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REVIEW ARTICLE

Multiple Risk Behavior Interventions: Meta-analyses of RCTs

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Context: Multiple risk behaviors are common and associated with developing chronic conditions such as heart disease, cancer, or Type 2 diabetes. A systematic review, meta-analysis, and meta-regression of the effectiveness of multiple risk behavior interventions was conducted.

Evidence acquisition: Six electronic databases including MEDLINE, EMBASE, and PsycINFO were searched to August 2016. RCTs of non-pharmacologic interventions in general adult populations were selected. Studies targeting specific at-risk groups (such as people screened for cardiovascular risk factors or obesity) were excluded. Studies were screened independently. Study characteristics and outcomes were extracted and risk of bias assessed by one researcher and checked by another. The Behaviour Change Wheel and Oxford Implementation Index were used to code intervention content and context.

Evidence synthesis: Random-effects meta-analyses were conducted. Sixty-nine trials involving 73,873 individuals were included. Interventions mainly comprised education and skills training and were associated with modest improvements in most risk behaviors: increased fruit and vegetable intake (0.31 portions, 95% CI=0.17, 0.45) and physical activity (standardized mean difference, 0.25; 95% CI=0.13, 0.38), and reduced fat intake (standardized mean difference, –0.24; 95% CI = –0.36, –0.12). Although reductions in smoking were found (OR=0.78, 95% CI=0.68, 0.90), they appeared to be negatively associated with improvement in other behaviors (such as diet and physical activity). Preliminary evidence suggests that sequentially changing smoking alongside other risk behaviors was more effective than simultaneous change. But most studies assessed simultaneous rather than sequential change in risk behaviors; therefore, comparisons are sparse. Follow-up period and intervention characteristics impacted effectiveness for some outcomes.

Conclusions: Interventions comprising education (e.g., providing information about behaviors associated with health risks) and skills training (e.g., teaching skills that equip participants to engage in less risky behavior) and targeting multiple risk behaviors concurrently are associated with small changes in diet and physical activity. Although on average smoking was reduced, it appeared changes in smoking were negatively associated with changes in other behaviors, suggesting it may not be optimal to target smoking simultaneously with other risk behaviors.

CONTEXT

Physical inactivity, eating an unhealthy diet, smoking, and excessive alcohol consumption are associated with greater risk of developing cancers, cardiovascular diseases, and Type 2 diabetes[1]; together, these conditions are estimated to account for more than 50% of preventable premature deaths globally.[2] Studies suggest the majority of adults report two or more risk behaviors and approximately 25% of the adult population report three or more risk behaviors.[3–5] Engaging in

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multiple risk behaviors is associated with greater risk of chronic disease and mortality compared with engaging in one or no risk behaviors.[6] Multiple risk behaviors are associated with health inequalities; people in unskilled work or with no qualifications are more likely to engage in two or more risk behaviors.[7–9]

High blood pressure and tobacco smoke are among the three leading risk factors for global disease burden, and unhealthy diet and physical inactivity accounted for 10% of all disease burden.[10] Interventions supporting people to make healthy choices receive high priority in most high-income countries because of potential to improve population health and reduce future demand on health care. Given risk behaviors rarely occur in isolation, tackling multiple rather than single behaviors may be a more effective approach. Since 2000, there has been a steady increase in studies evaluating multiple risk behavior interventions, with a sharp rise from 2010 onward. Between 2010 and 2013, more than 100 studies were published.[11] Findings from these studies have not yet been synthesized and, to the authors' knowledge, this is the first systematic review to evaluate which interventions are effective in changing which behaviors in adult, non-clinical populations. Which behaviors were targeted, by what type of intervention, and the achieved outcomes were investigated. This review also explored which factors were associated with improved outcomes.

EVIDENCE ACQUISITION

Eligibility Criteria

An iterative approach was used to determine inclusion criteria. This involved conducting a mapping exercise appraising the scope of the multiple risk behavior literature. No evidence was found suggesting restriction of studies to RCTs would limit types of eligible interventions.[11] Studies with the following characteristics were included.

Population. General adult (aged ≥16 years) or non-targeted subgroups of general adult populations (e.g., pregnant women, older adults, students) were included. Studies of targeted subgroups, where screening takes place to determine eligibility (e.g., to identify obesity, or those at risk of Type 2 diabetes), were excluded.

Intervention. Any non-pharmacologic intervention aiming to change at least two risk behaviors (risk behaviors were not determined a priori) was included. Studies of school- or family-based interventions were excluded to avoid duplication with registered protocol for a Cochrane systematic review.[12]

Comparator. Any comparator (such as attention control, single risk behavior non-pharmacologic intervention) was included.

Outcomes. The primary outcome was change in risk behaviors. This included any behavior that entailed potential risk to participants' health. Secondary outcomes were changes in weight, BMI, blood pressure, and cholesterol; intermediate outcomes included self-efficacy, attitudes, beliefs, and knowledge. Process-related outcomes were collected.

Information Sources

MEDLINE, EMBASE, PsycINFO, Science Citation Index, Cochrane Central Register for Controlled Trials, and Applied Social Sciences Index and Abstracts were searched from January 1990 to August 2016 with no language restrictions (Appendix, available online). Citation searches were carried out using Google Scholar, Scopus, Web of Science, and OVIDSP MEDLINE.[13]

Selection of Studies, Data Collection Process, and Risk of Bias Assessment

Final selection of studies, data extraction, and assessment of risk of bias was conducted by one reviewer and checked by a second. A modified version of the Cochrane Public Health Group's data extraction template was used (piloted on five studies to ensure consistency) and the Behaviour Change Wheel (Table 1) to classify intervention content according to nine functions: education, persuasion, incentivization, coercion, training, enablement, modeling, environmental restructuring, and restrictions (no policy-level interventions were found).[14]

The Oxford Implementation Index was utilized to assess intervention characteristics and contextual factors.[15] Both were adapted for the purposes of this review. The Cochrane Risk of Bias Tool was used to critically appraise included studies.[16]

For dichotomous outcomes, ORs and their 95% CIs were calculated, with values <1 favoring the intervention group. For continuous outcomes, standardized mean differences (SMDs) were calculated using Hedges's g.[17] Where a sufficient number of studies were available, mean differences were calculated on original scales (e.g., portions of fruit and vegetables).

Statistical Methods

Meta-analyses. Random-effects meta-analyses using Review Manager, version 5, were calculated. Control conditions were grouped into three categories (minimal intervention, information provision, active control) to examine differences in effect estimates across these conditions.

Heterogeneity assessment was based on visual inspection of forest plots and the I^2 statistic.[18] A Q-value (approximating χ^2 distribution) of $p<0.10$ indicated statistically significant heterogeneity. Statistical heterogeneity was explored using meta-regression.

Meta-regression analyses. Mixed-effects meta-regression analyses (where there were at least ten studies for an outcome) were conducted to examine the influence of implementation factors on effectiveness based on criteria from the Oxford Implementation Index[15] and the Behaviour Change Wheel.[14] A permutation test adjusted p-values to reduce risk of false positives.[19] Although meta-regression analyses were planned in advance, the findings should be considered exploratory given the large number of examined covariates.

Covariates relating to intervention characteristics included number of intervention functions; specific intervention functions (as defined

Table 1. Summary of Behavior Change Wheel

Functions	Definition	Examples
Interventions		
Education	Seeking to provide or increase knowledge	Educational material provided through lectures, online, or written materials
Persuasion	Seeking to induce positive or negative feelings that impacts on behavior	Using motivational interviewing to change behavior
Incentivization	Providing positive reinforcement to change behavior	Providing vouchers contingent on engaging in a particular healthy behavior
Coercion	Providing negative reinforcement or punishment to change behavior	Having to pay a fine for engaging in a risk behavior
Training	Training participants to develop skills that help them to engage in healthy behavior	Teaching cooking skills to people who have an unhealthy diet
Restriction	Using rules to reduce or increase a particular behavior	Prohibiting the use of novel psychoactive substances
Environmental restructuring	Intervening in the social or physical context to promote or reduce particular behaviors	Integrating a health promotion program within the regular social activities of an African American church to encourage behavior change in their members
Modeling	Providing an example of someone engaging in a behavior or changing their behavior	Recruiting people who inject drugs and train them to promote use of clean needles within their social networks
Enablement	Reducing barriers and providing support to help behavior change	Providing pedometers to help participants monitor their activity levels
Policies		
Communication/ marketing	Using media (e.g., newspapers, social media, TV) to promote healthy behavior	Conducting mass media campaigns
Guidelines	Developing guidance recommending engaging or not engaging in particular behaviors	National guideline programs such as the National Institute for Health and Care Excellence
Fiscal	Taxing unhealthy behaviors or offering subsidies to promote healthy behavior	Increase taxes on tobacco, high sugar foods
Regulation	Rules or principles that encourage healthy behavior	Voluntary agreements on advertising of unhealthy foods or drinks
Legislation	Legislating against unhealthy behavior	Prohibiting the sale of tobacco to certain age groups
Environmental/ social planning	Policies related to the physical or social environment	Town planning to make cycling safer and more accessible to citizens
Service provision	Providing a service that promotes healthy behavior	Local authorities providing affordable and accessible gyms

Source: Adapted From Michie et al.[14]

by the Behaviour Change Wheel); method of delivery; intervention duration; staff characteristics; participant characteristics; intervention setting; publication period; and duration of follow-up.

Additional analyses. Multivariate meta-analyses of correlated outcomes were compared with standard univariate meta-analyses. Subgroup analyses according to SES (studies with predominantly low SES versus mixed SES) and ethnicity (participants were predominantly from a black and minority ethnic population versus participants from majority and minority ethnic populations) were conducted.

EVIDENCE SYNTHESIS

Sixty-nine RCTs (comprising 73,873 participants) were included (Figure 1). Study quality was variable (Appendix Figure 1, available online). Blinding of participants and personnel was not included in the risk of bias assessment because it was not feasible given the nature of the interventions. Slightly more than half of the studies had high risk of bias for at least one domain: incomplete outcome data (attrition bias, n=27); other bias (n=8); blinding of outcome assessors (n=6); selective reporting (n=5); and allocation concealment (n=3).

Contextual factors, participant characteristics, and intervention characteristics were extracted according to the Oxford Implementation Index (Appendix, available online). Most studies were conducted in the U.S. (n=34); United Kingdom (n=9); Netherlands (n=6); and Australia (n=5). Settings varied, including homes, community centers, churches, universities, primary care clinics, hospitals, and prisons. Few studies reported information about the wider environment in which the intervention took place or characteristics of the delivering organization. Data on other

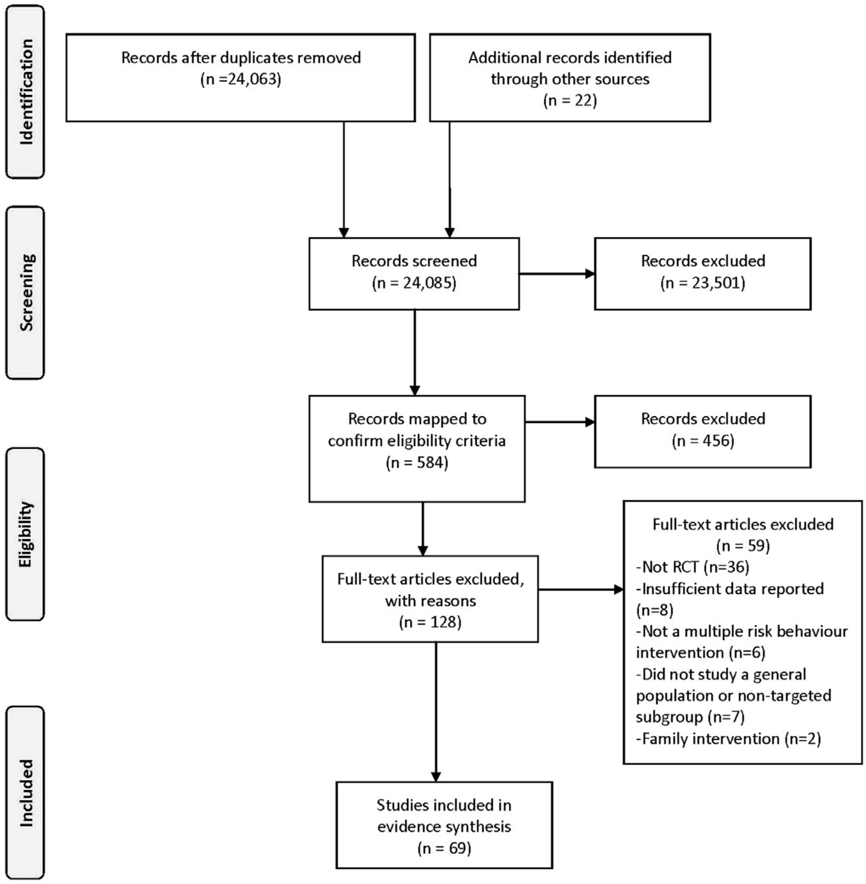

Figure 1. Study flow diagram.

contextual factors such as occurrence of important external events at the time of intervention were limited.

General adult populations were the focus in most studies (*n*=32). Others targeted students (*n*=13); older adults (*n*=8); pregnant women (*n*=4); and prisoners (*n*=1). Some specifically targeted those on low incomes (*n*=8) or black and minority ethnic groups (*n*=5). There is some overlap in categories; therefore, summing the totals exceeds the number of included studies.

Most studies targeted two risk behaviors (*n*=32). Fewer studies targeted three (*n*=17); four (*n*=13); or five behaviors (*n*=2) (Appendix, available online). Most (72%) targeted diet and physical activity, with 46% focusing exclusively on these behaviors; 35% targeted diet and smoking but few focused exclusively on these behaviors; and 23% targeted alcohol and smoking but few focused exclusively on these behaviors.

Number of intervention functions ranged from one (*n*=8) to five (*n*=4), with most including three functions (*n*=28). Coercion and restriction were not included as part of any intervention, and incentives and environmental restructuring were rarely used. Most (*n*=66) included an education function, and just more than half included education with training (*n*=39). Persuasion was also used in a number of studies (*n*=21). These functions are consistent with the mostly commonly adopted theoretic approaches, including Social Cognitive Theory,[20] the Health Belief Model,[21] and the Theory of Planned Behaviour[22] (the Appendix [available online] summarizes intervention functions classified using the Behaviour Change Wheel,[14] reported theoretic approaches, and targeted risk behaviors).

No clear patterns between particular risk behavior combinations and use of specific intervention functions were detected. Studies targeting a larger number of behaviors did not appear to adopt more intervention functions than studies targeting two behaviors.

Although most studies (*n*=47) reported the theoretic basis of interventions, few reported examining changes in intermediate outcomes (e.g., attitudes, beliefs, and knowledge) predicted by theory to mediate behavior change (Appendix, available online).

Twenty-three studies provided process evaluation data (Appendix, available online). These data were mostly related to participant uptake of materials such as pedometers, resistance bands, exercise calendars, and written/online materials. Only four studies reported analyses of intervention fidelity or challenges to implementation.[23–26]

Most studies that requested participant feedback found high levels of satisfaction both with provided materials (e.g., pedometers, exercise calendars, educational materials) and content of the intervention.[27–33] Though some studies did not find differences in satisfaction between participants in the intervention group compared with controls,[34–36] these interventions were compared with relatively active control groups.

Participant's perceived effectiveness of interventions and engagement in behavior change were less positive. Only 55% of participants in one study[27] felt the intervention helped them to improve their diet. Similarly, another study[29] found $<$50% of the participants considered the intervention effective in improving their diet and physical activity, with only 25% engaging in new activities. Although participants in another study[31] were satisfied with their motivational interviewing session, most provided neutral responses concerning perceived relevance. In another study,[37] several themes were identified in relation to participants' perception of the intervention and subsequent impact on behavior change: the importance of group interaction (such as accountability, but also disappointment when group members stop attending); encouragement provided by advisors (such as improved motivation); and specific helpful aspects of the intervention (such as use of pedometers, goal setting).

Summary estimates from the meta-analyses are presented in Tables 2 and 3. Subgroup analyses according to control group category (minimal intervention/information provision/active control) did not substantially change the pooled results and are not discussed further.

Compared with control groups, the intervention groups demonstrated a small increase in fruit and vegetable intake (0.31 portions, 95% CI=0.17, 0.45); a small reduction in calorie intake (–83.37, 95% CI= –148.54, –18.20) and fat intake (SMD= –0.24, 95% CI= –0.36, –0.12); and a small increase in physical activity (SMD=0.25, 95% CI=0.13, 0.38). However, the findings for physical activity were sensitive to an individual study[38] where the intervention was more effective than in other studies (SMD=2.94). When this study was removed from the analysis, the effect estimate (SMD=0.15, 95% CI=0.09, 0.21) and heterogeneity (I^2=61% vs 93% when considering all studies) were substantially reduced.

Small to moderate improvements were found in overall diet score, fiber intake, calorie intake, sodium intake, alcohol use, and reduction of sexual risk behaviors, but there were few studies and some results lacked precision (i.e., wide CIs). There was also a statistically significant reduction in smoking (OR=0.78, 95% CI=0.68, 0.90).

Two studies compared multiple and single risk behavior interventions.[37,39] One study[37] compared an intervention targeting two behaviors (smoking and diet) with an intervention targeting a single behavior (smoking). No statistically significant differences were found between groups for either smoking or diet. Another study compared physical activity alone, fruit and vegetable intake alone, combined physical activity and fruit and vegetable intake, and non-intervention control groups.[39] The diet-alone intervention was effective in increasing fruit and vegetable intake; there was also supportive evidence for the physical activity intervention improving physical activity. However, it was inconclusive (as it was a relatively small study) whether the combined intervention improved either fruit and vegetable intake or physical activity.

Minimal reductions in weight (–0.59 kg, 95% CI = –1.02, –0.16) and BMI (–0.27 points, 95% CI = –0.46, –0.07) were found, compared with control conditions. Small reductions were also found in systolic blood pressure (SMD = –0.11, 95% CI = –0.19, –0.04); diastolic blood pressure (SMD = –0.10, 95% CI = –0.16, –0.04); total cholesterol (SMD = –0.17, 95% CI = –0.27, –0.06); high-density lipoprotein cholesterol (SMD = –0.13, 95% CI = –0.31, 0.05); and low-density lipoprotein cholesterol (SMD = –0.17, 95% CI = –0.34, 0.00).

Data on intermediate outcomes were very limited. The most commonly reported (eight studies) outcome was self-efficacy, where there was no evidence for improvement (SMD = –0.06, 95% CI = –0.17, 0.06). Table 3 provides further details on secondary and intermediate outcomes.

A range of potential moderators of effectiveness were examined: intervention characteristics (e.g., follow-up time, intervention characteristics [content], sequential or simultaneous targeting of risk behaviors); contextual factors (e.g., setting, geographic location, significant external events occurring at time of intervention); and participant characteristics (e.g., ethnicity, income).

Length of follow-up was a statistically significant predictor for meeting recommendations for fruit and vegetable intake, explaining all heterogeneity. Longer follow-up was associated with reduced effectiveness compared with post-intervention follow-up ($<$6-month follow-up: slope=1.68, 95% CI=1.31, 2.17, p=0.002); 6 to 12–month follow-up: slope=1.54, 95% CI=1.26, 1.97, p=0.005). Length of follow-up was not associated with any other outcome.

Interventions including education, training, and enablement intervention content (slope=0.22, 95% CI=0.07,

Table 2. Summary Point Estimates From the Meta-analyses of Multiple Risk Behavior Interventions (Primary Outcomes)

Risk behavior outcome	Summary point estimate			Follow-up time
	All	Low SES	BME	
Dichotomous data				
Lack of fruit and vegetable intake: not adhering to FV recommendations	**OR 0.62 (95% CI 0.51 to 0.76) I^2=81%, K=11**	**OR 0.65 (95% CI 0.44 to 0.83) I^2=48%, K=3**	OR 0.65 (95% CI 0.38 to 1.12) I^2=N/A, K=1	Mean: 4 months Range: endpoint to 12 months
Intake of fat/ meat/dairy: not adhering to recommendations	**OR 0.70 (95% CI 0.61 to 0.81) I^2=0%, K=3**	**OR 0.73 (95% CI 0.61 to 0.88) I^2=N/A, K=1**	N/A	Mean: 5 months Range: endpoint to 8 months
Physical activity: not adhering to physical activity recommendations	**OR 0.73 (95% CI 0.65 to 0.83) I^2=64%, K=19**	OR 0.85 (95% CI 0.72 to 1.00) I^2=0%, K=4	**OR 0.58 (95% CI 0.38 to 0.87) I^2=N/A, K=1**	Mean: 4 months Range: endpoint to 12 months
Smoking	**OR 0.78 (95% CI 0.68 to 0.90) I^2=63, K=17**	N/A	N/A	Mean: 4 months Range: endpoint to 12 months
Alcohol misuse: not adhering to alcohol intake recommendations	OR 0.84 (95% CI 0.65 to 1.08) I^2=60%, K=5	N/A	OR 0.59 (95% CI 0.20 to 1.76) I^2=N/A, K=1	Mean: 5 months Range: endpoint to 12 months
Continuous data				
Calorie intake	**MD −83.37 (95% CI −148.54 to −18.20) I^2=80%, K=9**	N/A	N/A	Mean: 3 months Range: endpoint to 12 months
Fruit and vegetable intake (post-intervention)	**SMD 0.17 (95% CI 0.11 to 0.23) I^2=61%, K=22 Portions of fruit and vegetables: MD 0.31 (95% CI 0.17 to 0.45) I^2=56%, K=13**	**SMD 0.22 (95% CI 0.13 to 0.31) I^2=0%, K=2 Portions of fruit and vegetables: MD 0.48 (95% CI 0.32 to 0.64) I^2=0%, K=3**	**SMD 0.14 (95% CI 0.06 to 0.22) I^2=0%, K=3 Portions of fruit and vegetables: MD 0.37 (95% CI 0.15 to 0.59) I^2=0%, K=2**	Mean: 5 months Range: endpoint to 12 months
Intake of fat/ meat/dairy (post-intervention)	**SMD −0.24 (95% CI −0.36 to −0.12) I^2=82%, K=17**	**SMD −0.14 (95% CI −0.22 to −0.06) I^2=0%, K=3**	SMD −0.04 (95% CI −0.15 to 0.08) I^2=0%, K=2	Mean: 4 months Range: endpoint to 12 months
Physical activity (post-intervention)	**SMD 0.25 (95% CI 0.13 to 0.38) I^2=93%, K=27**	**SMD 0.05 (95% CI 0.18 to 0.29) I^2=56%, K=3**	**SMD 0.12 (0.01 to 0.23) I^2=32%, K=3**	Mean: 5 months Range: endpoint to 12 months

(continued on next page)

Table 2. Summary Point Estimates From the Meta-analyses of Multiple Risk Behavior Interventions (Primary Outcomes) *(continued)*

Risk behavior outcome	Summary point estimate: All	Low SES	BME	Follow-up time
Sexual risk behaviors	SMD −0.12 (95% CI −0.49 to 0.24) I^2=32%, K=3	N/A	N/A	Mean: 4 months Range: 1–6 months

Note: Results in bold are statistically significant.
BME, black and minority ethnic groups; FV, fruit and vegetable intake; K, number of trials; MD, mean difference; N/A, not applicable; SMD, standardized mean difference.

0.38, adjusted r^2=70.73%, adjusted p=0.015) and duration of intervention (slope=0.21, 95% CI=0.06, 0.36, adjusted r^2=64.23%, adjusted p=0.009) were associated with increased physical activity.

Enablement was associated with a reduced risk of smoking (slope=0.62, 95% CI=0.47, 0.81, adjusted p=0.007), and longer duration of intervention was associated with less effectiveness in reducing risk of smoking (slope=1.53, 95% CI=1.71, 2.01, adjusted p=0.001). Together, these factors explained 79.33% of heterogeneity.

All studies examined simultaneous change of risk behaviors. Three studies[40–42] compared simultaneous change with sequential change of risk behaviors and did not find statistically significant differences between interventions that aimed to changed diet and physical activity simultaneously and those that changed diet and physical activity sequentially. However, one study found that sequential interventions were more likely than simultaneous interventions to be effective in promoting smoking cessation (OR=1.51, p=0.004).[41]

There was insufficient evidence to determine whether contextual factors had any impact on effectiveness for any outcomes.

Overall, there were insufficient data to conclude whether effectiveness differs between lower- and higher-income groups, or between black and minority ethnic groups and majority ethnic groups (Table 2).

Table 3. Summary Point Estimates From the Meta-analyses of Multiple Risk Behavior Interventions (Secondary and Intermediate Outcomes)

Outcome	Summary point estimates: All	Low SES	BME	Follow-up time
Self-efficacy	SMD −0.06 (95% CI −0.17 to 0.06) I^2=71%, K=8	N/A	**SMD 0.16 (95% CI 0.02 to 0.30) I^2=N/A, K=1**	Mean: 4 months Range: endpoint to 9 months
Weight (kg)	**MD −0.59 (95% CI −1.02 to −0.16) I^2=57%, K=18**	MD −0.76 (95% CI −2.30 to 0.79) I^2=41%, K=3	**MD −0.88 (95% CI −1.47 to −0.29) I^2=N/A, K=1**	Mean: 5 months Range: endpoint to 12 months
BMI	**MD −0.27 (95% CI −0.46 to −0.07) I^2=65%, K=14**	MD −0.58 (95% CI −1.45 to 0.29) I^2=7%, K=2	**MD −0.31 (95% CI −0.53 to −0.09) I^2=N/A, K=1**	Mean: 5 months Range: endpoint to 15 months
Systolic blood pressure	**SMD −0.11 (95% CI −0.19 to −0.04) I^2=56%, K=13**	SMD 0.07 (95% CI −0.20 to 0.34) I^2=N/A, K=1	SMD −0.06 (95% CI −0.31 to 0.19) I^2=N/A, K=1	Mean: 6 months Range: endpoint to 24 months
Diastolic blood pressure	**SMD −0.11 (95% CI −0.19 to −0.04) I^2= 51%, K=13**	SMD 0.00 (95% CI −0.27 to 0.27) I^2=N/A, K=1	SMD −0.10 (95% CI −0.34 to 0.14) I^2=N/A, K=1	Mean: 6 months Range: endpoint to 24 months
Total cholesterol	**SMD −0.17 (95% CI −0.27 to −0.06) I^2= 81%, K=12**	SMD 0.00 (95% CI −0.27 to 0.27) I^2=N/A, K=1	SMD −0.09 (95% CI −0.34 to 0.16) I^2=N/A, K=1	Mean: 6 months Range: endpoint to 24 months
HDL cholesterol	SMD −0.13 (95% CI −0.31 to 0.05) I^2= 87%, K=9	SMD −0.12 (95% CI −0.39 to 0.15) I^2=N/A, K=1	SMD −0.11 (95% CI −0.35 to 0.13) I^2=N/A, K=1	Mean: 8 months Range: endpoint to 24 months
LDL cholesterol	SMD −0.17 (95% CI −0.34 to 0.00) I^2= 85%, K=9	SMD −0.04 (95% CI −0.31 to 0.23) I^2=N/A, K=1	SMD −0.09 (95% CI −0.33 to 0.15) I^2=N/A, K=1	Mean: 8 months Range: endpoint to 24 months

Note: Results in bold are statistically significant.
BME, black and minority ethnic groups; HDL, high-density lipoprotein; K, number of trials; LDL, low-density lipoprotein; MD, mean difference; N/A, not applicable; SMD, standardized mean difference.

Comparisons of univariate analyses with the multivariate analyses generally did not reveal substantial differences (Appendix, available online). The exception was the multivariate meta-analysis on smoking, meeting recommendations for fruit and vegetable intake, and meeting recommendations for physical activity. There was statistically significant evidence of improvement in fruit and vegetable intake in the univariate analyses (OR=0.62, 95% CI=0.51, 0.84, $p<0.0001$). However, in the multivariate meta-analysis, effectiveness in improving fruit and vegetable intake reduced substantially (OR=0.84, 95% CI=0.68, 1.03, p=0.09). This appears to be explained by a strong negative correlation between changes in smoking and fruit and vegetable intake ($r = -0.95$). In addition, changes in smoking behavior were negatively associated with improvements in physical activity although less strongly ($r = -0.44$).

Moderate-sized correlations were found between all of the other behaviors included in the multivariate meta-analyses. Improvements in fruit and vegetable intake ($r = 0.53$); calorie intake ($r = 0.56$); fat intake ($r = 0.52$); and physical activity ($r = 0.52$) were all associated with weight loss in a similar magnitude, suggesting that all are important strategies for reducing weight.

A stronger association was found between improvements in fruit and vegetable intake ($r = 0.56$) and changes to total cholesterol than fat intake ($r = 0.41$). Conversely, improvements in fat intake (systolic blood pressure, $r = 0.63$; diastolic blood pressure, $r = 0.43$) appeared to be more strongly associated with improvements in both systolic blood pressure and diastolic blood pressure than was fruit and vegetable intake (systolic blood pressure, $r = 0.52$; diastolic blood pressure, $r = 0.23$).

Increased physical activity was strongly associated with changes to total cholesterol ($r = 0.87$) and moderately associated with changes in systolic blood pressure ($r = 0.39$), but there was no association with changes to diastolic blood pressure ($r = 0.05$).

DISCUSSION

A systematic review was conducted assessing effects of multiple risk behavior interventions in general adult populations. Studies specifically targeting at-risk populations, including those at risk of cardiovascular disease or who are obese, were excluded. Sixty-nine RCTs were included with a total of 73,873 participants. Diet and physical activity were most frequently targeted and interventions consisted mainly of education combined with skills training. All 69 trials examined the simultaneous change of behaviors, and three[40–42] compared simultaneous with sequential change. Overall, small improvements in diet (e.g., fruit and vegetable, fat, and calorie intake); physical activity; and smoking were found, but effects diminished over time for fruit and vegetable intake. Multivariate analyses suggested weight loss was equally associated with improvements in fruit and vegetable intake, fat intake, calorie intake, and physical activity.

Reductions in smoking were negatively associated with improvements in fruit and vegetable intake and physical activity. This is consistent with the finding that interventions that targeted smoking and other risk behavior sequentially are more effective than those that seek simultaneous change.[41] By contrast, no statistically significant differences were found in the three studies that compared sequential and simultaneous change of diet and physical activity.[40–42]

Most interventions were based on a Social Cognitive Theory approach, but intermediate outcomes were reported infrequently, which makes it difficult to assess the theoretic assumptions of these interventions. Self-efficacy is a key component of Social Cognitive Theory and was the most commonly reported intermediate outcome. In studies that reported this outcome, interventions did not appear to be effective in improving self-efficacy. More consistent reporting of intermediate outcomes is needed to comprehensively evaluate the effectiveness of multiple risk behavior interventions and to examine the validity of their theoretic assumptions.

This systematic review adds to knowledge of multiple risk behavior change by providing a comprehensive evaluation of non-pharmacologic interventions targeting two or more risk behaviors in non-clinical adult populations. An earlier Cochrane review on multiple risk factor reduction assessed distal outcomes such as mortality and fatal and non-fatal coronary heart disease and found limited evidence of benefit from education and counseling interventions on these outcomes.[43] Similarly, a recent review of non-pharmacologic multiple risk behavior interventions delivered in the workplace found small benefits in diet, physical activity, and smoking.[44,45] However, the review did not distinguish between studies targeting multiple and single behaviors.

It was not possible to compare relative effectiveness of multiple and single risk behavior interventions as only two studies addressed this question. However, other systematic reviews have evaluated the effects of similar (non-pharmacologic) interventions on individual behaviors. Overall, the findings are comparable to those from this review. For example, interventions to improve diet in general populations increased servings of fruit and vegetables by a similar amount to the interventions included in this review (0.50 vs 0.31 more servings).[44,46] Reviews focusing on physical activity[47–49] reported small improvements (~SMD=0.20) similar to those found in this review (SMD=0.25).

The large number of studies and consistency of findings argues against further trials focusing on the use of education and skills training to target risky behaviors. Similarly, the large number of trials focusing on simultaneous change of multiple behaviors suggests no further evidence is needed. By contrast, a key evidence gap relates to the sequencing of intervention components. Only three studies examined sequential change, and therefore findings are inconclusive. Evidence is lacking on how various intervention components might be ordered to maximize impacts on risk behaviors. Understanding how people approach behavior change, especially when multiple behaviors are involved, is important. A United Kingdom–based qualitative study found that people differ in their strategies for change, with some preferring to make changes simultaneously, viewing each behavior as part of a healthier lifestyle and others sequentially, seeing behaviors as discrete and easier to change when broken down into manageable chunks.[50]

The present review indicates that interventions comprising education and skills training are associated with modest reductions in risk behaviors. At best, these interventions achieve small changes that may not translate into meaningful reductions in risk of mortality and cardiovascular disease–related mortality.[40] Although information and skills are important, they should be considered alongside other factors that influence behavior. Lack of social support; cost of adopting healthy behaviors; balancing health behaviors with everyday life (e.g., routines, time management); cultural preferences; and environmental barriers are likely to be equally important.[51] Individuals are influenced not only by their motivation and capability to make behavioral changes but also by opportunities afforded by the social and physical environment.[14] The impact of the physical and social environment on behavior is increasingly recognized, and advocates of the Social Ecological approach[52] argue that risk behaviors need to be understood within the context of social and physical environmental factors. These include the home and workplace as well as broader societal factors such as income inequality that impact on individuals and groups.[53]

However, the present systematic review identified few studies that incorporated environmental changes as part of the intervention package; where included, the focus was on the social rather than the physical environment. Despite the lack of evidence in support of environmental restructuring for changing health behaviors, findings from field and laboratory experiments suggest that human behavior is prompted by cues in the environment,[54,55] and such approaches have been explored extensively in the discipline of environmental psychology. This promising approach to large-scale behavior change requires thorough evaluation through good-quality observational studies and RCTs where feasible.

Limitations

Strengths of this review include comprehensive and rigorous searching and the mapping exercise to determine inclusion criteria.[11] It was assessed whether restricting to RCTs would limit the type of interventions eligible for inclusion and found this was unlikely to be the case. This is a particular issue with reviews of public health interventions and has been referred to as an "inverse evidence law" whereby least is known about the effects of interventions most likely to influence whole populations because they tend to be evaluated using less rigorous methods.[56]

Other strengths include use of the Behaviour Change Wheel to classify intervention components according to a standard set of functions. This enables identification of "active ingredients" across interventions and studies.

Limitations include the variable quality of the RCTs. Slightly more than half of the studies had a high risk of bias for at least one of the assessed domains. Studies varied in the way they measured behaviors, particularly physical activity and alcohol intake, which made comparisons difficult. Reporting of intermediate outcomes such as self-efficacy, attitudes, and knowledge was limited and, importantly, few studies provided contextual information, for example, about important external events occurring at the time of the intervention.

Few studies analyzed their results by subgroup. This is an important evidence gap: public health interventions, particularly those focusing on "downstream" interventions such as education and skills training, have the potential to increase health inequalities by disproportionately benefiting more-advantaged groups.[54,57] Although most studies reported data on income, occupation, education, ethnicity, and gender, and a few specifically targeted low-income[26,58–64] or black and ethnic minority groups,[25,33,63,65,66] it was not possible to explore equity effects in a meaningful way.

To ensure population homogeneity, this review focused on non-clinical adult populations, which means that a number of studies targeting specific at-risk populations, such as those who are obese or at high risk of cardiovascular disease, were excluded. Further systematic reviews are needed to address the effectiveness of multiple risk behavior interventions in these populations.

CONCLUSIONS

This is the first systematic review to provide overall estimates of the impact of non-pharmacologic interventions on multiple lifestyle risk behaviors in non-clinical, adult populations. Interventions, mainly consisting of education and skills training, targeting multiple risk behaviors resulted in small improvements in diet (e.g., fruit and vegetable intake) and physical activity and smoking. Such approaches result, at best, in small reductions in risk behaviors, which fail to translate into meaningful reduction in risk of overall mortality and cardiovascular disease–related mortality.

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SUPPLEMENTAL MATERIAL

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