline & PA at 3 months.  
Simultaneous: both PA and fat intake at baseline.  
Control arm: wait list control received both PA and fat intake after 6 mth follow-up.  
F: interactive on screen computer delivered with take home printed advice.  
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 | Physical activity  
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).  
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 | 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.  
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 |
|---|---|---|---|---|---|
| Hyman (2007, 2008) US [37, 38] | African Americans attending 2 primary care clinics | OM: fat intake per day, and consume less than 30% energy from total fat. T: 48-item food frequency questionnaire. | TB: PA and fat intake OM: increase of ≥ 60 mins moderate/vigorous PA and/or reduction of ≥ 30% energy derived from fat. T: as for individual behaviors | L: 50 min for each for PA and fat intake | 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. Fat intake 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. At 6 mths, both the sequential and simultaneous arms decreased total fat intake and energy from fat compared to the control. 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. No difference for those meeting guidelines at baseline at 6 or 24 mths. Physical activity and fat intake At 6 mths, no difference between sequential and simultaneous in successful change of none, one or 2 behaviors (no comparison to control). | the simultaneous mode in maintaining intervention effects. |</p>
<table>
<thead>
<tr>
<th>Study author (year/s) Country</th>
<th>Participants, risk status, age, gender, sample size (baseline), drop out (%), power calculation</th>
<th>Target Behaviors (TB), Outcome Measure (OM), Tool (T)</th>
<th>Design: number of arms, sequential treatment spacing, sequence, follow-up period</th>
<th>Intervention format (F), content (C), length (L)</th>
<th>Outcome</th>
<th>Conclusions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertensive and non-adherent for smoking, sodium intake, and physical activity</td>
<td>Age: 45 – 64 Mean age 53 years 67.3% female N= 281 Dropouts: 17.1% overall, 19.8% sequential, 19.6% simultaneous, 15.1% control Power calculation: 70% power to detect a 20% difference sequential vs simultaneous 99% power to detect a 15% difference between sequential and control 82% power to detect a 35% difference between simultaneous and control</td>
<td>Secondary outcomes: % of patients adherent to each targeted behavior TB: Physical activity OM: at least 10,000 steps per week higher than baseline PA level T: Pedometers TB: Sodium intake OM: Dietary sodium level less than 100 mEq/L per day T: 24-hour urine sodium TB: Smoking OM: Absence of urinary cotinine T: Urine cotinine</td>
<td>Sequential arm: Target behaviors introduced 1 at a time (order of introduction randomised). Simultaneous arm: all 3 target behaviors delivered at the same time. Usual care arm: educational materials regarding the 3 target behaviors Follow-up: 18 mths</td>
<td>(written manual and videotape), telephone counselling sessions C: assessment of stage of change, motivational interviewing, postcards, compared current behavior with behavioral goals. Based on transtheoretical stage of change model 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.</td>
<td>sequential or simultaneous and control at any time point. <strong>Physical activity</strong> No difference between sequential and simultaneous. No difference between sequential or simultaneous compared to control point. <strong>Sodium intake</strong> No difference between sequential and simultaneous. No difference between sequential or simultaneous and control at any time point. <strong>Smoking</strong> No difference between sequential and simultaneous at any time point. No difference between sequential or simultaneous compared to control at any time point.</td>
<td>sequentially is not superior, and may be inferior, to a simultaneous approach. NB: non-significant results demonstrated a trend in favour of the effectiveness of the simultaneous over the sequential intervention.</td>
</tr>
<tr>
<td>Schulz (2011, 2012, 2014) Netherlands [43-45]</td>
<td>Respondents to a community Dutch adult health monitoring survey No ‘at risk’ requirements Age: 18-65 (mean 44.15)</td>
<td>Primary outcome: risk factor score (ranged from 0: adhering to all guidelines to 5: adhering to no guidelines) RCT: Three arm trial 1 year sequential spacing Sequential: received interventions one at a time for their health risk</td>
<td>F: web-based, tailored computer program + option to print tailored advice C: personalised advice based on psychosocial</td>
<td><strong>Adherence to all risk behavior guidelines</strong> At 24 mths, no difference between sequential and simultaneous. Simultaneous arm (but not sequential) more effective than control at 24mths (p&lt;0.048) <strong>Smoking</strong> Evidence was found for the effectiveness of both programs. No simple conclusive finding could be drawn</td>
<td>Evidence was found for the effectiveness of both programs. No simple conclusive finding could be drawn</td>
<td></td>
</tr>
<tr>
<td>Study author (year/s) Country</td>
<td>Participants, risk status, age, gender, sample size (baseline), drop out (%), power calculation</td>
<td>Target Behaviors (TB), Outcome Measure (OM), Tool (T)</td>
<td>Design: number of arms, sequential treatment spacing, sequence, follow-up period</td>
<td>Intervention format (F), content (C), length (L)</td>
<td>Outcome</td>
<td>Conclusions.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>47.36% female N=5390 Drop outs: 73.0% overall, 75.1% sequential, 74.5% simultaneous, 69.1% control Power calculation: 80% power to detect an effect size of 0.2 on the risk factor score between conditions 80% power to detect a 10% difference in individual risk behaviors between conditions</td>
<td>Secondary outcomes: % of patients adherent to each targeted behavior TB: Smoking OM: Cessation of smoking T: self-report survey items. TB: Alcohol intake OM: ≤ 1 (women) or 2 (men) glasses alcohol/day T: Alcohol - 5-item Dutch Quantity-Frequency-Variability questionnaire TB: Fruit consumption OM: eating 2 pieces fruit/day T: 4-item food frequency Questionnaire TB: Vegetable consumption OM: eat 200gm vegetables/day T: 4 item Food Frequency Questionnaires TB: Physical activity</td>
<td>behaviors. Respondents could choose a second behavior after 1 year. 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) 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 Follow-up: 24 months</td>
<td>constructs: attitude, social influence, preparatory plans, and self-efficacy and coping. Based on I-change model. L: Over 2 years- multisession program, participants encouraged to revisit the website on an unlimited basis.</td>
<td>At 24 mths, sequential was more effective than simultaneous (p=.0004). No difference between sequential or simultaneous and control at 24 mths. Alcohol intake No difference between sequential and simultaneous. The sequential arm was more effective compared to control (p=0.048) at 24mths. Fruit consumption No difference between sequential and simultaneous. No difference between sequential or simultaneous and control at 24 mths. Vegetable consumption No difference between sequential and simultaneous. No difference between sequential or simultaneous and control at 24 mths. Physical activity No difference between sequential and simultaneous. No difference between sequential or simultaneous and control at 24 mths.</td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>Study author (year/s) Country</td>
<td>Participants, risk status, age, gender, sample size (baseline), drop out (%), power calculation</td>
<td>Target Behaviors (TB), Outcome Measure (OM), Tool (T)</td>
<td>Design: number of arms, sequential treatment spacing, sequence, follow-up period</td>
<td>Intervention format (F), content (C), length (L)</td>
<td>Outcome</td>
<td>Conclusions.</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------</td>
<td>----------------------------------------------------------</td>
<td>------------------------------------------</td>
<td>----------</td>
<td>-------------</td>
</tr>
</tbody>
</table>
| King (2013) US [42]         | Community based, recruited via mass mailings, media, and informal family care giving organisations | OM: moderately active 30 minutes 5 days/week  
T: Short Questionnaire to Assess Health-enhancing physical activity. | RCT: Four arm trial  
4 month sequential spacing  
Sequential (exercise first): exercise advice then nutrition advice added.  
Sequential (diet first): nutrition advice first, then exercise advice added.  
Simultaneous: exercise plus nutrition advice.  
Control: stress management attention control arm (telephone counseling)  
Follow-up: 12 months | 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  
L: 12 months; 1 face to face followed by 15 telephone contacts. Sequential groups received 21 calls, and 15 calls in simultaneous and control. Sequential- 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 | Physical activity  
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  
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.  
Diet  
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 $(p<0.0001)$  
- % 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.  
At 12 mths, a greater % in diet first, exercise first and simultaneous achieved recommended | 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. |
<table>
<thead>
<tr>
<th>Study author (year/s) Country</th>
<th>Participants, risk status, age, gender, sample size (baseline), drop out (%), power calculation</th>
<th>Target Behaviors (TB), Outcome Measure (OM), Tool (T)</th>
<th>Design: number of arms, sequential treatment spacing, sequence, follow-up period</th>
<th>Intervention format (F), content (C), length (L)</th>
<th>Outcome</th>
<th>Conclusions.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>percent of daily calories from fat, and one daily fruit or vegetable consumed between conditions</td>
<td>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</td>
<td>booster calls for second behavior. Simultaneous-30-40 min per call</td>
<td></td>
<td>intake compared to control ($p&lt;0.0001$, $p=0.05$, and $p=0.02$) % daily calories from saturated fat At 12 mths, 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 ($p&lt;0.0001$) 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. Multiple health behavior change 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 ($p&lt;0.001$)</td>
<td></td>
</tr>
</tbody>
</table>
## Appendix Table 1: Behavior change techniques [35] reported in each trial

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Goals and planning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1. Goal setting (behavior)</td>
<td>S</td>
<td>Y</td>
<td>Y</td>
<td>S</td>
<td>PA, D</td>
<td></td>
</tr>
<tr>
<td>1.2. Problem solving</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td>S</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>1.3. Action planning</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td>PA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4. Review behavior goal(s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Feedback and monitoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2 Feedback on behavior</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3 Self-monitoring of behavior</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PA, D</td>
</tr>
<tr>
<td>3. Social support</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1 Social support (unspecified)</td>
<td></td>
<td>S</td>
<td>Y</td>
<td>Y</td>
<td>S</td>
<td>Y</td>
</tr>
<tr>
<td>3.2 Social support (practical)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.3 Social support (emotional)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Natural consequences</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1 Information about health consequences</td>
<td>S</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.2 Salience of consequences</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.3 Information about social and environmental consequences</td>
<td>S</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>5.5 Anticipated regret</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.6 Information about emotional consequences</td>
<td></td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Associations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.3 Reduce prompts/cues</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S</td>
</tr>
<tr>
<td>7.4 Remove access to the reward</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S</td>
</tr>
<tr>
<td>8. Repetition and substitution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.6 Generalisation of target behavior</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S</td>
</tr>
<tr>
<td>9. Comparison of outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.1 Credible source</td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S</td>
</tr>
<tr>
<td>9.2 Pros and cons</td>
<td>S</td>
<td>Y</td>
<td>Y</td>
<td>S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Regulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.1 Pharmacological support</td>
<td>S</td>
<td>Y- S</td>
<td></td>
<td></td>
<td></td>
<td>S</td>
</tr>
<tr>
<td>13. Identity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.1 Identification of self as role model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
</tbody>
</table>

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

## Risk of bias

Overall, the methodological quality was classified as strong (ie. low risk of bias) for three trials [38, 39, 47], moderate for two trials [13, 44] and weak for one [41] (Table 3). In terms of individual methodological quality criteria, two trials were determined to be weak regarding selection bias as only 14% and 21% of selected individuals agreed to participate, respectively [41, 42]. Two trials were rated as weak regarding...
withdrawals and drop outs; one trial did not provide information regarding withdrawals or the proportion of participants that completed the trial [41], whilst the other trial did not provide reasons for drop outs and only 28% of those at baseline participated in follow-up data collection [44].

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

<table>
<thead>
<tr>
<th>Component Rating</th>
<th>Kalman</th>
<th>Joseph</th>
<th>Vandelanotte</th>
<th>Hyman</th>
<th>Schulz</th>
<th>King</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection Bias</td>
<td>Weak</td>
<td>Moderate</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Weak</td>
</tr>
<tr>
<td>Trial Design</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
</tr>
<tr>
<td>Confounders</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
</tr>
<tr>
<td>Blinding</td>
<td>Strong</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Data Collection methods</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
</tr>
<tr>
<td>Withdrawals and drop outs</td>
<td>Weak</td>
<td>Strong</td>
<td>Moderate</td>
<td>Strong</td>
<td>Weak</td>
<td>Strong</td>
</tr>
<tr>
<td>OVERALL SCORE</td>
<td>Weak</td>
<td>Strong</td>
<td>Strong</td>
<td>Strong</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

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

Effectiveness of sequential and simultaneous approaches compared to a control condition

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

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].

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

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

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

Adoptive/cessation and addictive/lifestyle behaviors

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

Impact of sequential and simultaneous delivery on participant drop-out

Drop-out ranged from 4.0% to 75.1% for sequential arms, 4% to 74.5% for simultaneous arms and 12% to 69.1% for control arms. Two trials [41, 47] only provided a drop-out rate for the trial overall (19.4% and 24.6%).
This review identified six trials that compared sequential and simultaneous approaches to MHBC. When compared to a usual care/control condition, most demonstrated that the MHBC intervention was efficacious. Three of the trials reported a difference between a sequential and simultaneous approach in their effectiveness in improving one of the MHBC outcomes measured in each trial. Of the trials favouring a sequential approach, both included intervention spacing of six months or more, and found a differential effect for addictive cessation behaviors (smoking and alcohol use). The trial favouring a simultaneous approach was also found for a cessation behavior (fat intake). Simultaneous or sequential delivery did not impact retention. The small number of trials and the heterogeneity between studies in terms of the behavior combinations targeted, the intervention length and content, the participant types, and the time between sequential interventions make it difficult to draw firm conclusions regarding the relative effectiveness of the sequential and simultaneous approaches, but a number of observations are worthy of comment.

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

Second, a difference in the effectiveness of a sequential or simultaneous approach was found for cessation behaviors only; none of the adoptive behaviors (e.g. increased physical activity) were influenced by the approach. It has been suggested that people differ in their ‘readiness to change’ for various behaviors [24, 51, 52] and that health behaviors are ‘domain specific’ [17]. The intervention strategies
targeting cessation behaviors may not affect adoptive behaviors if they do not address a common
stimulus, provide explicit links between behaviors, or teach a common coping mechanism [4]. Further, for
the two studies [39, 44] where the sequential approach favoured a cessation behavior, the cessation
behavior was an addictive behavior and the spacing of intervention in the sequential arm was six months
or one year. The precise mechanisms underlying the benefits of sequential versus simultaneous treatment
of addictive behaviors are still unclear. Traditionally, addictive disorders are treated using a sequential
approach, focused on the primary drug of concern, and clinicians often report anecdotal evidence that
multiple treatment targets over-burden poly-substance using clients [53]. More recent research on co-
occurring addiction and mental health problems, for example, contradict this notion, and demonstrate
the added benefits of addressing multiple addictive behaviors simultaneously in integrated interventions
that not only provide strategies for addressing MHBC, but incorporate a motivational approach to
encourage change, and teach clients to examine the ways in which their multiple health behaviors interact
and relate to each other [54].

Third, there was variation in reporting MHBC outcomes and hence the authors’ interpretation of
effectiveness. For example, Schulz et al nominated adherence to all risk behavior guidelines as the primary
outcome, and reported the outcomes for each behavior individually as secondary outcomes [44]. The
remaining five studies did not nominate a primary outcome and reported each behavior separately, with
three of these studies also describing intervention effects across behaviors. Reporting for each behavior
individually is the traditional approach when reporting effectiveness of MHBC intervention research [55-
57], while more recently a simple summative index has been used [56-58]. Both approaches have
limitations and researchers have now begun to examine alternate methods of analysis, such as the
creation of a combined change score and modelling an optimal linear combination of multiple risk factors
[57, 59]. Consensus regarding some form of standardised reporting is required to inform reporting in
research trials and to allow future reviews to more clearly synthesise the literature [57]. BCTs were
inadequately described in the included trials, as only two trials were published since the first published version of the taxonomy in 2008 [60].

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

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

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

The authors declare that there are no conflicts of interest.

Acknowledgement

The authors thank Debbie Booth who ran the search in the electronic databases. MJD is supported by a Future Leader Fellowship (ID 100029) from the National Heart Foundation of Australia. CES is supported by a National Health and Medical Research Council Early Career Fellowship (1090517). FKL is supported by a National Health and Medical Research Council Senior Research Fellowship (1110371). LW is supported by a National Health and Medical Research Council Career Development Fellowship. CV is supported by a Future Leader Fellowship (ID 100427) from the National Heart Foundation of Australia.
REFERENCES


