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## **The effectiveness of dietary workplace interventions: a systematic review of systematic reviews**

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**Title:** The effectiveness of dietary workplace interventions: a systematic review of systematic reviews

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**Abstract**

**Objectives:** To summarise findings of systematic reviews that distinctively report dietary intervention components and its effects on diet-, health-related and economic-related outcomes in the workplace setting.

**Design:** *Medline, EMBASE, CINAHL, Web of Science, Cochrane Library and Google Scholar* were searched in December 2014 and the search was updated in August 2017.

**Results:** The search identified 1137 titles, of which 19 systematic reviews from the initial search and two systematic reviews from the updated search met the inclusion criteria (n=21, published in 22 papers). Most systematic reviews were of moderate quality and focused on dietary behaviour change outcomes and some health-related biomarkers. Evidence was strongest for interventions to increase fruit and vegetable intake, reduce fat intake, aid weight loss and reduce cholesterol. Few reported workplace-related and evaluation outcomes.

**Conclusions:** These findings suggest that workplace dietary interventions can positively influence diet and health outcomes. Suggestions for effective interventions components have been made.

**Key words:** dietary intervention; workplace, health outcomes, literature review

## **Introduction**

In accordance with a growing interest in workplace wellbeing, the number of interventions in this field has increased over recent years. Researchers aim to identify most effective strategies for workplaces to encourage staff to live healthier lifestyles (e.g. facilitate healthy eating at work, provide facilities to exercise more frequently and/or offer services to quit smoking). Numerous studies of diet, physical activity, weight-loss and/or smoking behaviour change interventions in the workplace setting are published annually, to assess the impact of such interventions on health, diet and ultimately economic-related (i.e. work-related) outcomes. Simultaneously, the number of reviews, systematic reviews (SRs) and meta-analyses (MAs) summarising these interventions is increasing, attempting to synthesize the wealth of published evidence and to inform future intervention designs as well as guide policy makers.

Few SRs highlight findings from solely dietary interventions<sup>(1-5)</sup>. Therefore, it proves challenging to filter out intervention components successful in changing dietary behaviour as part of a workplace wellbeing project. To learn from previous research and implement diet behaviour change interventions likely to be most effective, relevant literature on dietary workplace interventions needs to be reviewed. When turning to SRs, it needs to be considered that new guidelines on how to conduct and report SRs have been introduced since the first SRs were conducted<sup>(6,7)</sup>. Hence, SRs are likely to differ in their reporting structure and quality. Therefore, the aim of this SR of SRs was to I) summarise the findings of published SRs reviewing either dietary interventions or multi-component lifestyle interventions that distinctively report dietary intervention components and its effects on diet, health- and economic-related outcomes in the workplace setting, II) assess the most effective intervention components, and III) to assess the quality of the SRs.

## **Methods**

A systematic search was carried out following a pre-defined search protocol in accordance with PRISMA guidelines <sup>(6)</sup>.

### **Inclusion criteria**

SRs and MAs had to meet the following criteria: I) being published in a peer-reviewed journal before August 2017; II) reviewing interventions based in the workplace setting; III) being published in the English language; IV) including adults aged  $\geq 18$  years; V) clearly describing dietary intervention components, or clearly describing the impact of a multi-component intervention on diet-related outcomes; VI) SRs describing the effect of dietary intervention components on either dietary behaviour-related outcomes (i.e. intake, knowledge, attitude, skills), health-related outcomes (i.e. weight, body mass index, waist circumference, blood pressure, blood lipids, fasted blood glucose) or economic-related outcomes (i.e. absenteeism, sick leave, productivity, return-on-investment); VII) SRs including the general population and/or 'at risk' groups. Narrative reviews, reports and position statement were excluded from the analysis.

### **Search strategy**

The search strategy was developed in *MEDLINE* and was then adapted for the following databases: *EMBASE*, *CINAHL*, *Web of Science*, *Cochrane Library* and *GoogleScholar* (Appendix, Figure 1). In addition, relevant studies were identified in *Zetoc* and *NHS evidence* and reference lists were hand-searched to identify studies that were not detected through the database search. The search was conducted in December 2014 and was updated in August 2017. Abstracts and full-texts were reviewed independently, by two reviewers (DS and JW), for inclusion in the SR of SRs. Any disagreement between reviewers was solved by discussion until an agreement was reached.

## **Data extraction**

The first reviewer (DS) extracted all outcomes under review (Table 2) into a structured template which was then reviewed by the second reviewer (JW) for completeness. Any discrepancies between reviewers were discussed and resolved. All results were condensed and reported as extracted from the original research paper. Where information from the primary studies was not summarised in the SRs, the researchers reported the findings as stated in the SRs and did not refer back to the primary studies.

## **Quality assessment**

The AMSTAR quality criteria tool has been recommended as the only validated tool for quality assessment of reviews <sup>(7)</sup> and was used to assess the quality of identified SRs. The AMSTAR criteria tool ranks SRs on eleven quality items. The SR quality rating was conducted by the two reviewers independently and any disagreements were discussed until consensus was reached.

## **Data synthesis**

The heterogeneity in reporting and in the studies under review did not allow carrying out statistical analysis in the form of a MA. Instead, the reviewers conducted a narrative synthesis and systematically extracted the results for each outcome under review addressed in the SRs and MAs.

## **Results**

The search generated 1137 potential articles after duplicates were removed (Figure 1), of which 39 SRs and SRs of SRs were identified that reported workplace interventions including dietary

components (Appendix Table 1). Out of these SRs, 19 SRs (published in 20 papers) were identified as distinctly reporting either the effect of dietary interventions or dietary intervention components on dietary behaviour and/or other outcomes. Two additional SRs were identified in the updated search so that the final analysis included 21 SRs (published in 22 papers).

### **Systematic review characteristics**

Amongst the identified SRs, three carried out a MA which all assessed different outcomes: weight<sup>(8)</sup>, dietary behaviour<sup>(9)</sup> and theoretical framework<sup>(10)</sup> and could therefore not be directly compared. To be included in this SR of SRs, the effect of the dietary part of the intervention had to be apparent. Only four of the SRs evaluated solely dietary interventions<sup>(1,2,5,11)</sup>, compared to other SRs that included general workplace wellness programs, including multiple behaviours such as physical activity, smoking and alcohol consumption. Interventions reviewed were mainly conducted in America or Western Europe. One SR explicitly reviewed interventions carried out in Europe<sup>(12)</sup>. All SRs included interventions carried out in both male and female adults. None of the SRs included focused on groups at high-risk of disease and two SRs focused on health care professionals<sup>(9,13)</sup>. Therefore, no conclusions could be drawn with regards to nationality, work-type, high-risk populations or other socio-demographic characteristics of the target population, as this was not examined in most SRs. Three SRs focused on weight loss interventions<sup>(8,9,14)</sup> and four SRs examined interventions focusing on environmental aspects<sup>(15–18)</sup>. One SR looked at interventions to reduce major cancer risk factors<sup>(19)</sup> and Steyn et al.<sup>(11)</sup> focused on interventions published by the World Health Organization. The aims and objectives, as well as the focus of the interventions and outcomes of each SR, are reported in Appendix, Table 1. Outcomes that could most commonly be linked to the dietary intervention component were diet-related outcomes, such as fruit and vegetable (FV) intake (rather than health- or economic-related measures).

### **Study quality**

Table 1 provides an overview of the quality of the SRs according to AMSTAR criteria <sup>(7)</sup>: five SRs were of high quality (8-11 points) <sup>(1,8,9,18,20)</sup>; 15 were of medium quality (4-7 points) <sup>(2-5,10-17,19,21,22)</sup>, and one was rated low quality (0-3 points) <sup>(23)</sup>.

### **Diet-related outcomes**

Dietary behaviour change outcomes most under review were FV consumption, overall diet and fat and fibre intake (descending in order of frequency) (Table 2). Strongest evidence was reported for improving fruit and/or vegetable intake. Three high quality SRs and all nine medium quality SRs that reported FV intake as an outcome found that the number of studies reporting an increase in FV consumption outweighed the number of studies reporting no effect. Individual studies reviewed in the SRs reported improvements in various ways, e.g. % of FV, grams of FV, portions or overall increase. The few SRs that reported an increase in portions found an improvement between 0.2 and 0.7 portions <sup>(1,3,5,13,15)</sup>. ‘Overall diet’ was reported in twelve SRs, with evidence being suggestive of a positive effect. Improvements in overall diet were defined as ‘significant improvements in any of the dietary factors’ <sup>(19)</sup> or ‘increased consumption of healthier foods’ (e.g. FV, fibre, low-fat products) <sup>(9,18)</sup> and two SRs <sup>(9,13)</sup> reported diet scores as well as other diet-related factors, however, no explanation was given on how individual studies calculated diet scores. Findings on the change in total fat consumption were reported in eight, and saturated fat in two SRs <sup>(9,13)</sup>, with mixed to positive results. Results on fat intake were generally reported as a reduction in fat consumption <sup>(9,17)</sup> and few studies reported a percentage reduction in total fat, e.g. a change between -9.1% and +1.3% in energy from total fat <sup>(1,3,19)</sup>. The evidence for change in fibre consumption was reported in four SRs and was conflicting. The four SRs that looked at total energy intake all demonstrated positive effects <sup>(1,9,18,20)</sup>, however, the number of individual studies included in these SRs was very limited.



The findings on diet-related behaviour change outcomes, such as diet knowledge, purchasing behaviour and attitudes towards healthy options, were also very limited. Three SRs reported favourable findings on effectiveness of dietary interventions to improve diet-related knowledge<sup>(1,2,11)</sup>. One of those SRs<sup>(1)</sup> described one study that reported an improvement of 1.34 scores (out of 10) whereas other SRs report a general knowledge improvement, without reporting scores<sup>(2,11)</sup>. The association between dietary intervention and attitude towards diet was only reported in one medium quality SR which concluded that results were not very strong, however, small positive results were reported<sup>(22)</sup>. Self-efficacy was reported in one SR<sup>(1)</sup> and food purchasing patterns were reported in five SRs<sup>(1,4,15,16,18)</sup>, however, the number of studies that reported on these outcomes was relatively small so that no conclusion could be made and further evidence is needed. Overall, changes, although positive, were small and the potential impact as well as long-term effectiveness on diet and health is unknown.

### **Health-related outcomes**

In total, 19 SRs included health outcomes five of which were from high quality SRs. However, only eight SRs clearly drew conclusions with regards to the effectiveness of dietary interventions alone (Table 1) and results mainly included weight-related outcomes<sup>(1-3,9,17)</sup>, and cholesterol<sup>(1,2,17,24)</sup>. Results from high quality SRs were not conclusive for dietary interventions alone, except for two SRs that reported positive outcomes regarding reductions in weight and HDL-C were based on a very limited number of studies. Overall results for weight-related outcomes ranged from a weight reduction between -4.4 kg and -1.0 kg<sup>(2,3,9)</sup>, which was in line with a reduction in kcal intake; to a statistically significant BMI (kg/m<sup>2</sup>) increase<sup>(1,3,17)</sup>. Cholesterol reductions were generalized in most studies as a ‘significant decrease in cholesterol’ and Geaney et al.<sup>(1)</sup> reported an increase in HDL cholesterol by 0.06 mmol/l. One SR reported overall positive long-term health improvements as a result of dietary interventions<sup>(23)</sup>. Blood pressure (BP) was another commonly reported measure; however, it was unclear whether change in BP was due to a change in dietary behaviour. That applies

to other health-related outcomes, such as blood glucose levels and overall morbidity and mortality, which were reported less often.

### **Economic-related outcomes**

In eight SRs (2 high quality, 3 medium quality and 1 low quality), work-related outcomes, i.e. productivity, return on investment, health care costs and sickness absenteeism were assessed (Table 1). Three of these SRs did not find information on economic outcomes in the individual intervention studies under review <sup>(1,3,14)</sup>. Furthermore, three SRs reported findings, but could not draw conclusions with regards to dietary interventions alone <sup>(8,20,23)</sup>. Only two medium quality SRs reported a positive change in work-related outcomes as a result of a dietary intervention, i.e. that interventions were cost-effective <sup>(11)</sup> and reduced absenteeism as well as costs due to loss of productivity <sup>(2)</sup>. No specific values were provided, except for one study included in the SR by Jensen that reported a reduction in absenteeism by 20% which was the equivalent of three days <sup>(2)</sup>. Kahn-Marshall & Gallant <sup>(16)</sup> also noted that environmental and policy-based interventions were low-cost to implement.

### **Evaluation outcomes**

Evaluation outcomes, such as attrition <sup>(14)</sup>, staff participation and feasibility of the interventions were often not reported. No adverse intervention outcomes or financial losses were found. A criticism of individual studies included in the SRs was that any problems in study implementation and study fidelity were frequently not reported <sup>(12,18)</sup>. Some SRs did report information on the intervention workplaces but did not make comments on intervention effectiveness with regards to the kind of workplace or workplace size, except for some SRs that highlighted that most interventions are carried out in medium and large sized businesses and interventions may not be suitable for smaller businesses <sup>(2,8,16,19,20)</sup>. Anderson et al. note that one potential benefit of workplace wellbeing projects would be to improve the relationship between staff and management <sup>(8)</sup>. Interventions were criticised, however, for not including qualitative evaluation findings that would help explore that aspect <sup>(3)</sup>.

## **Findings for most effective intervention**

Due to the high heterogeneity in the design of the interventions under review and in SRs, there was a lack of consistency in findings of what interventions were most effective. Therefore, a summary of suggestions that were pointed out by at least some of the SRs is presented in Table 3. Only findings from high and medium quality studies have been summarised.

## **Discussion**

### *Overall findings*

This SR of SRs synthesises best available evidence from SRs and MAs evaluating dietary workplace interventions. Individual workplace dietary interventions assessed a range of outcomes and the heterogeneity of reported findings made it challenging to summarise results. Overall, positive effects for increasing FV consumption and overall diet, increasing diet knowledge, aiding weight loss and reducing total cholesterol were reported. Improvements in health and diet-related outcomes were often small but may potentially be clinically significant, i.e. a reduction in total fat intake has been linked to a reduction in body weight and improvement in LDL cholesterol and total cholesterol, as well as the ratio between HDL and LDL cholesterol <sup>(25)</sup>. Furthermore, an improvement in FV intake by up to 0.7 portions is an important improvement, considering that FV intake has stagnated over recent years <sup>(26)</sup>. None of the SRs distinguished between dietary behaviour at home in comparison to dietary behaviour at work. Change in diet throughout the week, however, is important, as it might indicate whether or not employees are likely to continue with the positive changes they have made at work <sup>(1,3)</sup>. Few studies examined the effect of dietary interventions alone on work-related outcomes. Overall, findings suggest that outcomes from dietary interventions may help to reduce employer's expenses. Cancelliere et al. found that people who had a poor diet and were overweight were more likely to suffer from absenteeism <sup>(27)</sup>, which suggests that dietary interventions may result in cost savings due to preventing presenteeism as well as absenteeism. Further supportive evidence on cost

saving is available for workplace wellbeing projects in general, rather than specifically dietary interventions, that were not included in this SR of SRs<sup>(28,29)</sup>.

### *Type of intervention*

The majority of SRs looked at interventions targeting multiple health behaviours. The evidence whether dietary interventions alone or in combination with other health behaviours are more effective in improving health is mixed. A number of SRs suggested that intensive interventions (i.e. interventions with numerous intervention components) are most effective<sup>(8,17)</sup> and that environmental changes (e.g. improving food choices in canteens and vending machines and labelling healthy options) should be included<sup>(1,11,21)</sup>, although not all authors were able to draw that conclusion<sup>(3,18)</sup>. One large multicomponent randomised controlled trial (n=24 worksites) that included environmental aspects was conducted by Sorensen et al.<sup>(30)</sup> in the United States. The intervention comprised of education, food tastings, family training, increased availability of FV and food labelling. The study reported that the most intensive intervention arm (including the family component) was most successful and reported a significant increase in FV consumption. The Seattle 5 a day Worksite Program by Beresford et al.<sup>(31)</sup> (n=28 worksites) also delivered multiple intervention components such as changes to the work environment (catering policies, healthier options in vending machines, etc.) individual education components (e.g. cooking classes and posters) and reported an increase in FV consumption in the intervention sites compared to control sites.

This is in agreement with the report on *Overcoming Obesity* by the McKinsey Global Institute which outlines that healthy choices should be made easily accessible and less healthy choices should be made less easily accessible, to nudge healthier diet behaviour<sup>(32)</sup>. In a recent commentary, public health experts highlighted the need to reduce unhealthy nudges, that can be detrimental to efforts made in public health, and increase positive nudges<sup>(33)</sup>. One limitation of interventions that have reported changes of the environment is that these are often carried out in workplace canteens.

Therefore, the evidence for workplaces without canteen facilities on-site is limited and, in future, it should also be explored what works in smaller workplaces that often do not provide canteen facilities.

### *Systematic review quality*

The SRs were generally of medium quality, with few SRs of high quality. It has to be taken into account that AMSTAR criteria were published in 2007, before some of the earlier SRs were carried out, and therefore less guidance was available for researchers at the time. Furthermore, some of the criteria were not applicable and therefore the score may not accurately present the quality of each SR, i.e. I) ‘combining findings’ which indicates pooling of results and was not applicable for most SRs due to the heterogeneity and may be more applicable for MAs; II) ‘conflict of interest’ has only recently been introduced; III) ‘publication bias’, which is generally assessed through funnel plots, was also not applicable for most studies (the score for publication bias was given for SRs that did not carry out a MA when publication bias was discussed); IV) depth of information on ‘study characteristics’ varied widely between studies. The quality scoring criteria used also varied in most SRs, and few SRs performed a formal quality assessment. A point was given for this criterion for a less formal consideration of study designs. Under ‘quality in conclusions’, only SRs that clearly discussed their findings together with the quality of SRs were scored a point.

### *Strengths and limitations*

This SR has extracted the results from the best knowledge sources available on dietary interventions or dietary intervention components, so that researchers, policy makers and employers have a reliable source of information when implementing dietary interventions in the workplace. However, by including SRs only, important findings from other reviews may have been overlooked. Although we aimed to only review dietary interventions in the workplace, because most SRs targeted multiple

health behaviours, some of the conclusions made with regards to intervention delivery may overlap with recommendations for workplace interventions in general.

Publication bias (i.e. only successful interventions are published) and selection bias (i.e. participants who volunteered to take part in studies are more likely to want to change) in individual studies are a possible explanation for the positive findings of SRs <sup>(34)</sup>. However, the improvement in outcomes reported in each SR as a result of dietary interventions in the workplace is relatively small and therefore it seems unlikely that results were skewed by this bias. The limitations of the individual interventions are also limiting this SR of SRs in its conclusions, e.g. self-reporting of diet outcomes, imprecise reporting of work-related outcomes, limited follow up periods, missing information on intervention reach and lack of thorough evaluation, i.e. lack of process evaluation and use of qualitative as well as quantitative data collection. Osilla et al., for example, highlights that incentives are commonly used as part of workplace wellbeing programs <sup>(20)</sup>, however, there is little information on their effectiveness.

Another limitation of this SR is that scores for the quality of SRs were only given when the SRs clearly stated the required criterion and therefore some of the SRs may have been judged inappropriately. This will hopefully encourage researchers in future to clearly describe how quality criteria have been met to ensure researchers produce a good evidence base. The lack of rigorous study design, i.e. non-randomized and non-controlled trials, was commented on by a number of authors <sup>(8, 9, 17)</sup>, however, others argued that randomized controlled trials (RCTs) are not the most appropriate designs for public health interventions and that researchers should rather aim to increase efficacy, reach and uptake of interventions <sup>(12)</sup>. This argument was further explored by O'Donnell who argues that representative sampling, measures that appropriately assess the outcomes, correct use of statistical analysis and consideration of the elements of the program are more important in a robust study methodology than a RCT design <sup>(35)</sup>. Further, he argues that it is impossible to control the different factors of a comprehensive workplace program and mentions key factors that are more

important, including management support and a company-tailored program, which is in agreement with SRs discussed here <sup>(3,11,19)</sup>. Investors and business owners want to get the best return for their time and resource investment, which is another reason why RCTs may not be the most suitable design for these interventions and before and after designs are commonly implemented <sup>(36)</sup>. One way to evaluate non-controlled interventions would be to introduce intervention components in a staged manner <sup>(9)</sup>.

### *Comparison to the literature*

A limited number of SRs of SRs reported findings on behaviour change in the workplace, including a change in eating habits. Greaves et al. for example, found that engaging in social support and targeting both diet and PA behaviour as well as building interventions on behaviour change techniques increased intervention effectiveness in Type II Diabetes patients <sup>(37)</sup>. Findings from another SR of SRs suggested the workplace settings are most effective in changing diet, as well as other health behaviours compared to community-based settings or individual interventions <sup>(38)</sup> and that environmental changes to the canteen environment, such as increased availability of healthier food and drink options, together with the labelling of healthier options was effective in encouraging people to eat a healthier diet <sup>(39)</sup>. This is in agreement with the findings of this SR of SRs, as the majority of interventions recommended the inclusion of environmental changes when designing dietary interventions for workplaces. The most recent SR of SRs in this area of research included SRs on multiple health behaviours and only three SRs reported dietary interventions <sup>(40)</sup>. It also lacked quality assessment of the SRs and was therefore limited in its conclusions. By thoroughly assessing solely the dietary component of each SR under review, the outcomes of this research have added valuable insight into the effectiveness of dietary studies alone on diet-, health- and economic-related outcomes.

### *Application of findings*

The findings need to be considered with caution, as most SRs have looked at wellbeing interventions that addressed multiple behaviours. Improvement in diet could be clearly linked to the dietary components, however, conclusions drawn with regards to health- and economic-related measures are limited. The reviewed interventions were mainly carried out in the US or Western Europe and findings of this SR may not be applicable elsewhere. However, two SRs excluded here, discussed initiatives in Latin America <sup>(41)</sup> and New Zealand <sup>(42)</sup>. No recommendations can be made with regards to the type of work, age or gender, as these were not reported in the included SRs and the two SRs that looked at interventions in health care professionals were not able to draw conclusions <sup>(9,13)</sup>. Studies not included in the this SR also looked at blue collar workers <sup>(43)</sup>, health care professionals <sup>(44)</sup>, overweight and obese populations <sup>(45)</sup>, and groups at risk of cardiovascular disease <sup>(42,43)</sup>.

#### *Future research*

While there are a small number of studies looking at different study populations, there is a need for further research to identify the effectiveness of dietary workplace interventions in different populations. Interventions and messages should be tailored to the study population and adapted to the requirements of each workplace to increase effectiveness. For intervention success, it is essential to make use of the unique opportunity that the workplace setting provides, i.e. nudge the environment, involve employees in intervention planning and delivery and encourage effective leadership and management support. Intervention studies should also be set up over a longer period of time to assess long-term improvements. To improve comparability between study outcomes, gold standard measurements need to be developed to measure economic-related outcomes and a mixed-methods approach should be applied to assess the ‘how’ and ‘why’ as well as the ‘what’ has changed <sup>(1)</sup>.

As the ultimate goal of research is to enhance practice and learn from previous findings, it is important to carefully evaluate each intervention, and report in detail: I) all intervention components, planned and delivered, so that future research may be able to be replicate or tweak what has been done previously, II) participant as well as workplace characteristics (including management buy-in), III)



all relevant outcomes, including participant retention rate and fidelity of intervention delivery. MRC guidelines should be followed to design and evaluate complex interventions and TREND guidelines used for the accurate reporting of non-randomized trials.

## **Conclusion**

Dietary workplace interventions seem to have small, positive effects, in the short-term, on increasing FV intake, reducing fat intake, aiding weight loss and reducing cholesterol. There is no ‘one design fits all’ and intervention designers should shift their focus from finding the ‘perfect’ design and apply some crucial criteria that have been repeatedly mentioned to improve the chances of intervention success, including tailoring the intervention to the workforce, aiming for high participation and low drop-out rates, utilising the unique social and environmental assets of the workplace, ensuring management support and employee involvement, incorporating multiple components, considering eating habits at work and outside the workplace, carrying out mixed-methods process evaluation, and measuring health- and economic-related outcomes. More transparency in reporting of what did and didn’t work and what was well accepted by staff is encouraged, so that policy makers, employers and other researchers can learn from future efforts. Workplace dietary interventions seem to have the potential to improve some aspects of dietary behaviour and health outcomes, which is likely to save companies costs in the long-term.

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1

**Table 1** Quality of systematic reviews and meta-analysis under review rated according to the AMSTAR quality criteria

	Priori design	2 independent extractors	Comprehensive search	Publication status	List of studies	Study characteristics	Quality assessment	Quality in conclusion	Combine findings	Publication bias	Conflict of interest	Score
<b>High Quality</b>												
<i>Allan et al 2017</i> <sup>(18)</sup>	+	+	+	o	o	+	+	+	+	o	+	8
<i>Anderson et al., 2009</i> <sup>(8)</sup>	+	+	+	+	+	+	+	+	+	+	+	11
<i>Geaney et al., 2013</i> <sup>(1)</sup>	+	+	+	o	+	+	+	+	o	+	+	9
<i>Osilla et al., 2012</i> <sup>(20)</sup>	+	+	+	o	o	+	+	+	o	+	+	8
<i>Power et al., 2014</i> <sup>(9)</sup>	+	+	+	+	+	+	+	+	+	+	+	11
<b>Medium Quality</b>												
<i>Aneni et al., 2014</i> <sup>(21)</sup>	+	o	+	o	o	+	+	+	o	+	+	7
<i>Benedict &amp; Arterburn, 2008</i> <sup>(14)</sup>	+	+	+	o	o	+	+	+	o	+	o	7
<i>Engbers et al., 2005</i> <sup>(17)</sup>	+	o	+	o	o	+	+	+	o	+	o	6
<i>Glanz et al., 1996</i> <sup>(4)</sup>	+	o	+	o	o	+	+	+	o	o	+	6
<i>Hutchinson &amp; Wilson, 2011</i> <sup>(10)</sup>	+	o	o	o	o	o	+	+	+	+	o	5
<i>Janer et al., 2002</i> <sup>(19)</sup>	+	o	o	o	o	+	+	+	o	o	o	4
<i>Jensen., 2011</i> <sup>(2)</sup>	o	o	+	o	o	+	+	+	o	o	o	4
<i>Kahn-Marshall &amp; Gallant, 2012</i> <sup>(16)</sup>	+	o	+	o	o	+	+	+	o	+	+	7
<i>Maes et al., 2012</i> <sup>(12)</sup>	+	o	+	o	o	+	+	+	o	+	+	7
<i>Matson-Koffmann et al., 2004</i> <sup>(15)</sup>	o	o	+	+	o	+	+	+	o	+	+	7
<i>Ni Mhurchu et al., 2010</i> <sup>(3)</sup>	o	o	+	o	o	+	+	+	o	+	+	6
<i>Pomerlau et al., 2005</i> <sup>(5)</sup>	+	o	+	o	o	+	+	+	o	+	+	7
<i>Steyn et al., 2009</i> <sup>(11)</sup>	+	o	+	o	o	+	+	+	o	o	+	6
<i>Torquati et al., 2016</i> <sup>(13)</sup>	o	+	+	o	o	+	+	+	+	o	+	7
<i>Wilson et al., 1996</i> <sup>(22)</sup>	o	o	+	+	o	o	+	+	o	o	+	5
<b>Low Quality</b>												
<i>Riedel et al., 2001</i> <sup>(23)</sup>	o	o	+	+	o	o	o	o	o	o	o	2

2

+ - criteria met; o - criteria not met

3

4

**Table 2** Summary of dietary, health and economic-related outcomes extracted from each systematic review/ meta-analysis

Author Year Review type	Time range of studies included	Number of studies included (n)	Outcomes Diet-related (Intake, Knowledge, Attitude, Skills)	Health-related (Weight, BMI, WC, BP, Blood lipids, fasted blood glucose)	Economic-related (Absenteeism, sick leave, productivity, return-on- investment, health care costs)
<b>High Quality</b>					
<b>Allan et al., 2017</b> (18)  <b>SR</b>	Up to November 2014	n=22	n=13/22 D outcomes (FV consumption, increased sales of healthy options, reduction in total energy consumption) +  <i>Evidence from environmental interventions does not enable clear recommendations to be made</i>	Weight and BMI (n=1/2) + after 1 and 2 years, NC  <i>Further evidence required to understand impact on weight</i>	n/a
<b>Anderson et al., 2009</b> (8)  <b>SR &amp; MA</b>	Up to 2005	n=47 total, (n=10 D; n=27 D + PA)	n/a	Weight modest + (at 6-12 months), NC  <i>Consistent albeit modest effect on weight-related outcomes, NC</i>	Economic evaluation (n 8): more studies needed for definite conclusions, NC
<b>Geaney et al., 2013</b> (1)  <b>SR</b>	Up to Nov 2011	n=6 (12 articles)	FV (n=4/5) + ; Fat (n=1/3) +; Energy (n=1/1) +; Self-efficacy (n=1/1)+; Dietary knowledge (n=1/1) +; Food purchasing patterns (n=1/2) +  <i>Limited evidence suggests that workplace dietary modification interventions alone and in combination with dietary education increase FV intakes.</i>	BMI (n=1/1) -; HDL-C (n=1/1) +  Total cholesterol, Waist- hip ratio, perceived health: no change reported	ANR
<b>Osilla et al., 2012</b> (20)  <b>SR</b>	2000 to June 2011	33 (n=12 studies with D component)	Diet (n=6/12) + including: FV, fat, total energy +  <i>Small effects and mixed results, lack of rigorous evaluation</i>	Effects on endpoints such as BMI, BP reported, NC	(n=4) Absenteeism, Healthcare cost +, NC
<b>Power et al., 2014</b> (9)  <b>SR and MA</b>	Up to July 2012	n=13 RCTs (n=2 D; n=6 D + PA)	Overall diet (n=1/4) +; Total Energy (n=2/2) +; Fat (n=2/2) +; SFA (n=3/4) +; % Energy from Fat (n=2/4) +; F (n=3/3) +; V (n=2/2) +; Fibre (n=2/2) +; Diet score ns	Weight (n=1, D only) ns after 3 months, + after 6 months  <i>Greater weight loss when allocated to D and PA intervention.</i>	n/a

			<i>Differences reported at different time points – generally significant outcomes after 6/12 months</i>		
<b>Medium Quality</b>					
<b>Aneni et al., 2014</b> <sup>(21)</sup>	Up to Nov 2012	n=29 (n=12 measured diet outcome)	High-quality RCTs (n=4/9): + in a range of outcomes including improved dietary self-efficacy and attitude; greater intake of fruits, nuts, seeds; lower protein and sodium intake, (n=5/9) <i>ns</i>	NC	n/a
<b>SR</b>			FV (n=3) + follow up studies (low quality)		
			<i>Internet-based interventions are more likely to be successful if physical components included.</i>		
<b>Benedict &amp; Arterburn, 2008</b> <sup>(14)</sup>	1995-2006	n=11 (total), n=2 D, n=9 PA or multicomponent	n/a	Weight + NC; Lipids, BP modest +, NC	ANR
<b>SR</b>				<i>Worksite-based weight loss programs can result in modest short improvements in weight; long-term data on health lacking</i>	<i>Long-term data on economic outcomes lacking</i>
<b>Engbers et al., 2005</b> <sup>(17)</sup>	1985 - Jan 2004	n=13	FV (n=6/6) +; Fat (n=5/6) +; Fibre (n=1/3) +	Cholesterol (n=4) <i>ns</i> ; BMI (n=1/3) -; BP (n 1) <i>ns</i> , NC	n/a
<b>SR</b>			<i>Strong evidence of the effectiveness of interventions with environmental modifications on FV, fat intake</i>	<i>No evidence on the effectiveness of worksite health promotion programs on health risk indicators</i>	
<b>Glanz et al., 1996</b> <sup>(4)</sup>	1980 - 1995	n=26 (n=10 D; n=16 cholesterol)	Quality of evidence between suggestive and indicative; limitations in research methodology noted.	Quality of evidence between suggestive and indicative; limitations in research methodology noted.	n/a
<b>SR</b>					
<b>Hutchinson &amp; Wilson, 2012</b> <sup>(10)</sup>	1999 – March 2009	n=29 (n=7 reported solely D related outcomes post-intervention; n=2 reported diet outcomes change over time)	I) Theoretical approaches (education, social influence and cognitive behavioural) associated with small effects on diet (FV, fat); II) Motivational enhancement associated with larger effects and, perhaps,	Cholesterol, weight – results mixed, NC	n/a
<b>SR &amp; MA</b>					



			<p>maintenance over time. Considerable variation between studies.</p> <p>III) Studies targeting multiple health behaviours were associated with smaller effect sizes than those that focused on one health behaviour.</p> <p><i>Workplace suitable environment for making modest changes in diet</i></p>		
<b>Janer et al., 2002</b> <sup>(19)</sup>	Not stated	n=45 (n=16 D only or with D component)	<p>Overall diet (n=11/14) +; Fat (n=6/10) +; Fibre (n=3/5)+; V (n=6/7) +; F (n=4/5) +</p>	NC	n/a
<b>SR</b>					
<b>Jensen, 2011</b> <sup>(2)</sup>	n/a	n=30 (n=13 addressing direct economic consequences; n=17 addressing health factors expected to generate economic effects)	<p><i>Positive but modest intervention effects.</i></p> <p>Healthier diet (n=10/13) +; Dietary knowledge (n=4/4) +;</p> <p><i>Interventions capable of FV +; Fibre +; Fat + : small effect sizes</i></p>	BMI and Cholesterol (n=3/4) moderate + effects fairly well documented	<p>Absenteeism +; Cost of productivity loss in terms of presenteeism and high labour turnover +</p> <p><i>Well-targeted and efficiently implemented diet-related worksite health promotion interventions may improve labour productivity by 1-2%.</i></p>
<b>SR</b>					
<b>Kahn-Marshall &amp; Gallant, 2012</b> <sup>(16)</sup>	1995-2010	n=27 (n=3 D environmental/ policy only; n=5 D environmental/individual level interventions)	<p>I) Environment/Policy: Dietary behaviours (n=2/2) + ; methodological concerns;</p> <p><i>Inconclusive evidence for the effectiveness of environmental and policy changes alone to change employee dietary behaviours;</i></p> <p>II) Environmental/individual level: diet behaviours: modest +; FV (n=3/4): +;</p> <p><i>Moderate evidence for effectiveness of environmental/policy and individual level strategies;</i></p> <p>III) (N+PA) Dietary outcomes mostly +; FV (n=4/5) +</p>	NC	n/a
<b>SR</b>					

<b>Matson-Koffmann et al., 2004</b> <sup>(15)</sup>	1970- Oct 2003	n=129, (< 1990: n=18 WP+ restaurants; > 1990: n=13 WP)	<i>Evidence greatest for multicomponent interventions and with both environmental and individual-level strategies</i> Overall diet ( $\geq n=10$ quasi- or experimental studies): strong + for environmental interventions (all settings).	n/a	n/a
<b>SR</b>			Strongest evidence for influencing dietary behaviour in the workplace: Availability of healthier foods/choices, PoP strategies, dietary education and employer support		
<b>Maes et al., 2012</b> <sup>(12)</sup>	1990 – 1st Oct 2010	n=30 (n=17 D, n=13 D +PA)	<i>Policy and environmental interventions may promote good diet; research needed to determine long-term effectiveness.</i> <i>Moderate evidence of the effect of educational and multi-component dietary interventions on dietary behaviours. Combined D+PA interventions showed less positive results.</i>	<i>Inconclusive evidence</i>	n/a
<b>SR</b>			FV (n=12) +; Fat (n=9) +	Body weight (n=2/3) +; (n=1/3) -	ANR
<b>Ni Mhurchu et al., 2010</b> <sup>(3)</sup>	1995- April 2009	n=16	<i>In general, interventions led to positive changes in fruit, vegetable and total fat intake.</i>		
<b>SR</b>					
<b>Pomerlau et al., 2005</b> <sup>(5)</sup>	Up to April 2004	n=44 (n=11 WP)	FV (n=8/11) +; larger effects in studies either: (1) utilising social support activities; (2) offering larger numbers of activities; or (3) with higher greater participation.	n/a	n/a
<b>SR</b>					
<b>Steyn et al., 2009</b> <sup>(11)</sup>	1995 - 2006	n=30	<i>Larger effects for individuals at higher risk of disease.</i> Studies regarded as best practice studies practice (n=5) in terms of diet behaviour change: various intervention strategies successful including behavioural, educational and environmental;	Studies regarded as best practice in terms of clinical outcome: Lipids (n=2) +	Cost-effectiveness (n=4/5) + (these were organized by employees, not healthcare professionals)
<b>SR</b>					

			Best practice studies in terms of psychosocial outcomes produced changes in dietary knowledge.		
<b>Torquati et al., 2016</b> <sup>(13)</sup>	Up to October 2014	n=9 (n=6 Diet but only n=4 measured D outcomes)	Overall diet (n=2/2)+; FV (n 1/1) +; SFA (n=1/1) +; diet knowledge <i>ANR</i>	<i>NC</i>	n/a
<b>SR</b>			<i>Inconsistent evidence to support workplace interventions improve diet in nurses</i>		
<b>Wilson et al., 1996 (2x)</b> <sup>(22,24)</sup>	1968 to 1994	n=316	Dietary change and change in dietary attitude – suggestive/indicative for both	Cholesterol – suggestive/indicative Weight control - indicative	n/a
<b>SR</b>					
<b>Low Quality</b>					
<b>Riedel et al., 2001</b> <sup>(23)</sup>	1993 – 1998	n=146 (total)	n/a	Long-term healthy improvements +	Performance loss , <i>NC</i> ; Medical cost + (in the long term); RoI data lacking
<b>SR</b>					

6 + positive effect ; - negative effect; *ns* - not significant; *NC* – Data, as presented in SR, did not allow clear distinction between diet-related components; n/a – not assessed; *ANR* –  
7 outcomes were assessed but not reported; D – diet; PA – physical activity; F – Fruit; V- Vegetables; FV – Fruit and Vegetables; SFA – saturated fat; BP – blood pressure; BMI –  
8 body mass index; RoI – return on investment; PoP- Point-of-purchase labelling

**Table 3** Limitations from previous research and recommendations for future (high and medium quality studies only)

<b>Limitations from previous interventions</b>	<ul style="list-style-type: none"> <li>• <i>Low participation rates</i> <sup>(11,12)</sup> and <i>high attrition rates</i> <sup>(19)</sup></li> <li>• <i>Lack of thorough description of intervention content and delivery</i> <sup>(9,15,18)</sup></li> <li>• <i>Self-reported diet measures may have introduced bias and impact on validity of results</i> <sup>(5,13,20)</sup></li> <li>• <b>Evidence supported that workplace interventions provided benefits in the short-term</b> <sup>(4,16,20)</sup>, <b>however, information on long-term benefits was missing</b> <sup>(1,11,15,19)</sup></li> <li>• <i>Selection bias in studies, i.e. self-selected volunteers rather than the whole workplace that may have skewed results</i> <sup>(11,13)</sup></li> <li>• <i>Lack of cost-saving evaluation reported in studies</i> <sup>(14,20)</sup></li> </ul>
<b>Recommendations for future interventions</b>	<p><b>Designing interventions</b></p> <ul style="list-style-type: none"> <li>• <b>Obtain management support and commitment</b> as this is key for intervention success <sup>(8,16,19)</sup></li> <li>• <b>Maximize participation rates</b> and intervention adherence <sup>(11,12,16)</sup></li> <li>• <b>Involve employees</b> in planning, implementation, management <sup>(11,16)</sup></li> <li>• Plan for a <b>longer study duration</b> <sup>(11)</sup> – recommendations ranged from at least six months <sup>(19,21)</sup> to 12 months <sup>(1,9)</sup></li> <li>• Develop intervention <b>based on an underlying behaviour change theory</b> and explain reasoning <sup>(9–11)</sup></li> <li>• Intervene at <b>multiple levels</b> (e.g. environment and individual) and <b>utilise the social and organizational environment</b> in work for greater impact and develop the study <b>tailored to the workplace context and the population</b> <sup>(1,3,11,13,19)</sup></li> <li>• <b>Increase the availability of healthy options</b> at work <sup>(11,15,16)</sup></li> <li>• Include <b>multiple face-to-face contacts</b> <sup>(14,19)</sup></li> <li>• Address multiple behaviours <sup>(16)</sup> vs diet-only interventions <sup>(10,12)</sup></li> </ul> <p><b>Evaluating interventions</b></p> <ul style="list-style-type: none"> <li>• Carry out <b>detailed process evaluation</b>, using a mixed-methods approach (i.e. qualitative and quantitative evaluation) to report outcomes <sup>(1,3,9)</sup></li> </ul> <p><b>Reporting interventions</b></p> <ul style="list-style-type: none"> <li>• <b>Report objective measures</b> such as diet and health biomarkers (e.g. urine, blood) <sup>(1,21)</sup> or actual purchasing of items when canteen changes took place <sup>(5)</sup> and cost-effectiveness (e.g. absenteeism, productivity, presenteeism, health care costs) <sup>(1,3)</sup></li> <li>• <b>Report</b> adequately and in detail the <b>content delivered</b> <sup>(9,15,18)</sup></li> </ul>