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Article

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The impact of a complex workplace dietary intervention on Irish employees' off-duty dietary intakes

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Summary

A paucity of evidence exists regarding the impact of workplace dietary interventions on employees' off-duty dietary intakes. This study assessed the impact of workplace dietary interventions that included nutrition education and environmental dietary modification both alone and in combination on employees' dietary intakes inside (on-duty) and outside (off-duty) of work. A pre–post study on employees' on and off-duty dietary intakes was undertaken. Data were obtained from a complex workplace dietary intervention study (Food Choice at Work Trial). Four manufacturing workplaces were allocated to: Control ($n = 111$), nutrition education ($n = 226$), environmental dietary modification ($n = 113$) and nutrition education and environmental dietary modification combined ($n = 400$) (2013–14). Seven- to nine-month follow-up data were obtained for 517 employees (61% response) [Control ($n = 67$), Education ($n = 107$), Environment ($n = 71$) and Combined ($n = 272$)]. Dietary intakes were measured using 24-h dietary recalls. Differences between on and off-duty mean dietary intakes were compared and regression analyses adjusted for potential confounders. Significant reductions in on-duty intakes of total fat (−14.2 g/day, $p = 0.000$), saturated fat (−7 g/day, $p = 0.000$), salt (−1.4 g/day, $p = 0.000$) and total sugars (−8.9 g/day, $p = 0.003$) were observed in the Combined and in the Environment [total fat (−11.4 g/d, $p = 0.017$) and saturated fat (−8.8 g/day, $p = 0.000$)]. In the Combined, significant changes were also observed in off-duty intakes of total fat (−10.0 g/day, $p = 0.001$), saturated fat (−4.2 g/day, $p = 0.001$), salt (−0.7 g/day, $p = 0.020$) and total sugars (−8.1 g/day, $p = 0.020$). Food service can have a positive impact in our everyday environments, including inside and outside of work. Dietary interventions combining nutrition education and environmental dietary modification can improve employees' on and off-duty dietary intakes.

Key words: dietary modification, health promotion, dietary recall

INTRODUCTION

Excess dietary intakes of fat, saturated fat, sugar and salt and overconsumption of calories plays a fundamental role in the development of chronic diet-related diseases including obesity, hypertension, type 2 diabetes, cardiovascular diseases and some cancers (WHO, 2013). The increasing prevalence of diet-related diseases is a foremost contributor to global morbidity and mortality (WHO, 2013; Schulze *et al.*, 2018). Everyday environments influence individuals' dietary behaviours. It is acknowledged that modifications to these environments can stimulate both positive and negative changes to usual dietary behaviours (Story *et al.*, 2008; James *et al.*, 2017; Vadiveloo *et al.*, 2017).

Modification of food environments has become a popular strategy to promote healthy food choices at a population level (NICE, 2007; Lake, 2018). Owing to an increase in working hours and a growing reliance on workplaces to provide employees with at least one of their daily main meals, workplaces have been identified by the World Health Organisation (WHO) as priority environments in which to positively influence food choices (WHO, 2004; McGuffin *et al.*, 2013). Improving employees' dietary intakes while they are at work and at home may provide greater scope to stem the increasing prevalence of diet-related diseases (WHO, 2010, 2013). Evidence suggests that dietary interventions that positively alter workplace food choices can improve employees' dietary intakes in their work environment and can also increase sales of healthy foods (Engbers *et al.*, 2005; Lowe *et al.*, 2010; Geaney *et al.*, 2013; Mishra *et al.*, 2013). Moreover, when compared to singular interventions, interventions that combine strategies such as environmental dietary modification and nutrition education have been found to have a greater positive effect on employees' dietary behaviours while they are at work (Braeckman *et al.*, 1999; Lowe *et al.*, 2010; Geaney *et al.*, 2013). However, at present, evidence on the carry-over effect of workplace dietary interventions on employees' off-duty dietary intakes is limited. To date research has focused mainly on purchase data of healthy and unhealthy foods which is used to calculate total energy intake for employees while they are at work (Lowe *et al.*, 2010; Mackison *et al.*, 2016; Vasiljevic *et al.*, 2018). These outcomes do not facilitate an investigation into whether dietary interventions in the workplace can have a positive carry-over effect into employees' dietary behaviours outside of the work environment.

The Food Choice at Work (FCW) study was a cluster-controlled trial which assessed the comparative effectiveness of a complex workplace dietary intervention that included nutrition education and environmental dietary modification both alone and in combination versus a Control workplace (Geaney *et al.*, 2013). The findings of the trial demonstrate that combining nutrition education and environmental dietary modification reduced employees' dietary intakes of salt and saturated fat, reduced levels of obesity and improved nutrition knowledge (Geaney *et al.*, 2016). Using food consumption data derived from the FCW trial, this study aimed to assess the impact of the complex workplace dietary interventions on employees' dietary intakes both inside (on-duty dietary intakes) and outside (off-duty dietary intakes) of the workplace setting. The study investigated whether positive changes observed in employees' dietary intakes at work were also extended to their lives outside of their work environment.

MATERIALS

Data source

Details of the study design, intervention elements and methods of the FCW study have been published previously (Geaney *et al.*, 2013, 2016). Briefly, the FCW study was a clustered controlled trial conducted in four large multinational workplaces in Cork, Ireland for a period of 9 months (July 2013–March 2014) (Trial registration number: ISRCTN35108237). A total of 850 employees across the four workplaces participated in the study. No incentives were provided to participating employees. Employee participation was on a voluntary basis and all participants provided written informed consent. To ensure that all workplaces were able to fully comply with intervention elements for the study durations, workplaces were purposively selected and allocated to one of the following; no intervention (Control workplace $n = 111$), nutrition education alone (Education, $n = 226$), environmental dietary modification alone (Environment, $n = 113$) and nutrition education and environmental dietary modification combined (Combined, $n = 400$). Follow-up data at 7- to 9-month follow-up was collected from 517 employees (61% of those recruited at baseline); Control ($n = 67$), Education ($n = 107$), Environment ($n = 71$) and Combined ($n = 272$). The main reason for attrition was workplace restructuring (i.e. participants were relocated to other locations within the company) and participants were excluded during the study if their working structure had changed (i.e. no longer located in the study workplaces full-time, travelling more for work, long-term sick leave or pregnant). The Education intervention comprised three components; (1) detailed nutrition information (including daily calorie and traffic light menu labelling, posters, leaflets and emails), (2) individual nutrition consultations and (3) monthly group presentations. Environmental dietary modification comprised five elements; (1) menu modification (restriction of fat, saturated fat, sugar and salt), (2) increase in fibre, fruit and vegetables, (3) price discounts for whole fresh fruit, (4) strategic positioning of healthier alternatives and (5) portion size control.

The complex interventions were guided by a soft paternalistic 'nudge' theoretical perspective (Thaler and Sunstein, 2008). Nutrition education elements were designed to create positive reinforcement with indirect suggestions for healthy food choices and elements such as individual nutrition consultations and traffic light menu labelling were designed to prompt conscious consideration of food choices (Thaler and Sunstein, 2008). The environmental dietary modification elements were guided by choice architecture and were designed to trigger both conscious (repositioning of healthier alternatives to support habit disruption) and unconscious (menu modifications) thoughts (Geaney *et al.*, 2016).

Data collection

Data were collected during employees' working hours at the four individual workplaces (excluding employees' break times) at baseline prior to the implementation of the interventions and at 7- to 9-month follow-up post implementation of the dietary interventions. Data collection was conducted by trained research assistants as per the standard operating procedure at baseline and at follow-up (Geaney *et al.*, 2013). Research assistants were trained by a registered dietitian at baseline and re-trained at follow-up to ensure standardization of processes and procedures.

Physical and demographic measurements

Participants completed a sociodemographic questionnaire, The Health, Lifestyle and Food Questionnaire (HLFQ) (Harrington *et al.*, 2008), a tool which has been well-validated within the Irish population. The HLFQ included details of work life, general health status, usual dietary patterns at home and work, usual lifestyle patterns including physical activity, smoking status and alcohol consumption. Physical assessments (weight, height, midway waist circumference, resting blood pressure) were carried out at baseline and were repeated at 7- to 9-month follow-up.

Dietary intake

For the 24-h dietary recall method, an in-depth interview quantitatively measured food consumption over a 24-h period (Shim *et al.*, 2014). Two dietary recalls per employee were collected within 1 week at baseline and at 7- to 9-month follow-up to assess on and off-duty food consumption. For on-duty dietary recalls, employees needed to be in work the day of and the day before the recall was collected. For off-duty dietary recalls, employees needed to be in work the day of the recall but not present in work the day prior to the recall. During each recall, employees were asked to specify the location of where food was consumed. Dietary recalls are associated with underreporting of discretionary sources of salt, that is, salt added at the table or during cooking, therefore this study used a modified version of the UK 3-step dietary recall (Nelson *et al.*, 1997; Geaney *et al.*, 2013). Modifications included specific prompts to measure consumption of discretionary salt, accurate estimations of portion size (using digital food photographs), eating times and consumption of oil, water and food supplements. Each food, drink and portion size was coded according to the 24-h coding instructions based on the validated UK method (Geaney *et al.*, 2013) and McCance and Widdowson's Food Composition Tables. NetWISP© (Weighed Intake Software Program; Tinuviel Software) converted the dietary information to food quantities and nutrient values.

Statistical analysis

All data from the questionnaires, physical assessments and 24-h recalls were transferred into SPSS version 21.0 to be analysed. Descriptive statistics were calculated to give an overview of the socio-demographic characteristics of the study participants from the four workplaces who completed the FCW trial and were compared using proportions. Paired *t*-tests were performed to calculate the mean differences within each workplace in terms of employees' on-duty dietary intakes from baseline to follow-up at 7–9 and also in terms of employees' off-duty dietary intakes from baseline to follow-up at 7–9 months. Multiple linear regression compared changes in employees' on-duty and off-duty dietary intakes across the four intervention groups with adjustment for age, gender, education status, marital status, job position and BMI. Regression coefficients were presented for each nutrient and statistical significance was observed at the 5% ($p < 0.050$) level of significance.

RESULTS

Characteristics of study population

Socio-demographic characteristics of the employees' who completed the trial ($n = 517$) are presented in Table 1, by intervention. The majority of participants across the four workplaces were male (76%), aged 30–44 years (64%) and were married or cohabiting (73%). Tertiary education (obtained diploma, primary degree, postgraduate degree or higher) was predominant in all workplaces except for the Environment intervention and a total of 78% of all employees were in a non-managerial or supervisory role. Overall, 71% of employees were overweight and obese with 53% of employees were centrally obese. In this study, no significant differences were observed at baseline between employees who completed the trial and those who did

Table 1: Baseline socio-demographic characteristics of employees who completed the FCW trial, by workplace

Socio-demographic	Total $N = 517$ N (%)	Control $N = 67$ N (%)	Education $N = 107$ N (%)	Environment $N = 71$ N (%)	Combined $N = 272$ N (%)
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	99 (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 (93.0)
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	403 (77.9)	50 (74.6)	80 (74.8)	57 (80.3)	216 (79.4)
Weight status					
BMI (kg/m^2)					
Normal (18.5–24.9 kg/m^2)	147 (28.4)	17 (25.4)	34 (31.8)	18 (25.4)	78 (28.7)
Overweight (25–29.9 kg/m^2)	254 (49.1)	33 (49.3)	48 (44.9)	34 (47.9)	139 (51.1)
Obese (>30 kg/m^2)	116 (22.4)	17 (25.4)	25 (23.4)	19 (26.8)	55 (20.2)
Midway waist circumference (cm)					
Centrally obese	274 (53)	41 (61)	48 (45)	41 (58)	144 (53)

not in terms of BMI and dietary intakes of fat, saturated fat, salt and total sugars.

Differences in dietary intakes

On-duty dietary intakes

At 7- to 9-month follow-up, there were significant reductions in on-duty dietary intakes of total energy (−241.7 kcal/day), total fat (−14.2 g/day), saturated fat (−7.0 g/day), salt (−1.4 g/day) and total sugars (−8.9 g/day) in the Combined intervention. Significant reductions were also observed in the Environment intervention for on-duty dietary intakes of total fat (−11.4 g/day) and saturated fat (−8.8 g/day). A reduction in total energy intake (−156.6 kcal/day) was observed in the Education intervention, which was only slightly non-significant. No significant changes in on-duty intakes of fibre were observed in all interventions. Increases in all nutrients were observed in the Control workplace, however these were not significant (Table 2).

The multiple regression model (Table 3) estimated the effects of the interventions on employees' on-duty dietary intakes after 7- to 9-month follow-up and included individual potential confounder effects for each independent variable. In the Combined intervention, following adjustment for gender, significant mean differences were observed for pre–post changes in employees' on-duty intakes of total energy (−342.2 kcal/day), total fat (−18.5 g/day) and saturated fat (−9.4 g/day). In the Environment workplace, following adjustment for gender, significant mean differences were observed for pre–post changes in employees' on-duty intakes of total energy (−463.6 kcal/day), total fat (−23.5 g/day) and saturated fat (−11.6 g/day). No significant pre−post differences in employees' on-duty dietary intakes were observed following adjustment for age, education status, marital status, job position and BMI in all four workplaces. Gender was reported as having a significant effect across the interventions for differences in on-duty dietary intakes at 7- to 9-month follow-up. However, following separate analysis (Table 5) indicates that this effect is due to the higher proportion of male employees (83%) to female (17%) in the study population.

Table 2: Changes in employees' on-duty and off-duty dietary intakes from baseline to 7- to 9-month follow-up, by intervention

Nutrient	Workplace	On-duty dietary intakes			Off-duty dietary intakes		
		Baseline [mean (SD)]	Change from baseline to 7–9 months [mean (SD)]	*p*-value	Baseline [mean (SD)]	Change from baseline to 7–9 months [mean (SD)]	*p*-value
Total energy intake (kcal/day)	Control	1864.0 (574.2)	+26.5 (806.9)	0.789	1845.4 (774.7)	+222.3 (923.4)	0.054
	Education	2022.2 (675.0)	−156.6 (903.1)	0.076	2371.4 (888.5)	−292.1 (977.5)	**0.003**
	Environment	2140.3 (752.8)	−110.8 (737.8)	0.210	2088.0 (824.8)	+16.7 (828.2)	0.866
	Combined	2161.5 (754.5)	−241.7 (754.5)	**0.000**	2282.3 (761.6)	−169.4 (815.9)	**0.001**
Total fat (g/day)	Control	76.8 (30.0)	+1.9 (44.4)	0.725	70.9 (30.2)	+14.0 (43.1)	0.009
	Education	82.2 (36.6)	−7.1 (54.4)	0.177	97.0 (45.9)	−9.5 (56.7)	0.084
	Environment	90.9 (42.7)	−11.4 (39.4)	**0.017**	85.1 (41.9)	−0.6 (45.2)	0.905
	Combined	88.8 (36.5)	−14.2 (41.8)	**0.000**	97.1 (42.2)	−10.0 (47.9)	**0.000**
Saturated fat (g/day)	Control	28.2 (14.6)	+1.8 (21.1)	0.491	26.1 (12.5)	+7.1 (18.2)	**0.002**
	Education	30.5 (15.4)	−3.2 (24.7)	0.189	36.2 (19.6)	4.0 (23.7)	0.078
	Environment	36.8 (19.5)	−8.8 (18.5)	**0.000**	32.2 (17.6)	−1.7 (19.3)	0.447
	Combined	33.1 (15.9)	−7.0 (17.6)	**0.000**	36.9 (20.0)	−4.2 (21.3)	**0.001**
Salt (g/day)	Control	6.7 (3.0)	+0.7 (4.4)	0.208	6.0 (3.5)	+1.2 (4.8)	**0.041**
	Education	7.8 (4.3)	−0.6 (5.5)	0.260	8.3 (5.0)	−0.9 (5.8)	0.079
	Environment	7.6 (3.3)	−0.5 (4.1)	0.347	7.7 (3.9)	+0.1 (4.9)	0.840
	Combined	7.8 (3.7)	−1.4 (4.4)	**0.000**	8.1 (4.1)	−0.7 (4.7)	**0.020**
Total sugars (g/day)	Control	75.4 (39.4)	+9.1 (62.1)	0.234	79.1 (60.40)	+6.9 (67.7)	0.402
	Education	101.4 (49.3)	−6.8 (67.3)	0.295	114.1 (59.24)	−18.8 (62.3)	**0.002**
	Environment	106.7 (59.4)	−4.6 (53.6)	0.476	98.6 (57.2)	−2.1 (67.8)	0.795
	Combined	102.0 (47.9)	−8.9 (48.9)	**0.003**	104.0 (54.0)	−8.1 (56.8)	**0.019**
Fibre (g/day)	Control	18.5 (7.6)	+0.2 (11.2)	0.908	16.3 (9.2)	+1.8 (11.0)	0.187
	Education	19.5 (8.2)	−0.2 (12.1)	0.906	17.6 (8.7)	−1.1 (9.1)	0.193
	Environment	20.2 (8.1)	−0.4 (11.0)	0.772	16.7 (8.3)	+0.2 (10.8)	0.893
	Combined	22.0 (10.3)	+0.2 (11.9)	0.855	19.6 (10.6)	+0.4 (11.1)	0.559

Off-duty dietary intakes

At 7- to 9-month follow-up, smaller but significant reductions in off-duty dietary intakes of total energy (−169.4 kcal/day), total fat (−10.0 g/day), saturated fat (−4.2 g/day), salt (−0.7 g/day) and total sugars (−8.1 g/day) were observed in the Combined intervention. Significant reductions were also observed in the Education intervention with regards to off-duty dietary intakes of total energy (−292.1 kcal/day) and total sugars (−18.8 g/day). Significant increases in terms of off-duty intakes of total fat (+14.0 g/day), saturated fat (+7.1 g/day) and salt (+1.2 g/day) were observed in the Control workplace. No significant changes in off-duty dietary intakes of fibre were observed in all interventions (Table 2).

In the Combined intervention, following adjustment for gender, significant mean differences were observed for pre–post changes in employees' off-duty intakes of total energy intake (−312.0 kcal/day), total fat (−15.0 g/day), total sugars (−17.9 g/day) and salt (−2.1 g/day). Following adjustment for age, significant mean differences were also observed in the Combined intervention regarding pre–post changes in employees' off-duty intakes of saturated fat (−0.4 g/day) and salt (−0.1 g/day). In the Education intervention, following adjustment for gender, significant mean differences were observed for pre–post changes in employees' off-duty intakes of total energy (−656.3 kcal/day), total sugars (−26.0 g/day) and salt (−2.5 g/day). In the Environment intervention, following adjustment for gender, significant mean differences were observed for pre–post changes in employees' off-duty intakes of total energy (−562.2 kcal/day), total fat (−27.3 g/day) and saturated fat (−12.8 g/day). The significant increases in terms of off-duty dietary intakes of total fat, saturated fat and salt that were observed in the Control at 7- to 9-month follow-up did not retain significance in the regression model (Table 4). Separate analysis (Table 5) indicates that the significant by gender on changes in off-duty dietary intakes at 7- to 9-month follow-up is due to the higher proportion of male

Table 3: Multiple regression model for changes in employees' on-duty dietary intakes at 7- to 9-month follow-up, by intervention

	Control (n = 67)		Education (n = 107)		Environment (n = 71)		Combined (n = 272)	
	β (95% CI)	p-value	β (95% CI)	p-value	β (95% CI)	p-value	β (95% CI)	p-value
Total energy intake (kcal/day)	a. −15.7 (−36.7, 5.3)	0.140	a. −3.7 (−23.6, 16.2)	0.713	a. 14.3 (−8.5, 37.2)	0.214	a. −2.5 (−14.7, 9.8)	0.694
	b. 238.27 (−153.0, 629.1)	0.227	b. −27.4 (−378.4, 323.5)	0.877	b. −463.6 (−793.1, −134.0)	**0.007**	b. −342.2 (−571.3, −113.0)	**0.004**
	c. −14.0 (−196.7, 168.7)	0.879	c. 46.6 (−77.4, 170.7)	0.457	c. 129.5 (−16.0, 274.8)	0.080	c. 10.3 (−79.7, 100.3)	0.822
	d. 61.9 (−144.3, 268.1)	0.550	d. 32.0 (−119.0, 183.0)	0.675	d. −194.3 (−371.9, −16.7)	0.053	d. −11.6 (−105.1, 82.0)	0.808
	e. −166.7 (−434.3, 100.9)	0.217	e. 9.3 (−241.7, 260.3)	0.942	e. 122.8 (−146.3, 391.9)	0.365	e. 16.4 (−96.6, 129.3)	0.776
	f. −0.8 (−48.1, 46.4)	0.973	f. −19.9 (−56.9, 17.0)	0.287	f. 28.2 (−2.0, 58.4)	0.067	f. 0.1 (−22.0, 22.1)	0.998
Total fat (g/day)	a. −0.4 (−1.5, 0.6)	0.389	a. −0.4 (−1.5, 0.6)	0.408	a. 0.9 (−0.5, 2.3)	0.227	a. −0.3 (−0.9, 0.4)	0.398
	b. 19.0 (0.2, 38.1)	0.055	b. −7.1 (−24.8, 10.6)	0.429	b. −23.5 (−42.8, −4.1)	**0.018**	b. −18.5 (−30.7, −6.3)	**0.003**
	c. −5.3 (−14.5, 3.9)	0.257	c. 2.0 (−4.7, 8.7)	0.554	c. 4.8 (−3.8, 13.4)	0.267	c. −0.9 (−5.2, 7.0)	0.730
	d. 1.2 (−9.1, 11.4)	0.822	d. 0.8 (−7.3, 8.9)	0.847	d. −8.8 (−19.5, 1.9)	0.104	d. 0.1 (−5.7, 4.0)	0.996
	e. −17.3 (−31.1, −3.5)	0.051	e. −2.8 (−16.3, 10.6)	0.676	e. 8.8 (−7.4, 25.0)	0.283	e. 1.0 (−5.2, 7.0)	0.772
	f. −1.0 (−3.2, 1.3)	0.414	f. −1.3 (−3.2, 0.7)	0.197	f. 0.8 (−1.0, 2.7)	0.358	f. −0.4 (−1.6, 0.8)	0.529
Saturated fat (g/day)	a. −0.3 (−0.8, 0.2)	0.282	a. −0.2 (−0.7, 0.2)	0.357	a. 0.4 (−0.2, 1.5)	0.157	a. −0.2 (−0.5, 0.1)	0.160
	b. 6.9 (−2.3, 16.1)	0.139	b. −5.3 (−12.9, 2.2)	0.163	b. −11.6 (−20.3, −2.8)	**0.010**	b. −9.4 (−14.8, −4.1)	**0.001**
	c. −3.0 (−7.6, 1.6)	0.194	c. −0.1 (−2.9, 2.8)	0.989	c. 2.5 (−1.4, 6.5)	0.206	c. −0.1 (−2.2, 2.1)	0.947
	d. −0.9 (−6.2, 4.3)	0.725	d. 0.7 (−2.8, 4.1)	0.690	d. −2.8 (−7.8, 2.3)	0.276	d. 0.2 (−2.0, 2.4)	0.856
	e. −6.6 (−13.5, 0.3)	0.062	e. 1.0 (−4.7, 6.7)	0.734	e. 6.1 (−1.3, 13.5)	0.102	e. 0.5 (−2.1, 3.2)	0.690
	f. −0.4 (−1.6, 0.7)	0.456	f. −0.1 (−0.2, 0.1)	0.454	f. 0.5 (−0.3, 1.3)	0.247	f. −0.1 (−0.5, 0.5)	0.921
Total sugars (g/day)	a. 0.1 (−1.0, 1.8)	0.537	a. −0.5 (−2.0, 1.0)	0.501	a. 0.2 (−1.5, 2.0)	0.812	a. 0.2 (−0.7, 1.0)	0.700
	b. −7.1 (−30.8, 16.7)	0.553	b. 0.9 (−23.6, 25.3)	0.945	b. −12.9 (−38.1, 12.3)	0.310	b. −15.2 (−30.5, 0.1)	0.551
	c. 7.6 (−5.0, 20.2)	0.233	c. 1.9 (−7.3, 11.2)	0.677	c. 13.8 (2.6, 24.8)	0.056	c. 1.2 (−4.9, 7.3)	0.701
	d. −3.2 (−17.4, 11.0)	0.654	d. 8.8 (−2.2, 19.8)	0.117	d. −9.3 (−23.2, 4.7)	0.190	d. −1.5 (−7.8, 4.8)	0.636
	e. −1.9 (−20.5, 16.7)	0.837	e. 7.6 (−10.3, 25.6)	0.401	e. 4.2 (−17.0, 25.5)	0.693	e. 2.1 (−5.6, 9.8)	0.586
	f. −0.8 (−3.9, 2.3)	0.279	f. 0.3 (−2.3, 3.0)	0.795	f. 2.2 (−0.2, 4.5)	0.073	f. −0.1 (−1.5, 1.4)	0.955
Salt (g/day)	a. −0.1 (−0.1, 0.1)	0.376	a. 0.1 (−0.1, 0.1)	0.773	a. 0.1 (−0.1. 0.1)	0.920	a. −0.1 (−0.1, 0.1)	0.171
	b. 1.8 (0.3, 3.3)	0.081	b. −1.4 (−2.9, 0.9)	0.064	b. −2.2 (−3.9, −0.6)	0.068	b. −1.0 (−2.2, 0.2)	0.103
	c. −0.4 (−1.1, 0.4)	0.338	c. 0.1 (−0.5, 0.63)	0.859	c. −0.2 (−0.1, 0.5)	0.497	c. 0.2 (−0.3, 0.7)	0.373
	d. 0.3 (−0.6. 1.2)	0.478	d. −0.4 (−1.1, 1.2)	0.270	d. −0.1 (−0.9, 0.8)	0.929	d. 0.1 (−0.4, 0.6)	0.728
	e. −0.5 (−1.7, 0.6)	0.348	e. 0.1 (−1.1, 1.2)	0.902	e. −0.1 (−1.4, 1.3)	0.899	e. 0.1 (−0.5, 0.7)	0.705
	f. −0.1 (−0.23, 0.1)	0.604	f. −0.1 (−0.2, 0.1)	0.356	f. 0.1 (−0.2, 0.1)	0.374	f. 0.2 (0.1, 0.3)	0.878

Independent variables: a. age, b. gender (men vs women), c. education status (low vs high), d. marital status (married/cohabiting vs single/never married), e. job position (manager/supervisor vs non-manager/non-supervisor) and f. BMI.

Table 4: Multiple regression model for changes in employees' off-duty dietary intakes at 7- to 9-month follow-up, by intervention

Nutrient	Control ($n = 67$)		Education ($n = 107$)		Environment ($n = 71$)		Combined ($n = 272$)	
	β (95% CI)	p-value	β (95% CI)	p-value	β (95% CI)	p-value	β (95% CI)	p-value
Total energy intake (kcal/day)	a. −15.0 (−40.5, 10.7)	0.248	a. −16.5 (−39.4, 6.5)	0.157	a. −2.9 (−28.1, 22.3)	0.819	a. −9.6 (−22.9, 3.6)	0.152
	b. −695.9 (−1178.6, −213.3)	0.060	b. −656.3 (−1042.9, −269.7)	**0.001**	b. −562.2 (−959.2, −165.1)	**0.006**	b. −312.0 (−558.0, −66.4)	**0.013**
	c. 13.6 (−216.3, 243.5)	0.906	c. −85.8 (−229.5, 58.0)	0.239	c. −224.9 (−392.9, −56.8)	0.060	c. −21.5 (−120.0, 77.0)	0.668
	d. 79.8 (−172.8, 332.4)	0.529	d. 113.3 (−61.7, 288.2)	0.202	d. −13.0 (−224.6, 198.7)	0.903	d. 31.5 (−70.0, 133.0)	0.542
	e. −135.1 (−467.0, 196.8)	0.418	e. 2.5 (−282.0, 286.9)	0.986	e. −72.0 (−396.6, 252.5)	0.659	e. −62.8 (−184.8, 59.2)	0.312
	f. −41.7 (−100.0, 16.4)	0.156	f. −16.4 (−58.7, 25.8)	0.442	f. 7.1 (−28.4, 42.6)	0.692	f. 12.8 (−11.0, 36.5)	0.291
Total fat (g/day)	a. −0.8 (−1.9, 0.3)	0.135	a. −0.6 (−1.9, 0.8)	0.398	a. −0.4 (−1.7, 0.9)	0.529	a. −0.8 (−1.5, 0.1)	0.052
	b. −16.5 (−35.9, 2.9)	0.094	b. −20.0 (−41.7, 1.7)	0.070	b. −27.3 (−47.0, −7.7)	**0.007**	b. −15.0 (−29.0, −1.0)	**0.036**
	c. 0.8 (−8.8, 10.4)	0.865	c. −4.3 (−12.6, 3.9)	0.299	c. −12.3 (−21.0, −3.6)	**0.006**	c. −0.5 (−6.2, 5.1)	0.850
	d. 5.8 (−5.0, 16.5)	0.283	d. 4.7 (−5.3, 14.8)	0.352	d. 2.0 (−9.0, 13.0)	0.720	d. 1.5 (−4.4, 7.4)	0.620
	e. −2.6 (−16.6, 11.4)	0.710	e. −3.6 (−19.9, 12.7)	0.663	e. −8.3 (−24.9, 8.2)	0.317	e. −4.9 (−12.0, 2.1)	0.171
	f. −1.0 (−3.3, 1.5)	0.454	f. −1.0 (−3.4, 1.4)	0.403	f. 0.1 (−1.7, 2.0)	0.903	f. 0.5 (−0.9, 1.8)	0.517
Saturated fat (g/day)	a. −0.2 (−0.6, 0.2)	0.361	a. −0.3 (−0.9, 0.3)	0.289	a. −0.1 (−0.7, 0.4)	0.695	a. −0.4 (−0.8, −0.1)	**0.031**
	b. −7.0 (−15.1, 1.1)	0.088	b. −4.4 (−13.8, 4.9)	0.349	b. −12.8 (−20.9, −4.7)	**0.003**	b. −4.2 (−10.7, 2.4)	0.210
	c. −1.8 (−5.7, 2.1)	0.354	c. −2.7 (−6.2, 0.9)	0.143	c. −4.0 (−7.6, −0.3)	**0.033**	c. 0.4 (−2.3, 3.0)	0.777
	d. −0.3 (−4.7, 4.0)	0.875	d. 3.2 (−1.1, 7.6)	0.145	d. 0.1 (−4.5, 4.7)	0.964	d. −0.2 (−2.9, 2.6)	0.898
	e. −1.5 (−7.2, 4.2)	0.594	e. −2.3 (−9.4, 4.8)	0.519	e. −4.0 (−10.8, 2.9)	0.253	e. −2.9 (−6.2, 0.5)	0.091
	f. 0.1 (−0.1, 0.3)	0.914	f. −0.1 (−1.1, 1.0)	0.936	f. −0.1 (−0.8, 0.7)	0.876	f. 0.4 (−0.3, 1.0)	0.253
Total sugars (g/day)	a. −0.2 (−2.3, 1.9)	0.851	a. −1.0 (−2.6, 0.6)	0.220	a. −0.6 (−2.6, 1.4)	0.531	a. −0.2 (−1.2, 0.8)	0.676
	b. −46.8 (−82.8, −10.7)	0.082	b. −26.0 (−51.9, −0.2)	**0.049**	b. −11.3 (−40.8, 18.2)	0.447	b. −17.9 (−35.3, −0.6)	**0.043**
	c. −6.0 (−25.0, 13.1)	0.533	c. −5.2 (−15.0, 4.6)	0.295	c. −0.2 (−13.1, 12.7)	0.976	c. 1.4 (−5.7, 8.4)	0.700
	d. −1.2 (−22.3, 19.8)	0.909	d. 6.4 (−5.5, 18.4)	0.286	d. −8.9 (−25.3, 7.3)	0.273	d. −2.1 (−9.5, 5.2)	0.571
	e. −10.1 (−37.7, 17.4)	0.464	e. 1.5 (−17.8, 20.8)	0.876	e. −5.7 (−30.4, 19.1)	0.650	e. −0.7 (−9.5, 8.1)	0.873
	f. −1.8 (−6.6, 2.9)	0.437	f. 0.7 (−2.1, 3.5)	0.617	f. 1.1 (−1.7, 3.9)	0.422	f. 0.1 (−1.6, 1.8)	0.891
Salt (g/day)	a. −0.1 (−0.2, 0.1)	0.107	a. 0.1 (−0.1, 0.2)	0.740	a. −0.1 (−0.2, 0.1)	0.282	a. −0.1 (−0.2, −0.1)	**0.047**
	b. −1.4 (−3.6, 0.8)	0.203	b. −2.5 (−4.8, −0.3)	**0.027**	b. −1.5 (−3.5, 0.5)	0.133	b. −2.1 (−3.5, −0.7)	**0.004**
	c. −1.0 (−1.4, 1.1)	0.118	c. −1.2 (−2.0, −0.3)	0.008	c. −0.8 (−1.7, 0.1)	0.076	c. −0.3 (−0.9, 0.2)	0.225
	d. −0.1 (−1.4, 1.1)	0.818	d. 0.4 (−0.6, 1.5)	0.429	d. 1.2 (0.1, 2.3)	0.082	d. 0.2 (−0.4, 0.7)	0.587
	e. −1.3 (−2.9, 0.2)	0.094	e. 0.1 (−1.6, 1.8)	0.913	e. −0.5 (−2.2, 1.2)	0.555	e. −0.4 (−1.1, 0.3)	0.236
	f. 0.1 (−0.1, 0.4)	0.269	f. −0.1 (−0.3, 0.2)	0.884	f. −0.2 (−0.4, 0.1)	0.069	f. −0.1 (−0.2, 0.1)	0.135

Independent variables: a. age, b. gender (men vs women), c. education status (low vs high), d. marital status (married/cohabiting vs single/never married), e. job position (manager/supervisor vs non-manager/non-supervisor) and f. BMI.

Table 5: Regression model for changes in employees' on-duty and off-duty dietary intakes at 7- to 9-month follow-up, by intervention

	Control (n = 67)		Education (n = 107)		Environment (n = 71)		Combined (n = 272)	
	β (95% CI)	p-value	β (95% CI)	p-value	β (95% CI)	p-value	β (95% CI)	p-value
On-duty								
Total energy intake (kcal/day)	[a] 76.4 (−214.9, 367.6)	0.602	[a] −32.2 (−335.2, 270.8)	0.834	[a] −644.3 (−977.4, −311.1)	0.001	[a] −448.6 (−660.4, −236.7)	0.001
Total fat (g/day)	[a] 12.8 (−2.1, 27.8)	0.091	[a] −5.4 (−21.9, 10.9)	0.511	[a] −29.6 (−49.1, −10.0)	0.004	[a] −20.9 (−32.3, −9.4)	0.005
Saturated fat (g/day)	[a] 5.0 (−2.3, 12.4)	0.176	[a] −3.9 (−10.8, 2.9)	0.254	[a] −12.7 (−21.7, −3.7)	0.006	[a] −10.7 (−15.7, −5.7)	0.001
Total sugars (g/day)	[a] −9.1 (−28.9, 10.8)	0.366	[a] 0.5 (−21.7, 22.6)	0.966	[a] −31.2 (−59.2, −3.2)	0.092	[a] −23.4 (−38.6, −8.3)	0.050
Salt (g/day)	[a] 1.9 (0.4, 3.3)	0.110	[a] −1.2 (−2.6, 0.1)	0.088	[a] −2.5 (−3.9, −1.0)	0.002	[a] −1.2 (−2.3, −0.1)	0.050
Off-duty								
Total energy intake (kcal/day)	[a] −9.4 (−29.1, 10.2)	0.341	[a] −9.5 (−29.0, 10.0)	0.336	[a] −0.6 (−24.4, 23.3)	0.962	[a] −5.02 (−18.1, 8.1)	0.451
Total fat (g/day)	[a] −17.5 (−32.3, −2.8)	0.210	[a] −18.7 (−39.0, 1.6)	0.070	[a] −26.9 (−46.4, −7.6)	0.007	[a] −20.7 (−34.0, −7.3)	0.003
Saturated fat (g/day)	[a] −0.1 (−0.3, 0.3)	0.992	[a] 0.1 (−0.4, 0.4)	0.963	[a] −0.3 (−0.7, 0.1)	0.026	[a] −0.1 (−0.6, 0.4)	0.751
Total sugars (g/day)	[a] −0.4 (−1.9, 1.2)	0.622	[a] −0.6 (−1.8, 0.7)	0.392	[a] −1.3 (−2.9, 0.4)	0.125	[a] −0.4 (−1.4, 0.5)	0.364
Salt (g/day)	[a] −0.1 (−0.2, 0.1)	0.141	[a] 0.1 (−0.1, 0.2)	0.106	[a] −0.1 (−0.1, 0.1)	0.788	[a] −0.1 (−0.1, 0.1)	0.091

[a]Gender (men vs women).

employees (83%) to female (17%) in the study population.

DISCUSSION

This study complements and extends earlier findings from the FCW trial that demonstrate that workplace dietary interventions that combine nutrition education and environmental dietary modification can improve employees' dietary intakes. Specifically, this study sought to determine the impact of complex workplace dietary interventions that included nutrition education and environmental dietary modification both alone and in combination on employees' on and off-duty dietary intakes. For on-duty dietary intakes, positive changes were observed in the Combined and Environment interventions with significant reductions in employees' intakes of total energy, total fat and saturated fat. Smaller positive changes were also observed in the Combined intervention in employees' off-duty dietary intakes of total energy, total fat, saturated fat, sugar and salt. For the Combined intervention only, these findings suggest that the improvements observed in employees' dietary intakes at work were also extended to their lives outside of work.

The findings contribute to and are consistent with the current limited body of evidence-based research on the impact of workplace dietary interventions on employees' dietary on-duty dietary intakes. Previous research suggests that workplace interventions which combine environmental dietary modification and nutrition education strategies can improve employees' on-duty dietary intakes (Braeckman *et al.*, 1999; Lowe *et al.*, 2010; Ni Mhurchu *et al.*, 2010; Geaney *et al.*, 2013). Furthermore, Sharma *et al.* (Sharma *et al.*, 2016) emphasis the need for workplace interventions to incorporate environmental strategies which make healthier foods readily available in the workplace. A recent study also found that providing healthy foods and snacks in the workplace is an effective way of improving employees' on-duty dietary intakes of fat and fibre (Leedo *et al.*, 2017). In this study, the observed improvements in on-duty dietary intakes in the Combined and Environment interventions suggest that reengineering workplaces as supportive healthy eating environments where food choices are predominantly limited to healthy options, can help employees improve their dietary intakes. There is currently no available evidence which examines the impact of workplace dietary interventions on employee's dietary intakes outside of their work environments. However, the observed improvements in employees' off-duty dietary intakes in the Combined and Education interventions in this study suggest that the learned eating practices informed by the nutrition education and environmental dietary modification strategies are important tools that can provide employees with the nutrition knowledge and skills required to maintain their healthy dietary behaviours outside of a controlled workplace environment. Recent research into nutrition education strategies such as calorie labelling in workplace cafeterias suggests that nutrition education strategies should be implemented in workplaces as part of a wider set of measures to improve employees' dietary habits (Crockett *et al.*, 2018; Vasiljevic *et al.*, 2018).

It is important to acknowledge that seasonal variations between baseline data collection (February–July 2013) and 7- to 9-month follow-up data collection (January–March 2014) could be confounding the findings. Research has indicated that winter months are often associated with an increased daily consumption of calories and fat when compared to dietary intakes over the summer months (Ma *et al.*, 2006). Moreover, it is also widely reported that dietary patterns differ according to the day of the week. Weekend dietary intakes, when employees are typically not at work, are associated with higher intakes of total energy and fat and lower intakes of fruit, vegetables and fibre when compared to weekday dietary intakes (Hartline-Grafton *et al.*, 2010; Yang *et al.*, 2013; An, 2016). One factor that may be contributing to poorer dietary patterns at weekends is that out of home eating typically occurs more frequently at weekends. Research has indicated that out of home eating is associated with increased risk of obesity, increase in body fat, higher intakes of saturated fat and calories and lower intakes of fruit, vegetable and fibre (Lachat *et al.*, 2009; Nago *et al.*, 2014). As the majority of off-duty recalls that were recorded for this study were captured over weekend days, it is possible that employees have introduced an intra-week compensating behaviour to the findings. Employees may have underestimated their intakes of unhealthy foods and minimized differences in their reports of on and off-duty dietary intakes.

Strengths and limitations

The use of multiple 24-h dietary recalls which included weekend and off-duty periods, facilitated assessment of the impact of the Combined intervention outside of the work environment. Furthermore, although 24-h dietary recalls are traditionally associated with underreporting of discretionary sources of salt, the recall method used in this study included additional prompts for the use of salt (Laatikainen *et al.*, 2006; Geaney *et al.*, 2013). The gold standard for measuring salt intake is 24-h urinary excretion however, as FCW was a pragmatic trial, it was not feasible for large numbers of employees to collect 24-h urine samples within their workplaces. An additional strength of this study is that, the socio-demographic questionnaire used is a well-validated measurement tool within the Irish population (Harrington *et al.*, 2008).

As with any study of dietary intakes, this study has a number of limitations. First, gender was reported as having a significant effect across the interventions for on and off-duty dietary intakes. However, following separate analysis by gender this effect is owing to the higher proportion of male employees (83%) to female (17%) in the study population (Table 5). Second, there is the potential presence of selection bias. Despite employees being randomly selected to participate in the FCW trial, bias cannot be ruled out as healthy employees may have been more likely to participate in the study when compared to unhealthier employees. Similarly, although the 24-h recall method is an efficient method of data collection (Davy and Estabrooks, 2015), recall bias may have been introduced due to the self-report nature of the 24-h dietary recalls. It is also necessary to address the potential impact of relying on repeated recalls. Research has demonstrated that as the number of recalls increases, the quality of the data often decreases as there is fatigue in repeated recall and as a result, reported intakes can decline (Arab *et al.*, 2010; Martin *et al.*, 2014) and there is also the potential for social-desirability bias to be introduced as respondents may try to please the interviewer. Future research into dietary assessments should consider incorporating different methods such as the use of digital photography and electronic applications to minimize reliance on face-to-face recall methods.

This study demonstrates the potentially positive impact that food service can have in our everyday environments. Our exposure to food service is increasing with the population becoming more reliant on schools, universities and workplaces to provide their daily meals. Therefore, the findings of this study are of critical importance particularly to food service providers and also to public health policy makers and employers. The findings establish that the benefits of complex workplace dietary interventions that incorporate both nutrition education and environmental dietary modification strategies can extend beyond the workplace environment. Further research is required to measure if the carry-over effect of these interventions has an extended reach through to different settings (food consumption at home and out of home eating) for employees and to the lives of employees' families, friends and wider communities.

AUTHORS' CONTRIBUTIONS

All authors contributed to this work. S.F., L.B., F.G. and I.J.P. worked on the study design and methods. L.B. and S.F. were responsible for data analysis. S.F. and L.B. wrote the paper and all authors critically reviewed and approved the final manuscript.

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