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The effect of complex workplace dietary interventions on employees' dietary intakes, nutrition knowledge and health status: a cluster controlled trial

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ABSTRACT

Background. Evidence on effective workplace dietary interventions is limited. The comparative effectiveness of a workplace environmental dietary modification and an educational intervention both alone and in combination was assessed versus a control workplace on employees' dietary intakes, nutrition knowledge and health status.

Methods. In the Food Choice at Work cluster controlled trial, four large, purposively selected manufacturing workplaces in Ireland were allocated to control (N = 111), nutrition education (Education) (N = 226), environmental dietary modification (Environment) (N = 113) and nutrition education and environmental dietary modification (Combined) (N = 400) in 2013. Nutrition education included group presentations, individual consultations and detailed nutrition information. Environmental dietary modification included menu modification, fruit price discounts, strategic positioning of healthier alternatives and portion size control. Data on dietary intakes, nutrition knowledge and health status were obtained at baseline and follow-up at 7–9 months. Multivariate analysis of covariance compared changes across the four groups with adjustment for age, gender, educational status and other baseline characteristics. Results: Follow-up data at 7–9 months were obtained for 541 employees (64% of 850 recruited) aged 18–64 years: control: 70 (63%), Education: 113 (50%), Environment: 74 (65%) and Combined: 284 (71%). There were significant positive changes in intakes of saturated fat ($p = 0.013$), salt ($p = 0.010$) and nutrition knowledge ($p = 0.034$) between baseline and follow-up in the combined intervention versus the control. Small but significant changes in BMI (-1.2 kg/m^2 (95% CI -2.385, -0.018, $p = 0.047$) were observed in the combined intervention. Effects in the education and environment alone workplaces were smaller and generally non-significant.

Conclusion. Combining nutrition education and environmental dietary modification may be an effective approach for promoting a healthy diet and weight loss at work.

1. Introduction

The World Health Organisation (WHO) Global Action Plan for the Prevention and Control of non-communicable diseases (NCDs) 2013–2020 is focused on reaching specific targets to achieve a global goal of reducing NCD deaths by 2% per year and a halt in the increase of obesity and type 2 diabetes (WHO, 2013). Aside from smoking and physical activity, diet is a major contributor to the development of these diseases (WHO, 2013). Diets that are low in saturated fat, sugar and salt (target to reduce to 5 g per person per day) were among the priority cost-effective interventions highlighted at the UN High Level Meeting on NCDs in September 2011 (Beaglehole et al., 2011). It is accepted that the surrounding environments in which individuals live and work influences their health behaviours and that modifying these environments at both macro and micro levels is an important catalyst for behaviour change (Hollands et al., 2013; Das and Horton, 2012; Roberto et al., 2015; Kleinert and Horton, 2015). In particular, 'choice architecture' (based on the nudge theoretical perspective) is now recognised as a potentially valuable approach to influencing health related behaviours (Hollands et al., 2013; Regulating, 2011; Thaler and Sunstein, 2008).

The workplace has been recognised by the WHO as a priority environment to influence dietary behaviours given that individuals can spend up to two-thirds of their waking hours at work (WHO, 2013). In our previous review, there was limited evidence to suggest that workplace dietary modification interventions alone or in combination

Abbreviations: WHO, World Health Organisation; NCDs, non-communicable diseases; FCW, Food Choice at Work study; IPAQ, International Physical Activity Questionnaire; NetWisp, net weighed intake software program; SPSS, Statistical Package for the Social Sciences; MANCOVA, multivariate analysis of covariance.

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with nutrition education can increase fruit and vegetable consumption (Geaney et al., 2013a). Four out of six studies reported small increases in fruit and vegetable consumption (≤half serving/day). These studies involved workplace dietary modifications and three incorporated nutrition education. However, many of these interventions relied mainly on information provision and did not include potentially valuable nudging environmental strategies such as food modification. The interventions documented in the literature were of generally low intensity and poorly evaluated (Geaney et al., 2013a). Given the sub-optimal study designs, weak process evaluations and the lack of cost-effectiveness evaluations, it was difficult to draw definite conclusions on the effectiveness of workplace dietary interventions (Geaney et al., 2013a).

The aim of the Food Choice at Work (FCW) study was to assess the comparative effectiveness of a workplace environmental dietary modification intervention and a nutrition education intervention both alone and in combination versus a control workplace. It was hypothesised that the combined intervention (environmental dietary modification and nutrition education) of high intensity would be more effective than either intervention alone or no intervention in promoting positive changes in employees' dietary intakes, nutrition knowledge and health status outcomes. The combination of multiple components of environmental dietary modification and nutrition education and the implementation of these components on multiple levels within the workplace (system level: changes within the eating environment, employee level: individual nutrition consultations) formed this high intensity intervention.

2. Methods

2.1. Food Choice at Work intervention design

Details of the study design, intervention elements and methods of the FCW study have been published previously (Geaney et al., 2013b). Briefly, a cluster controlled trial was conducted in four large multinational manufacturing workplaces in Cork, Ireland. All participants were informed that they were involved in a university-led study designed to observe employees' dietary behaviours. In the control workplace, data was collected at baseline and follow-up. Nutrition education was provided in the second workplace (Education). Environmental dietary modification alone was implemented in the third workplace (Environment). The combined intervention which included nutrition education and environmental dietary modification was implemented in the fourth workplace (Combined). The complex intervention design was developed and evaluated using the MRC framework for 'Developing and evaluating complex interventions: new guidance' (Craig et al., 2008). The four phases of the framework included (A) development, (B) feasibility and piloting, (C) evaluation and (D) implementation (Craig et al., 2008). Details regarding the application of the framework were published in the study protocol (Geaney et al., 2013b).

The complex interventions complied with a soft paternalistic "nudge" theoretical perspective and a social ecological perspective where the interventions created positive reinforcement with indirect suggestions for healthy food choices to improve the employees' dietary behaviours (Regulating, 2011; Thaler and Sunstein, 2008; Bronfenbrenner and Bronfenbrenner, 2009; Baranowski et al., 2003; Stokols, 1996). Nutrition education comprised of three elements: monthly group nutrition presentations, detailed group nutrition information (daily traffic light menu-labelling and monthly posters, leaflets and emails) and individual nutrition consultations. Each participant attended three individual nutrition consultations (at baseline, follow-up at 3–4 months and follow-up at 7–9 months) (Geaney et al., 2013b). The individual nutrition counselling provided the employees from the combined intervention with personalised knowledge that enabled them to make healthy food choices within a modified workplace environment when compared to the other interventions (education alone and environment alone).

Environmental dietary modification included five elements: (a) menu modification: restriction of saturated fat, sugar and salt, (b) increase in fibre, fruit and vegetables, (c) price discounts for whole fresh fruit, (d) strategic positioning of healthier alternatives and (e) portion size control. Environmental engineering approaches were guided by 'choice architecture' (Thaler and Sunstein, 2008). For example, repositioning of certain healthy foods within the canteen supported habit disruption with the potential to trigger conscious thoughts (i.e. confectionary products were replaced with healthy snacks (fresh fruit, dried fruit, natural nuts) by the cash registers in the eating environments and in the vending machines) (Geaney et al., 2013b).

The intervention design was developed by the research team and advised by catering stakeholders. All environmental dietary modification elements were discussed with the catering stakeholders and a consensus was reached. For example, the research team suggested 3 chip free days but 2 chip free days was agreed. The research team also worked with the workplace stakeholders (human resources and catering managers) to implement the specific interventions within the context of the individual workplaces. Each workplace had a research workplace leader based on-site who collaborated with the workplace stakeholders to co-ordinate the data collection and monitor adherence to the interventions. Monthly observation visits (45 min per visit) were conducted by the research workplace leader without prior warning. Nutrition education displays and the eating environments (including the kitchen and vending machines) were carefully observed to ensure that there was constant compliance with all elements. Non-compliance was not observed in the different worksites during the trial period.

2.2. Sampling

Only workplaces that employed >250 employees; operated a daily workplace canteen and were able to commit to the intervention elements for the study duration were eligible. A list of Cork based manufacturing companies was obtained from the Irish Industrial Development Authority website (n = 107) and was systematically screened for eligibility over the phone in alphabetical order. From the overall list, the research team organised meetings with a total of 20 potentially suitable companies to discuss the feasibility of participating in the study. The four most suitable workplaces were then purposively selected and allocated to each intervention by the research team to ensure that all workplaces were able to fully comply with all of the intervention elements for the study duration.

Only permanent, full-time employees who purchased and consumed at least one main meal from their workplace canteens daily were eligible. Employees were excluded if they did not work in the workplace full-time (for example, worked from home 2 days a week); travelled regularly for work (≥once a month); were medically advised not to participate in the study; were on long-term sick leave, pregnant or were involved in an on-going diet programme external to work (for example, Weight Watchers). Complete lists of permanent, full-time employees were obtained from the human resources manager in each workplace. All employees were screened for eligibility over the phone by the research team. Employees were randomly contacted using random number generation software (Microsoft Excel) and invited to participate if eligible.

2.3. Determination of sample size

The number of employees recruited per workplace was proportionate to company size. The sample had 80% power at the 5% significance level to detect a 2 g average fall in dietary salt intake and a decrease in BMI by 1 kg/m^2 between the control and intervention groups post-delivery of the interventions (Geaney et al., 2013b). Fig. 1 illustrates the recruitment process throughout the study period.

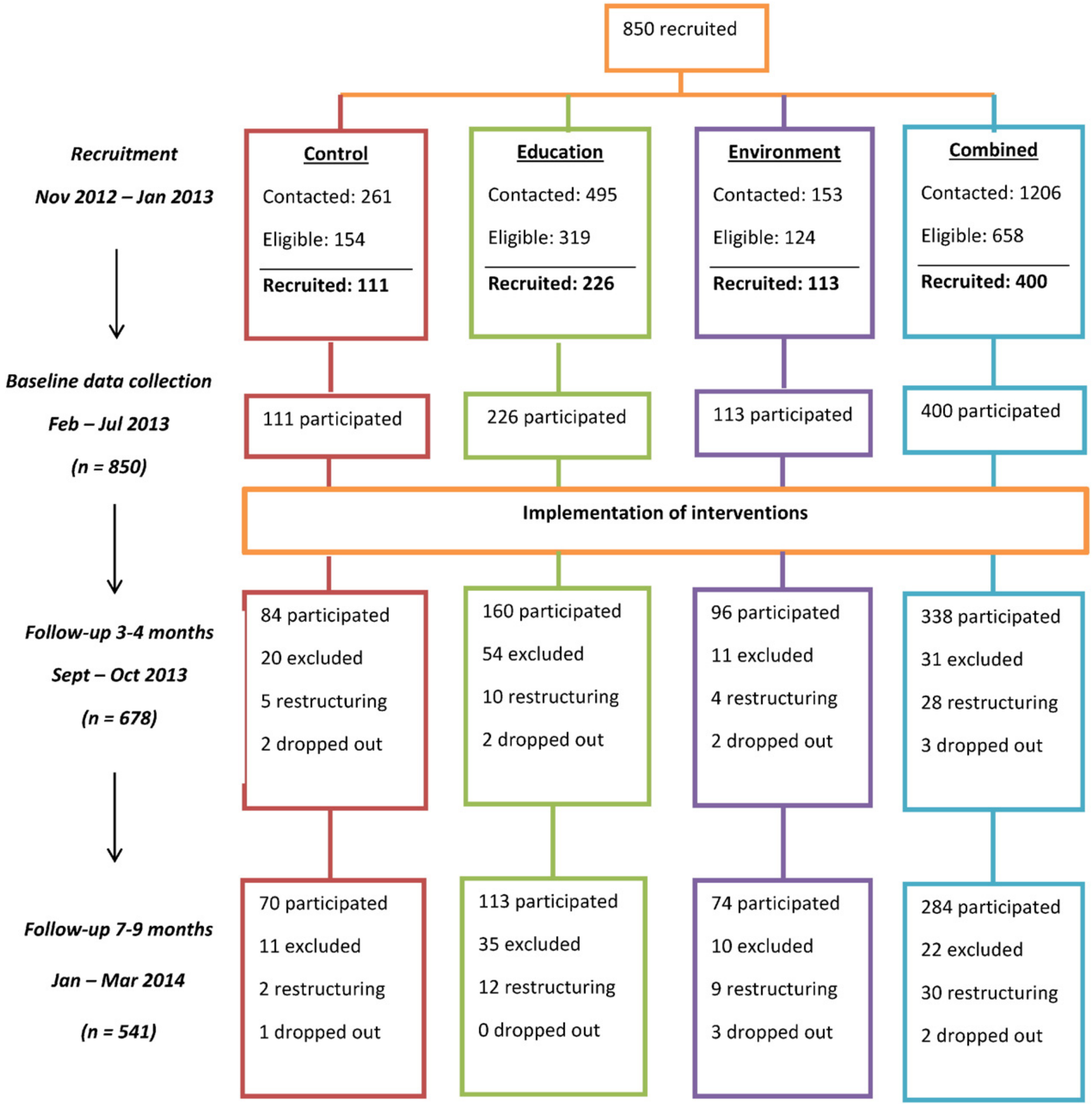

Fig. 1. Trial profile.

2.4. Study outcomes

The primary outcomes were changes in employees' dietary intakes of salt and body mass index (BMI) at 7–9 months follow-up. Secondary outcomes included changes in employees' dietary intakes of total fat, saturated fat, total sugars and fibre, nutrition knowledge, weight, midway waist circumference and resting blood pressure at 7–9 months follow-up.

2.5. Data collection

All data were collected during employees' work hours in the individual workplaces (excluding employees' break times). Participants were asked to self-complete two questionnaires including a socio-demographic and lifestyle questionnaire and a nutrition knowledge questionnaire pre and post intervention. Physical assessments (weight, height, midway waist circumference, resting blood pressure) and 24-h dietary recalls (on/off duty) were conducted by trained research assistants as per the standard operating procedure manual (Geaney et al., 2013c) at baseline and follow-up at 3–4 months and 7–9 months. No incentives were provided to employees participating in the study. The research team were trained at baseline and re-trained before the stages of follow-up data collection to ensure standardisation of processes and procedures.

2.5.1. Socio-demographic and lifestyle characteristics

Socio-demographic (gender, age, education, marital status and work-life) and lifestyle characteristics (smoking, alcohol consumption and physical activity) were recorded in the socio-demographic and lifestyle questionnaire (Harrington et al., 2008). Alcohol consumption was estimated using the units of alcohol consumed per week. An International Physical Activity Questionnaire (IPAQ) score was calculated for each participant (http://www.ipaq.ki.se/scoring.pdf). Scores were classified as low (<5000 steps/day), moderate (5000–10,000 steps/day) and high (>10,000 steps/day).

2.5.2. Nutrition knowledge

Nutrition knowledge was assessed using the validated general nutrition knowledge questionnaire which included four domains (1) advice from health experts, (2) food groups and food sources, (3) food choice and (4) diet-disease relationships (Parmenter and Wardle, 1999; Geaney et al., 2015). The internal consistency for the overall nutrition knowledge score assessed using the Cronbach's alpha statistic was 0.9 (Nunnally and B., 1994). As an indicator of validity of the nutrition knowledge score, it was found that participants with nutrition related qualifications had a higher nutrition knowledge score (73.2 (SD 8.3)) than those without these qualifications (66.9 (SD 13.2).

2.5.3. Physical assessment

During each physical assessment, weight, height, midway waist circumference and resting blood pressure were measured (details of which are published in the study protocol) (Geaney et al., 2013b; Geaney et al., 2013c).

2.5.4. Dietary data

One (on duty) 24-h dietary recall was collected at each stage of data collection from all participants (i.e. each participant needed to be in work the day of and the day before the recall was collected) using a modified version of the UK 3-step dietary recall (Geaney et al., 2013b; Nelson et al., 2007). Additional modifications to this method included specific prompts to measure consumption of discretionary salt (at the table and while cooking); accurate estimations of portion size, eating times; consumption of oil, water and food supplements. All recalls took approximately 20 min to complete. Each food, drink and portion size was coded according to the 24-h coding instructions based on the validated UK method (Geaney et al., 2013b; Nelson et al., 2007).

3. Statistical analysis

Food and nutrient analysis was calculated using NetWISP4© (Weighed Intake Software Programme; Tinuviel Software, Warrington, UK). Data were analysed using the Statistical Package for the Social Sciences (SPSS) version 21 for Windows (SPSS Inc., Chicago, IL, USA). Baseline characteristics of the participants within the four workplaces were compared using proportions. Paired t-tests were performed to calculate the mean differences within each workplace from baseline to follow-up at 7–9 months. Multivariate analysis of covariance (MANCOVA) was conducted to test differences between the conditions (control and the intervention groups) at 7–9 months follow-up. This analysis was adjusted for the potential confounding effects of other factors such as age, gender, education, usual working hours (i.e. shift work) and other baseline characteristics.

Table 1
Baseline socio-demographic and lifestyle characteristics of participants who completed the study, by workplace.

	Total n = 517 n (%)	Control n = 67 n (%)	Education n = 107 n (%)	Environment n = 71 n (%)	Combined n = 272 n (%)
Socio-demographic					
Age group (years)					
18–29	44 (8.5)	11 (16.4)	13 (12.1)	7 (9.9)	13 (4.8)
30–44	331 (64.0)	34 (50.7)	67 (62.6)	33 (46.5)	197 (72.4)
45–65	142 (27.5)	22 (32.8)	27 (25.2)	31 (43.7)	62 (22.8)
Gender					
Male	393 (76.0)	42 (62.7)	81 (75.7)	43 (60.6)	227 (83.5)
Female	124 (24.0)	25 (37.3)	26 (24.3)	28 (39.4)	45 (16.5)
Educational level					
None/primary/secondary	98 (19.1)	24 (35.8)	24 (22.4)	32 (45.1)	19 (7.0)
Tertiary	418 (80.9)	43 (64.2)	83(77.6)	39 (54.9)	253 (93)
Marital status					
Married/cohabiting	375 (72.5)	46 (68.7)	74 (69.2)	50 (70.4)	205 (75.4)
Separated/divorced/widowed	17 (3.3)	5 (7.5)	3 (2.8)	2 (2.8)	7 (2.6)
Single/never married	125 (24.2)	16 (23.9)	30 (28.0)	19 (26.8)	60 (22.1)
Job position					
Manager/supervisor	114 (22.1)	17 (25.4)	27 (25.2)	14 (19.7)	56 (20.6)
Non-manager/non-supervisor	393 (76.0)	44 (65.7)	80 (74.8)	57 (80.3)	212 (77.9)
Usual working hours					
Day-time (≤8 h)	337 (65.2)	52 (77.6)	76 (71)	40 (56.3)	169 (62.1)
Night-time (≤8 h)	6 (1.2)	0	6 (5.6)	0	0
Shift-work/rotating schedules	132 (25.5)	11 (16.4)	4 (3.7)	28 (39.4)	89 (32.7)
Missing	42 (8.1)	4 (6.0)	21 (19.6)	3 (4.2)	14 (5.1)
Working schedule					
Regular	416 (80.5)	54 (80.6)	104 (97.2)	42 (59.2)	216 (79.4)
Rotating	77 (14.9)	9 (13.4)	1 (0.9)	26 (36.6)	41 (15.1)
Irregular	23 (4.4)	4 (6.0)	2 (1.9)	2 (2.8)	15 (5.5)
Lifestyle					
Smoking status					
Never smoked	283 (54.7)	37 (55.2)	56 (52.3)	34 (47.9)	156 (57.4)
Former smoker	161 (31.1)	23 (34.3)	30 (28.0)	26 (36.6)	82 (30.1)
Current smoker	71 (13.7)	6 (9.0)	21 (19.6)	11 (15.5)	33 (12.1)
Alcohol consumption (units/week)					
None	94 (18.2)	13 (19.4)	18 (16.8)	15 (21.1)	48 (17.6)
1–14	189 (36.6)	19 (28.3)	43 (40.2)	20 (28.2)	107 (39.3)
>14	61 (11.8)	6 (9.0)	14 (13.1)	5 (7.0)	36 (13.2)
Missing	173 (33.4)	29 (43.3)	32 (29.9)	31 (43.7)	81 (29.7)
Physical activity					
Low	226 (43.7)	52 (77.6)	49 (45.8)	38 (53.5)	87 (32.0)
Moderate	136 (26.3)	9 (13.4)	30 (28.0)	18 (25.4)	79 (29.0)
High	153 (29.6)	5 (7.5)	27 (25.2)	15 (21.1)	106 (39.0)

With the exception of alcohol consumption and usual working hours, missing data was < 1% in all workplaces besides in the control group for job position (9%), smoking (1.5%) and physical activity levels (1.5%).

4. Results

4.1. Characteristics of study population

At baseline, a sample of 850 participants aged 18–64 years were recruited across the four workplaces as follows (N (response rate %)): Control: 111 (72%), Education: 226 (71%), Environment: 113 (91%), Combined: 400 (61%) (Fig. 1). Of the 850 participants, data was collected from 678 employees (80%) at 3–4 months follow-up and 541 employees (64%) at 7–9 months follow-up. Complete follow-up data was obtained for 517 participants (61%). Participants who did not complete all assessments (all questionnaires, physical assessments, dietary recalls) were excluded from analysis (Control: N = 3, Education: N = 6, Environment: N = 3, Combined: N = 12). Reasons for attrition included workplace restructuring (i.e. participants were relocated to other workplaces within the company) and participants were excluded during the study if they informed the research team that their working structure changed (i.e. no longer located in the study workplaces full-time, more travel for work, long-term sick leave, pregnant). No significant differences were observed between completers and non-completers at baseline in terms of the primary outcomes. For completers and non-completers, mean BMI was 27.3 and 27.0 ($p = 0.413$) and mean salt intake was 7.3 g and 7.3 g ($p = 0.954$) respectively. In terms of secondary outcomes, no significant differences were recorded between completers and non-completers at baseline with the exception of nutrition knowledge. For completers and non-completers, mean total fat intake was 86.2 g and 84.3 g ($p = 0.475$), mean saturated fat intake was 32.4 g and 32.1 g ($p = 0.763$), mean total sugars intake was 99.1 g and 99.5 g ($p = 0.918$), mean fibre intake was 20.8 g and 19.7 g ($p = 0.119$) and mean nutrition knowledge scores were 66.6 and 63.2 ($p = 0.001$) respectively.

Socio-demographic and lifestyle characteristics of the study participants are presented in Table 1. The majority of participants in the four workplaces were male (76%), aged 30–44 years (64%) and were married or cohabiting (73%). A higher proportion of employees in the control, education and combined workplaces had a tertiary education (Control: 64%, Education: 78%, Combined: 93%) than in the environment workplace (55%). Most employees were not in a managerial or supervisory role, ranging from 66% in the control to 80% in the environment intervention; usually worked during the day (56%–78%) and had a regular working schedule (59%–97%). Similar proportions of employees never smoked and reported no alcohol consumption (Table 1). A higher proportion of employees in the control (78%), education (46%) and environment (54%) workplaces had low physical activity levels compared to the combined workplace (32%).

4.2. Primary outcomes

4.2.1. Within each workplace

At 7–9 months follow-up, there were significant reductions in salt −1.4 g/day (SD 4.4), $p = 0.000$) and BMI −0.3 kg/m^2 (SD 0.8), $p = 0.001$) in the combined intervention (Tables 2 and 3). Smaller and generally non-significant reductions in dietary intakes of salt and BMI were observed in the education (salt: −0.6 g/day (SD 5.5), $p = 0.260$; BMI −0.2 kg/m^2 (SD 1.0), $p = 0.009$) and environment workplaces (salt: −0.5 g/day (SD 4.1), $p = 0.347$; BMI −0.1 kg/m^2 (SD 1.0), $p = 0.590$) at 7–9 months follow-up. Increased dietary intakes of salt and BMI levels were reported in the control workplace at 7–9 months follow-up (salt: +0.7 g/day (SD 4.4), $p = 0.208$; BMI: +0.2 kg/m^2 (SD 0.9), $p = 0.097$).

4.2.2. Intervention workplaces versus the control workplace

Significant positive changes in dietary intakes of salt (−1.3 g/day (95% CI −2.3, −0.3), $p = 0.010$) were noted between baseline and 7–9 months follow-up in the combined intervention versus the control workplace in the fully adjusted multivariate analysis of covariance (Table 4). Significant changes in BMI (−1.2 kg/m^2 (95% CI −2.4,

Table 2
Changes in dietary intakes and nutrition knowledge from baseline to 7–9 months follow-up in the study workplaces.

Variable	Workplace	Baseline (mean (SD))	Change from baseline to 7–9 months (mean (SD))	p-value
Dietary intakes				
Total energy intake (Kcal/day)	Control	1864.0 (574.2)	+26.5 (806.9)	0.789
	Education	2022.2 (675.0)	−156.6 (903.1)	0.076
	Environment	2140.3 (752.8)	−110.8 (737.8)	0.210
	Combined	2161.5 (679.0)	−241.7 (754.5)	0.000
Total fat (g/day)	Control	76.8 (30.0)	+1.9 (44.4)	0.725
	Education	82.2 (36.6)	−7.1 (54.4)	0.177
	Environment	90.9 (42.7)	−11.4 (39.4)	0.017
	Combined	88.8 (36.5)	−14.2 (41.8)	0.000
Total fat (E%)	Control	36.7 (7.8)	+0.2 (13.2)	0.904
	Education	35.8 (9.1)	−0.6 (14.8)	0.661
	Environment	37.3 (7.8)	−2.0 (10.5)	0.108
	Combined	36.7 (8.4)	−2.2 (10.3)	0.001
Saturated fat (g/day)	Control	28.2 (14.6)	+1.8 (21.1)	0.491
	Education	30.5 (15.4)	−3.2 (24.7)	0.189
	Environment	36.8 (19.5)	−8.8 (18.5)	0.000
	Combined	33.1 (15.9)	−7.0 (17.6)	0.000
Saturated fat (E%)	Control	13.2 (4.5)	+0.7 (6.4)	0.348
	Education	13.3 (4.6)	−0.7 (7.2)	0.340
	Environment	15.0 (4.5)	−2.7 (5.5)	0.000
	Combined	13.6 (4.5)	−1.6 (5.4)	0.000
Salt (g/day)	Control	6.7 (3.0)	+0.7 (4.4)	0.208
	Education	7.8 (4.3)	−0.6 (5.5)	0.260
	Environment	7.6 (3.3)	−0.5 (4.1)	0.347
	Combined	7.8 (3.7)	−1.4 (4.4)	0.000
Total sugars (g/day)	Control	75.4 (39.4)	+9.1 (62.1)	0.234
	Education	101.4 (49.3)	−6.8 (67.3)	0.295
	Environment	106.7 (59.4)	−4.6 (53.6)	0.476
	Combined	104.2 (48.3)	−11.1 (63.0)	0.004
Fibre (g/day)	Control	18.5 (7.6)	+0.2 (11.2)	0.908
	Education	19.5 (8.2)	−0.2 (12.1)	0.906
	Environment	20.2 (8.1)	−0.4 (11.0)	0.772
	Combined	22.0 (10.3)	+0.2 (11.9)	0.855
Nutrition knowledge score	Control (n = 61)	65.9 (10.2)	+1.2 (16.8)	0.103
	Education (n = 94)	66.9 (12.2)	+2.0 (9.1)	0.038
	Environment (n = 63)	60.8 (17.3)	+0.9 (10.3)	0.510
	Combined (n = 263)	69.5 (11.9)	+3.0 (7.6)	0.000

Table 3
Changes in health status from baseline to 7–9 months follow-up in the study workplaces.

Variable	Workplace	Baseline (mean (SD))	Change from baseline to 7–9 months (mean (SD))	p-value
Weight (kg)	Control	80.3(15.3)	+0.5 (2.6)	0.098
	Education	82.1(15.0)	−0.7 (3.0)	0.013
	Environment	82.0(17.8)	−0.04 (2.6)	0.898
	Combined	83.4(14.0)	−0.4 (2.5)	0.004
BMI (kg/m^2)	Control	27.6(4.2)	+0.2 (0.9)	0.097
	Education	27.1(4.1)	−0.2 (1.0)	0.009
	Environment	28.0(5.1)	−0.1 (1.0)	0.590
	Combined	27.1(3.8)	−0.3 (0.8)	0.001
Midway waist circumference (cm)	Control	91.9(12.3)	+0.8 (5.9)	0.274
	Education	91.3(12.4)	+0.1 (4.0)	0.871
	Environment	93.4(10.3)	−0.7 (3.5)	0.003
	Combined	93.5(10.3)	−0.7 (3.5)	0.003
BP: systolic	Control	123.4(15.0)	−5.7 (11.3)	0.000
	Education	123.6(13.8)	−7.3 (12.4)	0.000
	Environment	121.9(16.4)	−2.7 (11.1)	0.041
	Combined	120.9(14.1)	−1.4 (11.4)	0.051
BP: diastolic	Control	76.8(10.7)	−3.6 (9.4)	0.003
	Education	75.4(8.8)	−3.1 (7.0)	0.000
	Environment	75.1(9.9)	+0.6 (6.9)	0.505
	Combined	75.1(9.0)	−0.3 (7.9)	0.580

Table 4
Mean differences at 7–9 months follow-up between the interventions and the control workplace.

Variable	Workplace	Mean difference between I and C[a]	95% CI[b]	p-Value[c]
Weight (kg)	Education	−1.1	(−5.2, 3.0)	0.608
	Environment	+2.3	(−2.1, 6.8)	0.299
	Combined	−2.0	(0.3, −5.8)	0.303
BMI (kg/m^2)	Education	−0.8	(−2.1, 0.4)	0.196
	Environment	+0.3	(−1.1, 1.6)	0.711
	Combined	−1.2	(−2.4, −0.1)	0.047
Midway waist circumference (cm)	Education	−1.2	(1.8, 0.5)	0.480
	Environment	+0.5	(−3.2, 4.2)	0.796
	Combined	−1.0	(−4.3, 2.2)	0.530
BP: systolic	Education	−3.7	(−7.8, 0.4)	0.080
	Environment	+1.3	(−3.1, 5.8)	0.558
	Combined	−2.4	(−6.7, 1.4)	0.218
BP: diastolic	Education	−1.3	(−4.1, 1.4)	0.331
	Environment	+2.0	(−0.9, 5.0)	0.176
	Combined	+0.6	(−1.9, 3.2)	0.633
Total energy intake (kcal/day)	Education	−133.6	(−326.1, 58.9)	0.173
	Environment	+121.1	(−86.9, 329.0)	0.253
	Combined	−70.6	(−250.2, 109.0)	0.440
Total fat (E%)	Education	−2.2	(−5.0, 0.6)	0.115
	Environment	−1.5	(−4.5, 1.5)	0.338
	Combined	−2.3	(−4.8, 0.4)	0.095
Saturated fat (E%)	Education	−1.3	(−2.7, 0.1)	0.053
	Environment	−1.8	(−3.2, 0.3)	0.017
	Combined	−1.8	(−3.0, −0.5)	0.006
Total fat (g/day)	Education	−9.9	(−20.4, 0.6)	0.066
	Environment	−0.1	(−11.5, 11.2)	0.986
	Combined	−7.7	(−17.6, 2.0)	0.120
Saturated fat (g/day)	Education	−4.8	(−9.2, −0.4)	0.034
	Environment	−2.7	(−7.5, 2.0)	0.261
	Combined	−5.2	(−9.4, −1.1)	0.013
Total sugars (g/day)	Education	+7.2	(−6.9, 21.3)	0.318
	Environment	+16.4	(1.2, 31.6)	0.035
	Combined	+3.5	(−9.6, 16.6)	0.601
Salt (g/day)	Education	−0.8	(−1.9, 0.3)	0.144
	Environment	−0.4	(−1.6, 0.7)	0.459
	Combined	−1.3	(−2.3, −0.3)	0.010
Fibre (g/day)	Education	−0.1	(−3.1, 2.9)	0.923
	Environment	+1.1	(−2.2, 4.3)	0.510
	Combined	+2.6	(−0.2, 5.4)	0.071
Nutrition knowledge score	Education (n = 94)	+1.6	(−2.7, 5.9)	0.462
	Environment (n = 63)	−5.2	(−9.9, −0.6)	0.026
	Combined (n = 263)	+4.2	(0.3, 8.2)	0.034

[a] Mean difference between intervention workplaces (Education, environment, combined) and control workplace at 7–9 months follow-up, adjusted for age, gender, education, usual working hours and other baseline characteristics (marital status, job position, working schedule, smoking, alcohol and physical activity (numbers rounded >0.5).
[b] 95% confidence interval for adjusted differences.
[c] p-value for the adjusted differences.

−0.1), p = 0.047) were also detected (Table 4). Effects in the education alone (salt: p = 0.144; BMI: p = 0.196) and environment alone (salt: p = 0.459; BMI: p = 0.711) workplaces were smaller.

4.3. Secondary outcomes

4.3.1. Within each workplace

Significant reductions in dietary intakes of total fat (−14.2 g/day (SD 41.8), p = 0.000), saturated fat (−7.0 g/day (SD 17.6), p = 0.000) and total sugars (−11.1 g/day (SD 63.0), p = 0.004) were observed in the combined intervention at 7–9 months follow-up. No difference in fibre intake was observed (+0.2 g/day (SD 11.9), p = 0.855) (Table 2). Overall, there were smaller reductions in dietary intakes in the education and environment workplaces. However, a significant reduction in dietary intakes of total fat (−11.4 g/day (SD 39.4), p = 0.017) and saturated fat (−8.8 g/day (SD 18.5), p = 0.000) were reported in the environment workplace at 7–9 months follow-up. No differences in dietary intakes were detected in the control workplace.

The greatest nutrition knowledge improvements were reported in the combined intervention (+3.0 (SD 7.6), p = 0.000) followed by the education workplace (+2.0 (SD 9.1), p = 0.038) (Table 2). A significant fall in average weight was observed in the combined intervention workplace (−0.4 kg (SD 2.5), p = 0.004) and the education workplace (−0.7 kg (SD 3.0), p = 0.013) at 7–9 months follow-up (Table 3). A reduction in midway waist circumference was observed in the combined intervention (−0.7 cm (SD 3.5), p = 0.003) and the environment workplaces (−0.7 cm (SD 3.5), p = 0.003) at 7–9 months follow-up. Significant reductions in systolic and diastolic blood pressure were also observed in the control (systolic: −5.7 (SD 11.3), p = 0.000; diastolic: −3.6 (SD 9.4), p = 0.003) and education workplaces (systolic: −7.3 (12.4 SD), p = 0.000; diastolic: −3.1 (SD 7.0), p = 0.000) at 7–9 months follow-up.

4.3.2. Intervention workplaces versus the control workplace

In the fully adjusted multivariate analysis, significant positive changes in dietary intakes of saturated fat (p = 0.013), energy proportion from saturated fat (p = 0.006) and nutrition knowledge (p = 0.034) were noted between baseline and follow-up at 7–9 months in the combined intervention versus the control workplace (Table 4). Effects in the education alone and environment alone workplaces were smaller. In the education workplace, significant falls in dietary saturated fat intakes (p = 0.034) were observed. In the environment workplace, a significant decrease in energy proportion from saturated fat (p = 0.017), an increase in total sugars (p = 0.035) and a decrease in nutrition knowledge (p = 0.026) were recorded when compared to the control workplace at 7–9 months follow-up. No other differences were observed in total energy, total fat, fibre, weight, midway waist circumference and blood pressure (Table 4).

5. Discussion

In this study, we hypothesised that a combined intervention of high intensity (nutrition education and environmental dietary modification) would be more effective than no intervention and either the nutrition intervention or environment intervention alone in the promotion of positive changes in employees' dietary intakes, nutrition knowledge and health status outcomes.

The combined intervention was associated with reduced dietary intakes of salt and a lower BMI in addition to reduced intakes of saturated fat, a lower energy proportion from saturated fat and higher nutrition knowledge in the fully adjusted multivariate analysis when compared to the control workplace at 7–9 months follow-up. The education workplace was associated with a lower dietary saturated fat intake. The environment workplace was associated with a lower energy proportion from saturated fat, a higher intake of total sugars and lower nutrition knowledge. No other changes were observed in total energy, total fat, fibre, midway waist circumference and blood pressure. These findings are consistent with the current limited evidence on the effectiveness of combined workplace dietary interventions (Geaney et al., 2013a). Braeckman and colleagues in a study testing the effect of environmental dietary modification and nutrition education found that the combined intervention was associated with significant reductions in energy intake, energy proportion from total fat and polyunsaturated fat and higher intakes of carbohydrate and protein. Positive effects on nutrition knowledge and BMI were also reported in the study (Braeckman et al., 1999).

The ‘Food Choice at Work’ study has a number of strengths. This high-intensity complex workplace dietary intervention study has been developed and evaluated drawing on a systematic review conducted by the study authors and based on a theoretical framework (Geaney et al., 2013b; Craig et al., 2008). The FCW study was conducted according to a published study protocol with pre-specified outcomes and findings reported in a standardised manner and consistent with the TREND statement (Des Jarlais et al., 2004). The key primary outcomes reported in this study represent a subset of the overall pre-specified outcomes.

As mentioned in the published study protocol, the interventions were designed using a participatory approach where catering and workplace stakeholders were involved in the study design and implementation of the interventions in the individual workplaces (Geaney et al., 2013b). Participatory and theory-based approaches to workplace health promotion have been recommended for ensuring the effectiveness of nutrition workplace health promotion (Sahay et al., 2006). Intensive training and retraining were provided for the research assistants and outcomes were measured objectively where possible including BMI, resting blood pressure and midway waist circumference (Geaney et al., 2013b). Validated questionnaires were utilised to measure potential confounders and cofactors that may have been associated with the effectiveness of these interventions. There was no risk of contamination among the sample as all employees worked in different companies located in different geographical areas in Cork. Workplaces were not given detailed information on the other participating workplaces. There were few missing data for all variables apart from alcohol consumption.

Limitations of the present study include the involvement of atypical multinational manufacturing workplaces which potentially limits the generalizability of the findings, the use of a non-randomised design with no allocation concealment and potential measurement error. The workplaces were purposively selected to ensure that all components of the interventions could be implemented successfully. Random selection of the participating workplaces for interventions at this level of intensity or blinding was not feasible. However, the positive findings in the selected settings provide important evidence on the potential feasibility of the combined education and environmental dietary modification intervention in a wide range of workplace settings.

The use of a non-randomised design poses significant threats to the validity of the study. In particular the issue of measurement (interview) bias is a concern. To minimise this potential source of bias, the research team participated in intensive training before and during data collection to ensure that all data were collected in a standardised manner.

With regard to the issue of randomisation, workplace dietary interventions are complex and highly context dependent and it is increasingly recognised that the classic randomised controlled trial paradigm is not necessarily appropriate in the evaluation of effectiveness for these studies (Rutter, 2012). In the 2014 McKinsey Global Institute Report *Overcoming obesity*: *An initial economic analysis*, the authors highlight the need for pragmatism in the assessment of low risk interventions such as that addressed in the current study in tackling the societal challenges of obesity and poor diet (Institute, M.G., 2014).

Selection bias cannot be ruled out as healthy employees may have been more likely to participate. The study participants were masked to the study hypotheses. The study participants were similar to the general workforce across the four sites in terms of gender (general workforce: 64% male; participants: 76% male). The characteristics of the study participants across the four workplaces were similar, including work schedules, company type, skilled and educated workforces.

There is also a possibility of non-systematic misclassification (measurement error) in the assessment of dietary intakes. Recall bias may have been introduced as the 24-h dietary recalls were self-reported. Social desirability reporting bias cannot be ruled out either as employees with higher nutrition knowledge may have overestimated their intakes of healthy foods in the dietary recalls. It is also important to note that the total sugars dietary intake represented both intrinsic and extrinsic sugars. Therefore, it is possible that the increased intake of total sugars in the environment workplace may have been linked to an additional intake of intrinsic sugars (i.e. fruits and vegetables) during the intervention period.

6. Conclusion

The FCW study has shown that a well-structured complex workplace dietary intervention that combines nutrition education and environmental dietary modification reduces employees' dietary intakes of salt and saturated fat, improves their nutrition knowledge and decreases their BMI at 7–9 months follow-up. This study provides critical evidence on the effectiveness of complex workplace dietary interventions in a manufacturing working population. The FCW combined dietary intervention is scalable and wide scale implementation should be considered in local, national and international workplaces. At a more global level, the increasing prevalence of NCDs is one of the dominant public health issues of our time. It is likely that the WHO will not reach their specific targets (2% per year reduction in NCD deaths and a halt in the increase of obesity and type 2 diabetes in adults and adolescents) without positive changes to our food environments at local, national and transnational levels because obesogenic food environments are the main drivers of the obesity epidemic and of the increasing prevalence of diet-related NCDs (WHO, 2013; Roberto et al., 2015; Kleinert and Horton, 2015; Hawkes et al., 2015).

Ethics

Ethical approval was granted by the Clinical Research Ethics Committee of the Cork Teaching Hospitals in Ireland, March 2013. All participants provided written informed consent.

Competing interests

The authors have declared that no competing interests exist.

Contributors

FG co-ordinated the study and was responsible for the study design. FG, CK, JS and IJP contributed to the acquisition of funding, acquisition of data, statistical analysis and revision of the paper. JH, APF and BAG contributed to the statistical analysis and revision of the paper. All authors approved the final version of the paper for publication.

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