# The effect of complex workplace dietary interventions on employees dietary behaviours, nutrition knowledge and health status

A thesis submitted to University College Cork for the degree of Doctor of Philosophy in the Department of Epidemiology and Public Health, School of Medicine.

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## LIST OF ABBREVIATIONS

| ABBREVIATION | TERM |
|---|---|
| ALA | Alpha-Linolenic Acid |
| AMI | Acute Myocardial Infarction |
| ANCOVA | Analysis of Covariance |
| ANOVA | Analysis of Variance |
| BMI | Body Mass Index |
| BP | Blood Pressure |
| CHD | Coronary Heart Disease |
| CHDR | Centre for Health and Diet Research |
| CI | Confidence Interval |
| CMAI | Catering Managers Association of Ireland |
| CVD | Cardiovascular Disease |
| DALYs | Disability Adjusted Life Years |
| DASH | Dietary Approaches to Stop Hypertension |
| DEBQ | Dutch Eating Behaviour Questionnaire |
| DHA | Docosahexaenoic Acid |
| DWL | Deadweight Loss |
| EAB | Employee Advisory Board |
| ENWHP | European Network for Workplace Health Promotion |
| EPA | Eicosapentaenoic Acid |
| EPIC | European Prospective Investigation of Cancer |
| EQ-5D | EuroQol-5D |
| EU | European Union |
| FCW | Food Choice at Work Study |
| FDA | Food and Drug Administration |
| FFQ | Food Frequency Questionnaire |
| FMQ | Food Motives Questionnaire |
| FSAI | Food Safety Authority of Ireland |
| GBD | Global Burden of Disease Study |
| GDP | Gross Domestic Product |
| GNKQ | General Nutrition Knowledge Questionnaire |
| HBM | Health Belief Model |
| HDL | High Density Lipoprotein |
| HLFQ | Health, Lifestyle and Food Questionnaire |
| Hr | Hour |
| HRB | Health Research Board |
| ICERs | Incremental Cost Effectiveness Ratios |
| IDA | Industrial Development Authority of Ireland |

| | |
|---|---|
| **IHF** | Irish Heart Foundation |
| **IPAQ** | International Physical Activity Questionnaire |
| **ISBNPA** | International Society for Behavioural Nutrition and Physical Activity |
| **IT** | Information Technology |
| **Kcal** | Kilocalorie |
| **LCA** | Latent Class Analysis |
| **MGI** | McKinsey Global Institute |
| **MH** | MeSH Heading |
| **MRC** | Medical Research Council |
| **NACL** | Sodium Chloride |
| **NCD** | Non-Communicable Diseases |
| **NICE** | National Institute for Health and Clinical Excellence |
| **NK** | Nutrition Knowledge |
| **OR** | Odds Ratio |
| **PABA** | Para-aminobenzoic Acid |
| **PRISMA** | Preferred Reporting Items for Systematic Reviews and Meta-Analysis |
| **QALY** | Quality Adjusted Life Years |
| **RCT** | Randomised Controlled Trial |
| **RR** | Relative Risk |
| **SCT** | Social Cognitive Theory |
| **SD** | Standard Deviation |
| **SEM** | Social Ecological Model |
| **SOP** | Standard Operating Procedures |
| **SPSS** | Statistical Package for the Social Sciences |
| **TREND** | Transparent Reporting of Evaluations with Non-randomised Designs |
| **TTM** | Transtheoretical Model |
| **UK** | United Kingdom |
| **WC** | Waist Circumference |
| **WHO** | World Health Organisation |

**DECLARATION**

I declare that this thesis has not been submitted for another degree at this or any other University. The work, upon which this thesis is based, was carried out in collaboration with a team of researchers and supervisors who are duly acknowledged in the text of the thesis. The library may lend or copy this thesis upon request.

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## DECLARATION OF AUTHORSHIP

The candidate has taken responsibility for all aspects of the work presented in the thesis from its inception. For the systematic review, with guidance from Dr Paul Beirne (Cochrane reviewer and lecturer, Department of Epidemiology and Public Health, University College Cork), the candidate developed the selection criteria, search strategy and designed the data extraction form. The candidate was primarily responsible for the assessment of study quality and interpreted the results of the included studies. The candidate was the lead author for the related publication.

The candidate was the lead investigator for the overall 'Food Choice at Work Study'. With guidance from Professor Ivan Perry, she developed the study design for the cluster controlled trial, designed the complex workplace dietary interventions following advice from the Catering Manager's Association of Ireland (CMAI), recruited the study workplaces and employees and approved the final version of the study protocol for publication. The candidate was also responsible for co-ordinating data collection at baseline, follow-up at 3-4 months and 7-9 months. She liaised with the workplace stakeholders on a regular basis regarding the compliance of the workplace interventions. For the effectiveness study, the candidate co-ordinated the data entry using Survey Monkey, NetWisp and

Microsoft Excel. She conducted the data analysis using the Statistical Package for the Social Sciences (SPSS) following advice from Dr Tony Fitzgerald (Biostatistician, Department of Epidemiology and Public Health, University College Cork). The candidate prepared and co-wrote the publication with Prof Ivan Perry.

For the intervention related sub-study, the candidate conducted the study design and constructed the Dietary Approaches to Stop Hypertension (DASH) and nutrition knowledge scores. She was responsible for the data analysis following guidance from Dr Tony Fitzgerald and Dr Janas Harrington (nutrition epidemiologist, Department of Epidemiology and Public Health, University College Cork). The candidate was responsible for the final content of the publication. The candidate wrote this thesis with supervision from Professor Ivan Perry, Dr Janas Harrington, Dr Birgit Greiner and Dr Kenneth McKenzie.

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Most of all, I would like to thank my family for their patience and encouragement. For my parents who supported me throughout my college years and thesis journey. They are both great role models to me and have taught me about the importance of hard work, resilience, self-respect and about working well within a team. I would also like to thank my sister and brother, Regina and Matthew for their consistent support. Last but not least, I would like to thank my grandmother, Lizzie for her warm wishes and Noreen, Irwin, Lauryn, Eve and Abby for being a welcomed distraction during busy times.

**THESIS ABSTRACT**

**Background**

The growing prevalence and associated burden of diet-related non-communicable diseases is a global public health concern. The environments in which people live and work influences their dietary behaviours.

**Aims and objectives**

The core focus of this thesis was on the effectiveness of complex workplace dietary interventions. The comparative effectiveness of a complex workplace environmental dietary modification intervention and an educational intervention were assessed both alone and in combination relative to a control workplace setting.

**The thesis objectives were as follows:**

1. To conduct a systematic review of the existing literature on the effectiveness of workplace dietary modification interventions alone or in combination with nutrition education.
2. To develop high intensity complex workplace dietary interventions that were focused on environmental dietary modification and/or nutrition education in large manufacturing workplace settings.
3. To assess the effectiveness of a workplace environmental dietary modification intervention and an educational intervention both alone and in combination versus a control workplace on employees' dietary behaviours, nutrition knowledge and health status at 3-4 months and 7-9 months follow-up.
4. Intervention related sub-study: To test the hypothesis that higher nutrition knowledge among employees' is associated with better diet quality and lower risk of hypertension.

**Methods**

The systematic review was guided by the PRISMA statement and potential biases were measured using the Cochrane Collaboration's risk of bias tool. In a cluster controlled trial, four workplaces were purposively allocated to control, nutrition education alone (Education), environmental dietary modification alone (Environment) and nutrition education and environmental dietary modification (Combined intervention). The interventions were guided by the MRC framework and the NICE guidelines and reported according to the TREND statement. In the control workplace, data was collected at baseline and follow-up and participants were informed that they were involved in a university-led

study designed to observe employees dietary behaviours. Nutrition education strategies included: group presentations, individual consultations and detailed nutrition information (traffic light menu-labelling, posters, leaflets and emails). Environmental dietary modification strategies included: menu modification (restriction of fat, saturated fat, sugar and salt), increase in fruit and vegetables, price discounts for fruit, strategic positioning of healthier alternatives and portion size control. The primary study outcomes were changes in employees' dietary intakes of salt and BMI at 7-9 months follow-up. Secondary outcomes included changes in dietary intakes (total fat, saturated fat, total sugars and fibre), diet quality (DASH diet score), nutrition knowledge (General Nutrition Knowledge Questionnaire) and health status (weight, midway-waist circumference and resting blood pressure). In the intervention related sub-study, the relationships between nutrition knowledge, diet quality and hypertension were examined.

**Results**

The findings from the systematic review provided limited evidence for the effectiveness of workplace dietary modification interventions apart from some evidence that these interventions can increase fruit and vegetable consumption. In the FCW study, 850 employees aged 18-64 years were recruited at baseline with N (response rate %) in each workplace as follows: Control: 111(72%), Education: 226(71%), Environment: 113(91%), Combined intervention: 400(61%). Complete follow-up data was obtained for 517 employees (61%). There were significant positive changes in dietary intakes of saturated fat (p=0.013), salt (p=0.010) and nutrition knowledge (p=0.034) between baseline and follow-up at 7-9 months in the combined intervention versus the control workplace in the fully adjusted multivariate analysis. Small but significant changes in BMI (-1.2kg/$m^2$ (95% CI -2.385, -0.018, p=0.047) were also observed in the combined intervention. Changes in the DASH score (p=0.028) were significant in analysis adjusted for age and gender but not in multivariate analysis. No significant changes in waist circumference and blood pressure were observed. Effects in the education alone and environment alone workplaces were smaller and generally non-significant. In the sub-study, nutrition knowledge was positively significantly associated with diet quality and blood pressure in the multivariate analyses but no evidence of a mediation effect of the DASH score was detected between nutrition knowledge and blood pressure.

**Conclusion**

This thesis provides critical evidence on the effectiveness of complex workplace dietary interventions in a manufacturing working population. The FCW combined dietary intervention has been described in sufficient detail to allow replication and is potentially scalable. In future work, it is proposed that the combined dietary intervention will be tested in a large-scale cluster randomised controlled trial.

## 1. THESIS SUMMARY

## 1.1. Introduction

The growing prevalence and associated burden of non-communicable diseases (NCDs) is a global public health concern. Other than smoking, harmful alcohol consumption and physical inactivity, the prevention of NCDs revolves around the promotion of a healthy diet. The promotion of diets that are low in fats, sugar and salt (target to reduce to 5g per person per day) were among the priority cost-effective interventions highlighted at the UN High Level Meeting on NCDs in 2011 [1]. This NCD prevention agenda provides the background and context for the current thesis.

The environments in which people live and work influences their dietary behaviours and therefore modification of these environments in addition to increased nutrition education are potential mechanisms for diet improvements [2, 3]. The workplace has been recognised by the WHO as a priority environment to influence employees dietary behaviours given that individuals can spend most of their waking hours in their workplaces [4, 5]. The core focus of this thesis is on the effectiveness of workplace dietary interventions.

## 1.2. Aim

The primary aim of this thesis was to assess the comparative effectiveness of a complex workplace environmental dietary modification intervention and a complex educational intervention both alone and in combination versus a control workplace on employees dietary behaviours, nutrition knowledge and health status.

## 1.3. Objectives

The objectives for this thesis were:

- To conduct a systematic review to evaluate the effectiveness of workplace dietary modification interventions alone or in combination with nutrition education (Chapter 3).
- To develop high intensity complex workplace dietary interventions that are focused on environmental dietary modification and/or nutrition education in large manufacturing workplace settings (Chapter 4).
- To assess at 3-4 months and 7-9 months follow-up the comparative effectiveness of a workplace environmental dietary modification intervention and an educational intervention both alone and in combination versus a control workplace on employees dietary behaviours, nutrition knowledge and health status (Chapter 5).
- Intervention related sub-study: To test the hypothesis that higher nutrition knowledge among employees is associated with better diet quality and lower risk of hypertension (Chapter 6).

## 1.4. Research settings

A cluster controlled trial (Food Choice at Work Study (FCW)) was conducted in four large purposively selected multi-national manufacturing workplaces in Cork in the Republic of Ireland. The workplaces manufactured products for the food, health, information technology (IT) and automotive sectors. This work was supported by the Health Research Board (HRB) Centre for Health and Diet Research grant

(HRC2007/13) which is funded by the Irish Health Research Board and by the Department of Agriculture, Fisheries and Food. Student bursaries were awarded from the Irish Heart Foundation (IHF) and the Nutrition and Health Foundation to students involved in the study.

**1.5. Thesis outline**

The work presented in this thesis forms part of an on-going study called the 'Food Choice at Work Study' (FCW). The short-term (3-4 months), medium-term (7-9 months) and long-term (20-23 months) effectiveness of the complex workplace dietary interventions is being measured using a mixed methods approach that includes: 1. an intervention trial, 2. a process evaluation and 3. a cost-effectiveness analysis. This thesis is focused on the short and medium term effectiveness of the intervention trial only. The long-term data, process and cost-effectiveness evaluations are subject of a separate thesis.

This thesis includes four papers as illustrated in Figure 1. The systematic review presented in Chapter 3 was conducted to examine the existing literature regarding the effectiveness of workplace dietary modification interventions alone or in combination with nutrition education. This review was guided by the PRISMA statement and potential biases were measured using Cochrane Collaboration's risk of bias tool. The findings from the systematic review provided limited evidence for the effectiveness of workplace dietary modification interventions. There was some evidence that these interventions can increase fruit and vegetable consumption.

Ambiguity remains regarding the long-term effects on dietary behaviour, clinical health status and economic cost outcomes.

The Food Choice at Work Study (FCW) protocol is explained in Chapter 4. Based on the findings of an earlier observational study and the systematic review, the structured workplace dietary interventions were developed. In a cluster controlled trial, four workplaces were purposively allocated to control (Control), nutrition education alone (Education), environmental dietary modification alone (Environment) and nutrition education and environmental dietary modification (Combined intervention). Nutrition education included: group presentations, individual consultations and detailed nutrition information (unique traffic light menu-labelling, posters, leaflets and emails). Environmental dietary modification included: menu modification (restriction of fat, saturated fat, sugar and salt), increase in fibre, fruit and vegetables, price discounts for fruit, strategic positioning of healthier alternatives and portion size control. Environmental engineering approaches were guided by the social ecology theory and the nudge theory (choice architecture). The interventions were guided by the Medical Research Council (MRC) framework and the National Institute for Health and Clinical Excellence (NICE) guidelines and reported according to the Transparent Reporting of Evaluations with Non-randomised designs (TREND) statement. In the control workplace, data was collected at baseline and follow-up and participants were informed that they were involved in a university-led study designed to observe employees dietary behaviours.

The intervention design was developed by the research team and advised by catering stakeholders (Catering Managers Association of Ireland (CMAI)). The research team worked with the workplace stakeholders (human resources, occupational health and catering managers) to implement the specific interventions within the context of the individual workplaces. (Trial registration: Current Controlled Trials ISRCTN35108237).

Chapter 5 evaluates the effect of these interventions. The main outcomes were changes in employees' dietary behaviours (as measured by 24-hour dietary recalls and food frequency questionnaires (FFQ) for which a DASH diet score was derived), nutrition knowledge (as measured using a validated questionnaire tool) and health status (as measured by body mass index (BMI), waist circumference and blood pressure) over a period of 9 months. Data were obtained at baseline, follow-up at 3-4 months and 7-9 months.

In the FCW study, 850 employees aged 18-64 years were recruited at baseline with N (response rate %) in each workplace as follows: Control: 111(72%), Education: 226(71%), Environment: 113(91%), Combined intervention: 400(61%). Complete follow-up data was obtained for 517 employees (61%). There were significant positive changes in dietary intakes of saturated fat (p=0.013), salt (p=0.010) and nutrition knowledge (p=0.034) between baseline and follow-up at 7-9 months in the combined intervention versus the control workplace in the fully adjusted multivariate analysis. Small but significant changes in BMI (-1.2kg/$m^2$ (95% CI -

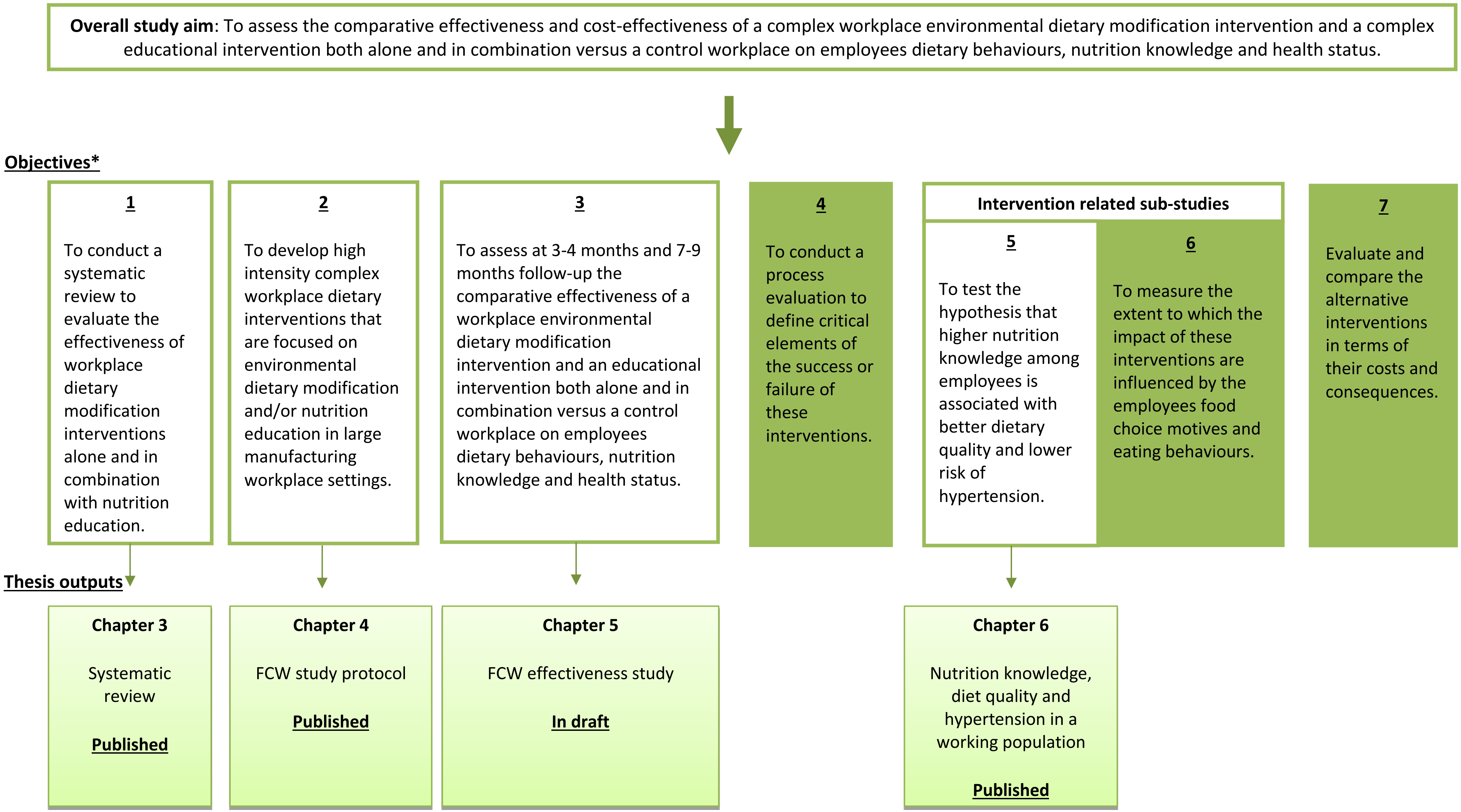
2.385, -0.018, p=0.047) were also observed in the combined intervention. Changes in the DASH score (p=0.028) were significant in analysis adjusted for age and gender but not in the multivariate analysis. No significant changes in waist circumference and blood pressure were observed. Effects in the education alone and environment alone workplaces were smaller and generally non-significant.

In an intervention related sub-study, the relationships between nutrition knowledge, diet quality and hypertension were examined in chapter 6. Nutrition knowledge was measured using the General Nutrition Knowledge Questionnaire (GNKQ). Diet quality was measured using the DASH score. Nutrition knowledge was positively associated with diet quality after adjustment for age, gender, health status, lifestyle and socio-demographic characteristics. The odds of having a high DASH score (better diet quality) were 6 times higher in the highest nutrition knowledge group compared to the lowest group (OR=5.8, 95%CI 3.5 to 9.6). Employees in the highest nutrition knowledge group were 60% less likely to be hypertensive compared to the lowest group (OR=0.4, 95%CI 0.2 to 0.87). However, no evidence of a mediation effect of the DASH score was detected between nutrition knowledge and blood pressure.

Chapter 7 of this thesis summarises and reflects on the findings from these four papers. This thesis provides critical evidence on the effectiveness of complex workplace dietary interventions in a manufacturing working population. The FCW combined dietary intervention has been described in sufficient detail to allow replication and is potentially scalable. In future work, it is proposed that the combined dietary intervention will be tested in a large-scale cluster randomised controlled trial. The findings if confirmed will inform food policy regarding improvements in dietary behaviour, nutrition knowledge and health status. Wide-scale implementation will need to be considered in local, national and international workplaces.

On a broader level, the increasing prevalence of NCDs is one of the challenging public health problems of our time. The WHO Global Action Plan for the Prevention and Control of NCDs 2013-2020 is focused on reaching specific targets to reduce NCDs (including a reduction in NCD deaths by 2% per year and a halt in the increase of obesity and type 2 diabetes). These targets will not be achieved without changes to our food environments at local, national and transnational levels. Strengthened research regarding complex environmental dietary interventions, widespread implementation of these interventions and increased accountability from the food industry would support governmental objectives to implement policies and would enable progress towards reducing the prevalence and burden of diet-related NCDs.

Figure 1. FCW study outline




*Objectives 1, 2, 3 and 5 are part of this thesis. Objectives 4, 6, and 7 are not part of this thesis (the candidate has assisted in the study design, data collection and publications for these objectives also).

## 2. BACKGROUND

## 2.1. Overview of background

This chapter describes the global burden of NCDs. The relationships between the most common NCDs and their known risk factors (tobacco use, physical inactivity, harmful use of alcohol, unhealthy diets, obesity) are described with a particular emphasis on the effects of an unhealthy diet. The global political framework to tackle NCDs is then discussed followed by an overview of the recommended action plan going forward to limit an unhealthy diet. Specifically, the World Health Organisation's (WHO's) Global Action Plan for the Prevention and Control of NCDs 2013-2020 has suggested that nutrition promoting environments should be developed in suitable settings.

The workplace has been recommended as one of these suitable settings. This chapter will explain why the workplace is a priority setting for health promotion and will discuss the evolutionary process of workplace health promotion. The underlying principles for successful workplace health promotion will also be described followed by two sustainable examples of health promotion interventions within the Irish context.

The limited evidence regarding the effectiveness of workplace dietary interventions will be considered. The role of behavioural science theory in the development of these interventions will be examined. The reasons for developing these interventions within a complex intervention framework will also be explained. Finally, this chapter will outline how to develop and evaluate a complex workplace dietary intervention based on the recommended MRC's framework for developing and evaluating complex interventions.

### 2.2. Defining NCDs

Non-communicable diseases, also known as chronic diseases do not result from an infectious process and are therefore not passed from person to person. Characteristics of NCDs include a complex aetiology, multiple risk factors, non-contiguous origin, a long latency period, prolonged course of illness and functional impairment or disability [6]. These diseases do not resolve spontaneously but require an accurate diagnosis and a careful treatment plan. However, in many cases a complete cure is rarely accomplished [6]. Behavioural risk factors including tobacco use, physical inactivity, the harmful use of alcohol and an unhealthy diet increase the risk of developing NCDs.

### 2.3. Global burden of NCDs

Globally, the prevalence of NCDs is increasing due to changing social and economic environments [7]. This is a global public health concern and has an impact on individuals in all countries regardless of age, gender and socio-economic status [8].

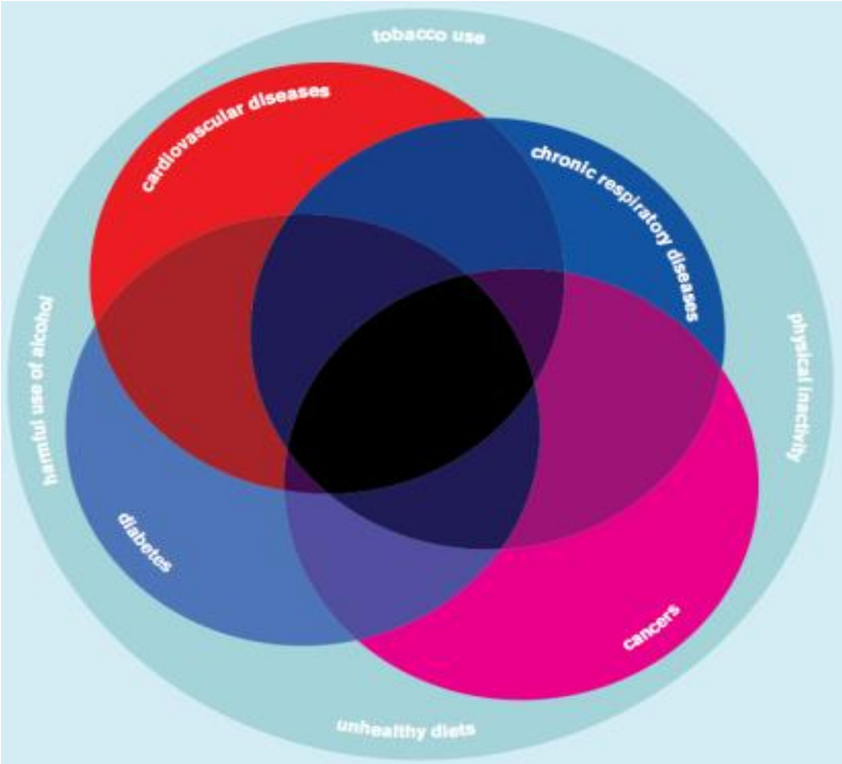
NCDs, specifically cardiovascular diseases, cancers, chronic respiratory diseases and diabetes are said to be the world's biggest killers [4]. More than 36 million people die each year from NCDs (63% of global deaths), including 14 million deaths at a younger age (30-70 years). The effect of NCDs on disability is also deteriorating. Approximately 54% of disability-adjusted life years (DALYs) worldwide were attributable to NCDs in 2010 while only 43% were attributable in 1990 [9]. Low and middle income countries endure 86% of the related burden of these premature deaths. This burden is forecast to cause cumulative economic losses of US$7 trillion over the next 15 years and a poverty confinement for millions of people [4].

### 2.4. Understanding the relationships between the main NCDs and their known risk factors

The major risk factors for NCDs have been well studied and are similar across the world [10]. Tobacco use, physical inactivity, harmful consumption of alcohol and consumption of foods that are high in saturated and trans fats, salt and sugar (especially from drinks with high volumes of added sugar), causes over two-thirds of all new incidences of NCDs and increases the risk of complications for individuals with pre-existing NCDs [11]. These risk factors in addition to obesity are responsible for a large proportion of the global disease burden, directly or via conditions such as hypertension, elevated blood glucose and high cholesterol [12]. More than 80% of heart disease, stroke and type II diabetes could be prevented and the incidence of cancer could be reduced by a third by eliminating these known risk factors [5, 11].

The relationships between the major NCDs (cardiovascular diseases, cancers, chronic respiratory diseases and diabetes) and their risk factors (tobacco use, physical inactivity, harmful use of alcohol, unhealthy diets) will be discussed in this section (Figure 2). Given the extensive literature available regarding these relationships, only findings from meta-analyses, large prospective cohort studies and the INTERHEART case control study will be mentioned [10, 13].

**Figure 2. Relationship between the major NCDs and their risk factors**




Source: WHO, 2008 [5]

2.4.1. Tobacco use

Tobacco use alone is responsible for one in six of all NCD deaths [11]. Each day more than 1 billion people smoke cigarettes or chew tobacco due to their nicotine addiction and approximately 15,000 individuals die from tobacco-related diseases [11]. Over 100 million individuals died worldwide as a result of tobacco-related diseases during the 20th century [14]. At a population level in China, one of the top five cigarette consuming countries, the proportion of deaths attributable to smoking was estimated at 3.1% for women and 12.9% for men [15]. With the elimination of smoking, at 50 years, life expectancy was estimated to increase by

2.3-2.5 years in the US population and 1.1-2.2 years in the populations of nine other high-income countries [16].

The harmful consequences of smoking on mortality from cardiovascular diseases, cancers and respiratory diseases have been understood for many years [17]. Large epidemiological studies have provided solid evidence to show the harmful health effects of smoking. The British Doctors Prospective Cohort Study developed by Doll and Hill [18] found a significant association between smoking and the incidence of lung cancer among their recruited sample of 34,439 male doctors. In addition to the existing findings, the 50 year follow-up showed that for men born between 1900-1930 who smoked cigarettes only and continued to smoke died on average about 10 years younger than life-long non-smokers [19]. The excess mortality was due to smoking related diseases that included vascular, neoplastic and respiratory diseases. Positively, smoking cessation at age 60, 50, 40 or 30 years gained, respectively, approximately 3, 6, 9 or 10 years of life expectancy [19].

### 2.4.2. Physical inactivity

The health effects of physical activity have been studied since the 1950s using epidemiological studies such as large-scale cohort studies [20, 21]. The levels of physical activity from walking, cycling and workplace tasks used to be major sources of total energy expenditure but these levels have greatly decreased in recent years among many industrial and urban populations [17].

Global data shows that there are low levels of physical activity and extended periods of sedentary behaviours in high income and urbanised countries which is in contrast to rural populations where higher activity levels have been reported due to farming activities, walking and cycling [17]. On a global level, 31% (95% CI 30·9–31·2) of adults are physically inactive, with proportions ranging from 17% (16·8–17·2) in Southeast Asia to about 43% in America and the eastern Mediterranean. Inactivity rises with age and is higher in women than in men [22].

It is estimated that if worldwide inactivity was decreased by 10% or 25%, more than 533,000 and 1.3 million deaths, respectively could be avoided each year [22]. Additionally, Lee et al*.* suggest that elimination of physical inactivity could increase the life expectancy of the world's population by 0.68 (0.41 – 0.95) years and these findings are comparable to the established risk factors of smoking and obesity [22]. Elimination of this unhealthy behaviour could improve health sustainability and reduce the prevalence of non-communicable diseases [22].

2.4.3. Harmful consumption of alcohol

Approximately, 2.7 million annual deaths and 3.9% of the global burden of disease are due to alcohol consumption [17, 23]. Alcohol consumption is associated with many diseases and injuries. The main contributors to the alcohol-attributable disease burden are cancers, chronic liver disease, unintentional injuries, alcohol-related violence, neuropsychiatric conditions, and mortality from CVD in some areas (especially eastern Europe) that have a high prevalence of binge and harmful alcohol consumption [17, 23, 24]. Relative to the other risk factors, alcohol consumption causes a greater contribution to global disease burden from injuries and nonfatal neuropsychiatric conditions rather than to mortality rates [23].

Epidemiologic studies that have measured both the amount and patterns of alcohol consumption have found that moderate alcohol consumption has also been found to be a protective factor for CVD. Marmot et al. found that a U-shaped curve explained the relationship between alcohol consumption and CVD. Following 10-years of follow-up, the findings showed that mortality rates were lower in men reporting moderate alcohol intake than in either non-drinkers or heavier drinkers (>34g alcohol per day) [25]. Other studies have also reported similar findings that moderate alcohol intake was associated with decreased CVD risk but abstention and high consumption (>2 drinks per day) was associated with increased triglycerides, hypertension, heart failure and all-cause mortality [26-28].

Results from the INTERHEART study showed that moderate alcohol consumption (<3 times per week) was associated with a decreased risk of myocardial infarction (RR (Relative Risk) 0.91, 95% CI (Confidence Interval) 0.82-1.02), with a population attributable risk of 6.7% [10]. However, binge drinking is a major risk factor for CVD [29]. Other adverse health, social and economic effects also result from harmful alcohol consumption for the individuals who drink but also for those around them [30, 31].

### 2.4.4. Unhealthy diets

The WHO's Global Strategy on Diet, Physical Activity and Health described a healthy diet as energy balanced with limited dietary intakes of total fat (particularly saturated and trans fatty acids), added sugars and salt and increased consumption of fruit, vegetables, whole grains and nuts [32]. However, in recent years, there is an increased availability of unhealthy food commodities in our existing environments including soft drinks and processed foods that are usually high in salt, sugar and fat [33, 34]. Over consumption of these foods is said to be responsible for 40% of all deaths from NCDs [35]. In particular, excess consumption of salt causes 30% of all cases of hypertension [36]. This shift in food preferences from a traditional diet (low salt, saturated fat and glycaemic indexes) to a more palatable yet heavily processed Western diet (high in saturated fat, sugar and salt and low in fruit and vegetables) is causing the increasing prevalence of obesity and the associated NCDs [37]. Furthermore, low dietary intakes of fruits, vegetables, whole grains, nuts and seeds or high intakes of salt are independently accountable for 1.5% to greater than 4% of the global disease burden [23].

### 2.5. Salt, sugar and fat dietary intakes and health

For several years, nutritional epidemiology has focused on understanding the relationships between specific foods, nutrients and dietary patterns and diet-related diseases such as diabetes, cancers and cardiovascular diseases [38, 39]. Metabolic conditions such as weight gain, increased blood pressure, insulin resistance, high cholesterol and hyperglycemia are risk factors that lead to the development of these diseases [40-43]. Besides genetic factors, many of these metabolic conditions are caused by unhealthy diets that comprise of excess calories and high dietary intakes of salt, sugar and saturated fat. Many studies have been conducted to show the harmful effects of these unhealthy diets and the health benefits of lower salt and sugar intakes, the replacement of saturated fats with unsaturated fats and healthy dietary patterns [41, 43-49]. These studies will be discussed in this section.

#### 2.5.1. Salt intake and diet-related disease

Salt is a compound of sodium chloride (NaCl) (1 gram (g) of salt = 0.4g sodium or 17.1mmol sodium) [50]. Over 90% of sodium in the diet is represented by sodium chloride (i.e. salt) [51]. Sodium is an essential nutrient that is required for maintenance of plasma volume, acid-base balance, transmission of nerve impulses and normal cell function [52-54]. In addition, to being almost half of the compound of the common table salt, sodium also occurs naturally in foods such as meat, shellfish and milk. Sodium is also added by the food industry to improve taste in condiments (soy and fish sauces), processed foods such as crackers, breads, cheese, meats (especially cured meats) and snack foods (crisps, popcorn) [55, 56]. A diet with a high consumption of processed foods and a low consumption of fruit and vegetables is generally high in sodium which puts individuals at risk of hypertension and related NCDs [57].

Epidemiological, experimental and intervention studies have established the relationship between habitual dietary salt intake and blood pressure [46, 47, 54]. A meta-analysis of 107 randomised interventions published in 2014 found that 103 trials found a linear dose-response relationship between reduced sodium intake and blood pressure which was equally modified according to age, race and the presence or absence of hypertension [58]. In this study, the mean level of sodium consumption globally was estimated to be 3.95g per day in 2010 (regional means from 2.18g to 5.51g per day) which was almost double the WHO's recommendation of 2 g/day (equivalent to 5g of salt). Specifically, of the 181 countries out of the 187 studies included, 99.2% of the world's adult population exceeded the WHO's recommendation and 88.3% of the adult population surpassed the recommendation by more than 1g per day [58, 59]. Findings also showed that globally, 1.65 million annual deaths from cardiovascular causes were associated with a sodium intake above 2g per day; 61.9% of these deaths occurred in men and 38.1% in women. These deaths were accountable for almost 1 of every 10 deaths from cardiovascular causes (9.5%). Four of every 5 deaths (84.3%) happened in low- and middle-income countries and 2 out of 5 deaths (40.4%) occurred before 70 years of age [58].

Since the relationship between salt intake and health is now well understood, public health interventions need to target salt reduction to reduce the risk of developing these associated diseases. Significant scope exists to ease the morbidity and mortality burden associated with overconsumption of salt. In 2010, it was predicted by Bibbins-Domingo et al. that a reduction in dietary salt by 3g per day (1200 mg of sodium) (on the basis of the current average consumption in the United States (men: 10.4g per day, women: 7.3g per day) would reduce the annual number of incidences of coronary heart disease by 60,000 to 120,000, cases of stroke by 32,000 to 66,000, and cases of myocardial infarction by 54,000 to 99,000 and would reduce the annual number of deaths from all causes by 44,000 to 92,000 [60].

### 2.5.2. Sugar intake and diet-related disease

Excess consumption of added sugars offers many calories, no nutritive value and an increased risk of diet-related diseases. Added sugars are generally present in processed foods (i.e. cakes and confectionary) and in sugar sweetened beverages. Consumption of sugar sweetened beverages (soft drinks (soda), fruit drinks (excluding 100% fruit juice)) and energy and vitamin water drinks has been increasing worldwide in recent years [48]. In the United States, sugar sweetened beverages are the main source of added sugars and these drinks include sucrose, high-fructose corn syrup or concentrates of fruit juice and these all have the same metabolic effects [61]. Habitual sugar sweetened beverage consumption is associated with tooth decay, an increased risk of obesity, metabolic syndrome and type 2 diabetes owing to its high sugar content, large volumes, quickly absorbable carbohydrates (i.e. sucrose) and incomplete compensation for total energy at following meals [62, 63]. The intake of these liquid calories also increases dietary glycemic load which can cause insulin resistance, cell dysfunction and inflammation [64].

A meta-analysis from 2010 that included 310,819 participants and 15,043 cases of type 2 diabetes, showed that participants in the highest quintile of sugar sweetened beverages (most often 1–2 servings/day) had a 26% greater risk of developing type 2 diabetes than those in the lowest quintile (none or <1 serving/month) ([RR] 1.26 [95% CI 1.12–1.41]) [48].

2.5.3. Fat intake and diet-related disease

Fatty acids are the chemical compounds that make up fats. All fatty acids comprise of chains of carbon, hydrogen and oxygen atoms. Differences between fatty acids lie in the variations of their molecular configuration which cause different health effects [65].

There is extensive evidence regarding the relationship between the different fatty acids and health effects. A prospective cohort study of 80,082 healthy women (no known cardiovascular disease, cancer, hypercholesterolemia, or diabetes) aged 34-59 years in the Nurses' Health Study found that the ratio of polyunsaturated to saturated fat was strongly and inversely associated with coronary heart disease (CHD) risk (multivariate RR for a comparison of the highest with the lowest deciles: 0.58; 95% CI: 0.41, 0.83; *p* for trend < 0.0001). On the contrary, higher ratios of red meat to poultry and fish consumption and of high-fat to low-fat dairy consumption were associated with significantly higher risk [66]. In addition, commercially produced *trans* fatty acids are associated with a higher risk of CHD even more so than saturated fatty acids (on a gram-for-gram basis) while diets that are high in omega-6 polyunsaturated fatty acids and low in trans fatty acids have been shown to have the lowest risk [67, 68].

A 2010 meta-analysis that incorporated 16 prospective cohort studies and participants aged 30-89 years presented pooled RR estimates (95% CIs) for extreme quintiles of saturated fat intake of 1.07 (0.96, 1.19) for CHD, 0.81 (0.62, 1.05) for stroke and 1.00 (0.89, 1.11) for total CVD [69]. Randomised controlled trials have demonstrated that CHD risk can be reduced by replacing saturated fat with polyunsaturated fat [44]. Particularly, for populations who adhere to a Western diet (high in saturated fat, sugar and salt and low in fruit and vegetables), replacing 1% of energy intake from saturated fatty acids with polyunsaturated fatty acids has been associated with a 2–3% reduction in the incidence of CHD [44, 70]. However, if saturated fat is substituted with a carbohydrate rich diet, which is usually the case in many populations, the effect on CVD risk is small [71, 72].

2.5.4. Dietary patterns and health

Although, it is necessary to understand the health effects of specific nutrients and foods, individuals do not consume isolated nutrients or foods. There is an increasing interest in dietary patterns and their effects on health outcomes. Although there are other dietary patterns, the candidate has focused on the DASH, Mediterranean and the OmniHeart dietary patterns.

**2.5.4.1. Dietary Approaches to Stop Hypertension (DASH) dietary pattern**

The DASH-Sodium randomised controlled feeding trial with 412 participants allocated participants to eat either a control diet which was typical of the intake in the United States or the DASH diet. This DASH diet was high in fruits and vegetables, moderate in low-fat foods, low in animal protein (red meat) with a substantial amount of vegetable protein (nuts and legumes) and wholegrains with small amounts of sweets and sugar-containing beverages [46, 47]. Within the allocated diets, participants were advised to consume foods with high, intermediate and low levels of sodium for 30 consecutive days each in a random order. The trial found that additional sodium restriction (<100 mmol per day) allowed for an even greater reduction in blood pressure. Specifically, as compared with the control diet with a high sodium level, the DASH diet with a low sodium level led to a mean systolic blood pressure that was 7.1 mmHg lower in participants without hypertension, and 11.5 mmHg lower in participants with hypertension [46]. The DASH diet has also been associated with reduced low-density lipoprotein cholesterol levels [73] in addition to a lower risk of coronary heart disease (CHD) and stroke among middle-aged women during a 24 year follow-up study [47]. The DASH diet is now internationally recommended [74, 75].

#### 2.5.4.2. Optimal Macronutrient Intake Trial to Prevent Heart Disease (OmniHeart) dietary pattern

The OmniHeart trial was a randomised, 3-period, crossover feeding study which tested the effect of 3 different diets where the macronutrient content of the DASH diet was modified with a diet high in carbohydrates; in protein (half from plant protein) and in unsaturated fat (mainly monounsaturated fat). The sample included 164 adults with prehypertension (systolic: 120-139 mmHg or diastolic: 80-89 mmHg) or stage 1 hypertension (systolic: 140-159 mmHg or diastolic: 90-99 mmHg). Each of the 3 feeding periods lasted 6 weeks and body weight was kept constant.

Findings showed that compared with the carbohydrate diet, the protein diet additionally decreased mean systolic blood pressure by 1.4 mmHg ($p = 0.002$) and by 3.5 mmHg ($p = 0.006$) among those with hypertension and decreased low-density lipoprotein cholesterol by 3.3 mg/dL (0.09 mmol/L; $p = 0.01$), high-density lipoprotein cholesterol by 1.3 mg/dL (0.03 mmol/L; $p = 0.02$), and triglycerides by 15.7 mg/dL (0.18 mmol/L; $p < 0.001$). Compared with the carbohydrate diet, the unsaturated fat diet decreased systolic blood pressure by 1.3 mmHg ($p = 0.005$) and by 2.9 mmHg among those with hypertension ($p = 0.02$), had no significant effect on low-density lipoprotein cholesterol, increased high-density lipoprotein cholesterol by 1.1 mg/dL (0.03 mmol/L; $p$ = 0.03), and lowered triglycerides by 9.6 mg/dL (0.11 mmol/L; $p$ = 0.02). Estimated 10-year CHD risk was lower when compared with the carbohydrate diet and similar for the protein and unsaturated fat diets. Thus, the results showed that by replacing some of the carbohydrate proportion in the DASH diet with either plant protein or unsaturated fat enabled an additional improvement in lipid profile, a further drop in blood pressure and reduced estimated CHD risk [76].

**2.5.4.3. Mediterranean diet**

The Mediterranean diet refers to the traditional diet of populations who live by the Mediterranean Sea. Although, there are varied dietary components within these populations, most individuals comply with a diet that is rich in fruits and vegetables, vegetable protein (legumes and nuts) and monounsaturated fat with a moderate to high fish consumption and a low intake of meat and meat products. Alcohol intake (red wine) is moderately consumed and generally with meals. Olive oil is also frequently used for cooking and in salads [77-80].

Since the seven countries study, many prospective cohort studies have reported on the beneficial health effects of the Mediterranean diet including the association with reduced total mortality [81-85], reduced risk of CVD [45, 80, 86], cancer [87, 88] and neurodegenerative diseases [89] in different healthy populations. Mechanisms that may describe these associations are reductions in blood pressure and insulin resistance and enhancements in lipid profiles and anti-inflammatory effects [90].

**2.6. Obesity**

Obesity is a complex, systemic problem that is embedded in the sedentary lifestyle of modern living, increased availability of unhealthy foods and psychological stimuli such as stress and epigenetic triggers [91]. The increasing prevalence of obesity is one of the main drivers for the increasing prevalence of NCDs [91].

Global burden of obesity

Over 2.1 billion people, approximately 30% of the global population are overweight or obese which is almost two and half times the 840 million who are undernourished [91, 92]. Specifically, the 2013 Global Burden of Disease Study reported that 38% of women and 37% of men had a BMI of 25 kg/m$^2$ or greater. Since 1980, this is an increase of 28% in adults and 47% in children [92]. Although some countries have noticed a deceleration of the rise of obesity prevalence since 2006, significant decreases have not been observed for three decades [92, 93]. By 2030, if the prevalence of obesity continues on its current trajectory, nearly 50% of the global adult population will be overweight or obese [94].

The burden of obesity has incurred vast individual, social and economic costs. Obesity is now accountable for 3.8% of the global burden of disease and for nearly

5% of all global deaths [23]. The global economic burden for this preventable condition is approximately 2.8% of global gross domestic product (GDP) which is roughly comparable to the global impact of armed violence, war, terrorism or smoking [91]. The impact of obesity on health-care systems is between 2%-7% of all healthcare expenditure in developed economies [95]. In Ireland, the economic costs for overweight and obesity in 2009 were approximately €1.13 billion in the Republic of Ireland and approximately €0.51 billion in Northern Ireland. Overall, these costs accounted for 2.7% and 2.8% of total health expenditure in the Republic of Ireland and Northern Ireland respectively [96].

The increasing prevalence of obesity in some countries has been led by changes in the food environment [97] including the improved food distribution systems that make food much more accessible and convenient; the increased supply of cheap, palatable, energy-dense foods and more persuasive food marketing [92, 98-100]. These obesogenic environments support weight gain and obesity. Therefore, it is necessary to create healthy food environments instead that will shift population diets towards dietary patterns that meet recommended dietary guidelines [32, 99, 101, 102].

Holistic approach to address the prevalence of obesity

Obesity is a critical public health problem that requires a sustainable intervention strategy to be implemented at a global scale [91]. The McKinsey Global Institute (MGI) recently published a discussion paper that focused on a holistic approach to address the prevalence of obesity. MGI identified a comprehensive list of 74 worldwide behavioural interventions which were in use or being piloted by employers, schools, health care providers, food retailers, manufacturers, food service providers and governments. All of the interventions were assessed based on their cost-effectiveness and potential impact [91]. The report showed that nearly all of the interventions were cost-effective for society regarding savings on health care costs. Higher productivity as a consequence of these interventions could also provide the funding needed to deliver these interventions when assessed over the full lifetime of a target population [91].

The MGI recommends that it is vital to co-ordinate an obesity program at a global scale that (1) delivers as many interventions as possible effectively across all sectors, (2) recognises how to co-operate between the sectors with aligned incentives for all and (3) does not concentrate on prioritising interventions because it can hinder progress [91].

The MGI suggests that multiple comprehensive interventions must be developed and implemented by many sectors including governments, retailers, food companies, restaurants, employers, media organisations, educators and health care providers to halt the increasing prevalence of obesity [91]. To change public health outcomes, a combination of top-down government and corporate interventions with bottom-up community led interventions should be delivered at the same time [91].

However, these interventions need to incorporate both education and environmental modification strategies to reduce the prevalence of obesity. Interventions that focus on education and personal responsibility are important but they are not enough. Additional intervention elements that concentrate on environmental modification and social norms are essential as they do not rely on conscious individual choices. These intervention elements can reset the default options (e.g. replacing French fries with baked potatoes in a work canteen) and thus ensure that the healthy choice is the easier choice for individuals. These modifications reduce the need for and reliance on individual willpower. Environmental modification strategies for example could include reducing portion sizes in packaged food products or changing the physical activity curriculum in schools to include 20 minutes of activity per day for all students [91].

The scientific evidence for obesity related interventions is limited and further research is imperative. However, this is currently a barrier to effective action. Given that we do have adequate knowledge regarding the positive effects of some of these interventions and that most of the interventions are low risk, it is necessary to implement as many of these interventions as possible following primary testing to enable positive progress at a population level [91].

## 2.7. Global political framework to tackle NCDs

Addressing the global NCD crisis has been of paramount importance to global public health leaders with the past 15 years as the overall burden of NCDs has continued to escalate [5]. It is known that disability and premature deaths from NCDs could be prevented if global public health policies were targeted towards limiting the known risk factors for NCDs (tobacco use, an unhealthy diet, physical inactivity, harmful use of alcohol, obesity) in our current environments [4]. As this thesis is focused on limiting one of those risk factors (an unhealthy diet in the workplace environment), it is important to learn from the global political framework which guides the NCD crisis.

### 2.7.1. Building on the past to inform the future

Since the endorsement of the Global Strategy for the Prevention and Control of NCDs in 2000, progress has been slow regarding reducing the risk of an unhealthy diet. Only approximately 30 countries had adopted recommendations suggested by the Global Strategy on Diet, Physical Activity and Health by 2007 [32]. Thus, the World Health Assembly asked the Director-General to translate the global strategy into tangible actions [5]. Consequently, the World Health Assembly approved resolution supporting the 2008-2013 Action Plan for the Global Strategy for the Prevention and Control of Non-communicable Disease [5]. The action plan included objectives, recommended actions to be adopted, performance indicators and aimed to effect populations at a national, regional and global level with the continued focus on low- and middle-income countries and other vulnerable populations [5].

Nevertheless in September 2011, the Moscow Declaration and the UN Political Declaration on NCDs acknowledged the immense accessible knowledge and experience regarding the preventability of NCDs and vast opportunities to control them. Thus, based on the progress from the 2008-2013 action plan and the minutes from the UN high-level meeting of the General Assembly on the Prevention and Control of NCDs, Heads of State and Government agreed to commit themselves to a further action plan. To do this, the World Health Assembly recommended the WHO’s Global Action Plan for the Prevention and Control of NCDs 2013-2020 in May 2013 [4].

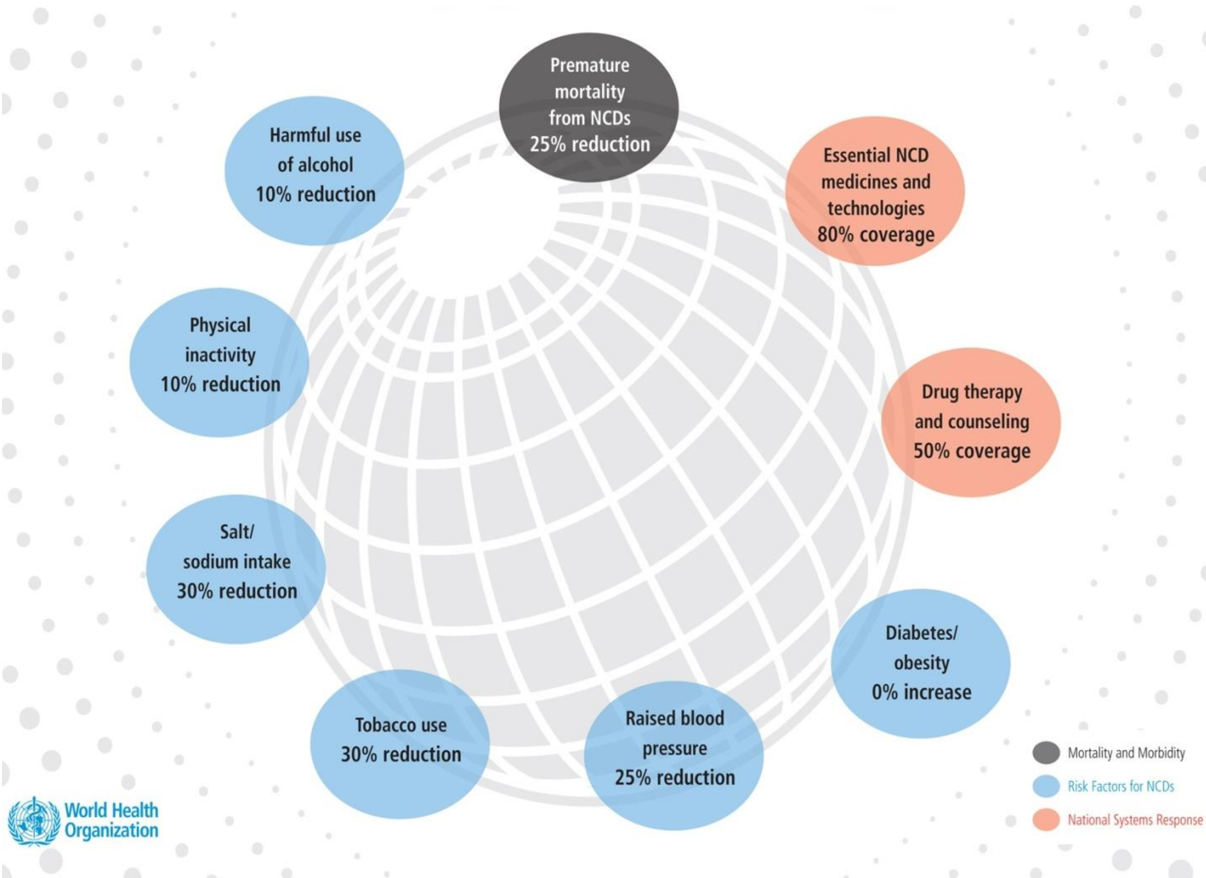
### 2.7.2. Global action plan for prevention and control of NCDs 2013-2020

The action plan's goal is "to reduce the preventable and avoidable burden of morbidity, mortality and disability due to NCDs by means of multi-sectorial collaboration and cooperation at national, regional and global levels, so that populations reach the highest attainable standards of health, quality of life and productivity at every age and those diseases are no longer a barrier to well-being or socioeconomic development" [4]. The plan is focused on developing a wider communication structure by engaging with other stakeholders like public health experts, foundations, civil society organisations, academics, partnerships and the private sector [4]. National government accountability will also be emphasised within the plan as governments will be expected to provide leadership and to promote healthy living on the basis of scientific evidence including data and resources.

The plan offers the WHO, members states and the international partners a road map and a menu of policy options which, when implemented cooperatively between the years of 2013 and 2020, will facilitate the progress on 9 voluntary global NCD targets (Figure 3) and a 25% relative reduction in premature mortality from NCDs by 2025 [4]. This thesis is concentrated on one of those policy options which states to: "Create health-and nutrition-promoting environments, including through nutrition education, in schools, child care centres and other educational institutions, workplaces, clinics and hospitals and other public and private institutions" [4].

The action plan acknowledges that the surrounding environments in which individuals live and work influences their dietary behaviours and that modifying these environments at both macro and micro levels is an important catalyst for change [4]. The work presented in this thesis is therefore centred on developing, implementing and evaluating carefully structured nutrition-promoting workplace environments that use environmental dietary modification and/or nutrition education strategies to improve employees' dietary behaviours. The information presented in this thesis will provide critical evidence for policy makers regarding the effectiveness of workplace dietary interventions on employees dietary behaviours, nutrition knowledge and health status.

**Figure 3. Set of 9 global NCD targets for 2025**




Source: WHO, 2013 [4]

### 2.8. Workplace health promotion

The workplace has been recognised as one of the priority settings for health promotion in the 21st century [103, 104]. Given that employees can spend a large proportion of their waking hours at work, the workplace influences the physical, mental, economic and social wellbeing of employees and consequently the health of their families, communities and society [4, 5, 103, 104]. The controlled workplace environment provides an ideal setting and suitable infrastructure to promote health to a generally stable population some of whom can sometimes be difficult to reach within the health services (for example adult men and lower socio economic groups) [105]. However, workplace health promotion has experienced an evolutionary progression since the 1970s. Specifically, the concept of the health-promoting workplace has only been circulated within the past 30 years [106]. The evolutionary process of workplace health promotion will be discussed from the 1970's to the present day in the following section.

#### 2.8.1. Evolutionary process of workplace health promotion: from healthy individual to health promoting workplace

##### 1970s

In the early stages of workplace health promotion in the 1970s, activities in the workplace focused on an independent illness or risk factor or on changing a single lifestyle habit or behaviour of individual workers [106]. For example, an evaluation of a work health programme published by Alderman and Schoenbaum in 1975 was designed to improve blood pressure control among employees with asymptomatic and uncomplicated hypertension. The main components of the programme were an educational campaign that included presentations by the program physician, individual screening of employees and one year individual treatment plans which were all monitored by medical professionals.

The USA study was based in Gimbels's New York City department store where 186 employees were diagnosed with hypertension and recruited to the treatment program. Of the 94 employees who participated in the programme, 97% followed the treatment therapy with no negative effects and 81% of these employees had blood pressure reductions. Although the authors claimed that this programme appeared to be effective, this narrow individual approach failed to consider the social, environmental and organisational workplace factors that may have been associated with the prevalence of hypertension among the employees [106, 107].

1980s

In the early 1980s, workplace health promotion actions concentrated on 'wellness' programmes which were very common in Western industrialised countries such as the United States [108, 109]. The wellness programmes incorporated various methods to deliver a wide range of interventions that were focused on risk factors known to be associated with employee health [106]. Interventions included health information presentations, exercise and back care programmes, health screening, nutrition and weight control, drug and alcohol abuse prevention and stress management programmes [106, 110, 111]. However, most of the wellness programmes still targeted individual behaviour change without consideration for the wider socio-economic, environmental and organisational factors that influence employees health [112]. Nevertheless, the wellness concept continues to be a key factor in workplace health programmes today particularly in many large industrial companies in affluent countries.

In the late 1980s, workplace health promotion evolved based on the Ottawa Charter (1986) as it began to comply with a more holistic 'settings' approach that incorporated both individual risk factors, the wider environmental and organisational workplace factors. The Ottawa Charter specified five priority action areas that included building healthy public policies, creating supportive environments, strengthening community action, developing personal skills and re-orienting the health services [113]. The 'settings' approach to health promotion identified the need to integrate the five key action areas in all health promotion activities and recommended that all health promotion activities should be well co-ordinated, versatile and comprehensive [113, 114].

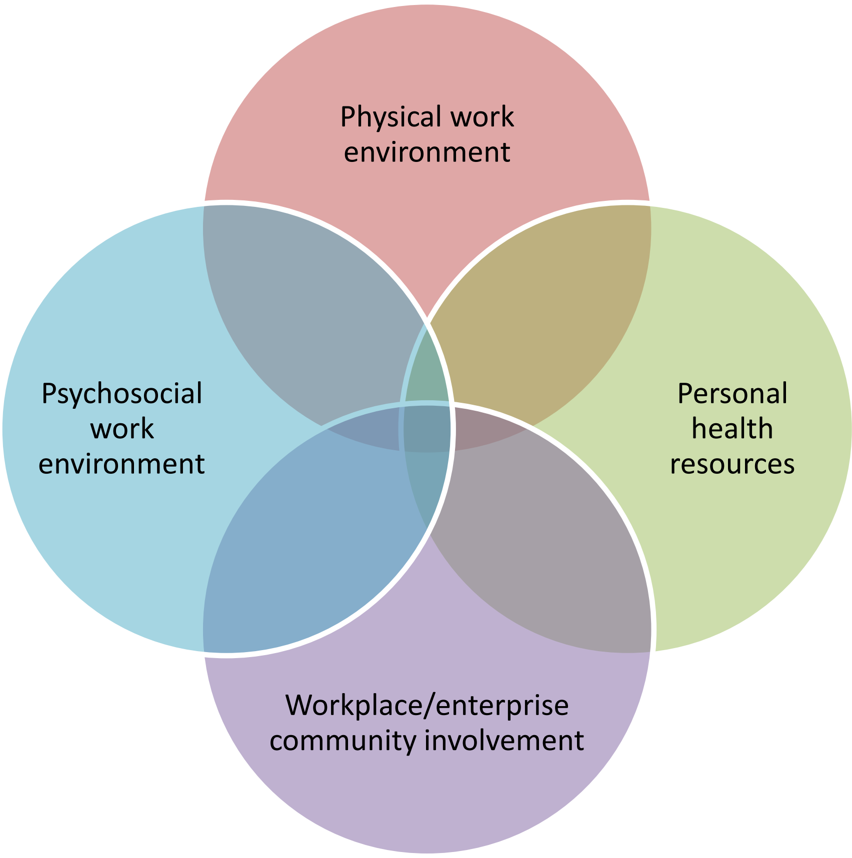
<u>1990s-2015</u>

Recognising the improved understanding of the determinants of workers' health and using the guidance from the Ottawa Charter, workplace health promotion leaders recommended that health promotion should be incorporated as an integral part of the workplace culture [106]. Rather than using the workplace as a convenient location for health professionals to deliver health promotion programmes targeted at individual employees, workplace health promotion should use a multi-level approach that combines the efforts of both employees and workplace management [106, 115].

The World Health Assembly of the WHO approved the 'Workers' health: global plan of action to provide new impetus for action by Member States in 2007 [116]. This plan was informed by the 1996 World Health Assembly global strategy for occupational health for all, the 2006 Stresa Declaration on Workers' Health, the 2006 promotional framework for occupational health and safety convention and the 2005 Bangkok charter for health promotion. The action plan defined a healthy workplace as "one in which workers and managers collaborate to use a continual improvement process to protect and promote the health, safety and well-being of all workers and the sustainability of the workplace by considering the following, based on identified needs: health and safety concerns in the physical work environment; health, safety and well-being concerns in the psychosocial work environment, including organisation of work and workplace culture; personal health resources in the workplace; and ways of participating in the community to improve the health of workers, their families and other members of the community" [116].

For all workplace health promotion activities, the action plan recommends a model which emphasises that a workplace needs to consider influential areas where effective health promotion actions by employers and employees can take place. According to systematic literature and expert opinions, the four main action areas are: the physical work environment; the psychosocial work environment; personal health resources and the enterprise involvement in the community [116]. Figure 4 shows that these areas of influence often overlap.

**Figure 4. Influential areas in workplace health promotion**




Source: WHO, 2010 [116].

**Physical work environment:** The physical work environment relates to the structure, air, equipment, furniture, products, materials and production processes within the workplace. In the context of workplace eating, it can also refer to the physical setting of the canteen and the food environment. These elements can have an impact on the workers' physical health, safety, mental health and well-being. Implementing a smoke-free workplace or building a well-equipped gym would be examples of how to influence the physical environment [116].

**Psychosocial work environment:** The psychosocial work environment includes the work characteristics associated with the organisation of work and the organisational culture, including attitudes, beliefs and daily practices in the workplace that can affect the mental and physical well-being of employees. Factors that can cause emotional stress are often called workplace 'stressors'. Examples of workplace stressors are problems with work demands, time pressure, lack of job clarity and a lack of support for healthy lifestyles. Methods to influence the psychosocial work environment would include allowing employees more time to complete work tasks, open communication regarding job descriptions and providing employees with sufficient time to eat during their breaks [116].

**Personal health resources in the workplace:** Personal health resources include the health services, information and broader supportive environment that a workplace provides to employees to support their interest in improving or maintaining a healthy lifestyle. This also incorporates the workplace's responsibility to monitor and support their physical and mental health. For example, employees' unhealthy diet may be caused from a lack of access to healthy snacks or meals at work. A method to influence personal health resources would include providing and subsidising healthy food choices in cafeterias and workplace vending machines [116].

**Workplace/enterprise community:** Workplaces also have an impact on the surrounding communities in which they are located. This involvement usually refers to the expertise and resources that a workplace may have to support the social and physical wellbeing of its surrounding community. Examples would include if a workplace provided funding for community bike paths or if a company subsidised bikes to enable employees to cycle to work [116].

2.8.2. Underlying workplace health promotion principles: keys to success

There a number of key principles that should be complied with to increase the likelihood of successful workplace health promotion initiatives/interventions [116].

1. Leadership engagement based on core values: This principle pivots on three core elements. The first element relates to the mobilisation and commitment provided by the major workplace stakeholders because all health promotion actions must be

incorporated into the workplace's business aims and values. The second element is receiving the appropriate permission, support and resources from senior managers, union leaders and informal leaders. It is essential to receive buy-in from these stakeholders before attempting to commence any health promotion activities. The third element refers to the evidence of this commitment. An all-inclusive policy that explains that the specific health promotion initiatives are part of the workplace's business strategy should be developed and signed by the appropriate higher level management. This policy should also be openly communicated to all employees.

2. Involve workers and their representatives: The employees being targeted by the health promotion initiative/intervention should be actively involved in every stage of the process from planning and development to evaluation.

3. Gap analysis: A needs assessment of the current workplace structure and environment should be completed to expose potential areas for health promotion initiatives/interventions.

4. Learn from others: It is essential to obtain the appropriate knowledge and expertise to implement and evaluate a workplace health promotion initiative/intervention if the workplace stakeholders tasked with developing the initiative do not have the expertise. Researchers from a university, national

organisations (e.g. Irish Heart Foundation), other workplaces or e-technologies may be able to provide this information.

5. Sustainability: Continuous evaluation and improvement is critical for sustainability as is integrating the healthy workplace initiatives into the workplace's business strategy. The workplace environment can tolerate the implementation of long-term health promotion initiatives/interventions [117]. These interventions can positively influence employees health and work performance and consequently have a benefit for employees, employers and society [118, 119].

6. The importance of integration: To ensure that there is efficient integration, it is important to develop a strong senior management supportive structure for future workplace health promotion initiatives/interventions. It is also useful to consider the elements of a healthy workplace when a workplace issue is being addressed. For example, if musculoskeletal disorders are common among employees who are working long hours at a manual production line, it would be useful to examine the ergonomics of those work tasks. In addition, it would also be necessary to investigate any personal health issues that may be causing these disorders e.g. lack of physical fitness or obesity. Tailored workplace health promotion initiatives can be developed according to the needs of the workplace [116].

Although, these six principles are critical for successful workplace health promotion, it is also important to understand that there are external factors that have an impact on workplaces. These include governments, national and regional laws and standards, civil society and economic market conditions [116].

### 2.8.3. Workplace health promotion within the Irish context

An overview of global workplace health promotion is beyond the scope of this thesis. However, given that workplace health promotion is context dependent, it is appropriate to review work done in this area within the Irish context. Two sustainable Irish health promotion initiatives/interventions will be discussed in this section.

#### 2.8.3.1. Smoke-free workplaces

In 2004, Ireland was the first country in Europe to successfully ban tobacco smoking in all enclosed workplaces including bars and restaurants [120]. The smoking ban was implemented using a participatory approach after a consultation process with major stakeholders. Based on strong scientific evidence of the harmful health effects from second-hand smoking, scientists, politicians, public servants, trade unions and non-governmental organisations all worked together to advocate for smoke-free workplaces [121].

As a result of the implementation, findings showed that there were improvements in the respiratory health of bar employees and healthier air quality in the Irish bars [122, 123]. This worthwhile example shows that it is possible to limit one of the risk factors (i.e. tobacco use) responsible for the prevalence of NCDs in the workplace environment. It also highlights the importance of using a participatory approach to achieve sustainable implementation of an intervention. Smoking bans have the potential to affect many individuals at minimal cost. These bans create a conducive environment that support individuals who are interested in quitting and reduces the tobacco consumption of those who continue to smoke tobacco [114].

#### 2.8.3.2. Evaluation of a workplace cardiovascular health promotion programme in Ireland

The Happy Heart at Work programme has been offered to workplaces since 1992 by the Irish Heart Foundation (IHF), a voluntary organisation established in the Republic of Ireland in the 1970s to promote cardiovascular health [124]. This programme aims to provide a practical action plan for the workplace, in order to develop positive attitudes and behaviours at both the individual and organisational level, towards modifiable risk factors for cardiovascular disease. The programme includes various active, participative, passive and organisational change strategies that are packaged within four key elements (healthy eating, going smoke-free, exercise in the workplace and stress management) and a purposively designed manual. The Happy Heart at Work programme recognises the importance of a needs assessment and a supportive environment [124].

A comprehensive process evaluation of the Happy Heart at Work programme was conducted in 2002 using Nutbeam's framework [114, 124]. The framework suggests that evaluations of health promotion programmes should use varied methods that combine the benefits of qualitative and quantitative techniques and also incorporate mid-way and long-term health outcomes such as lifestyle, and morbidity [114]. Findings showed that there was agreement in the survey data that participating workplaces promoted a smoke-free environment (mean rating on five-point scale = 4.4), employee health and well-being (4.2) and good nutritional practice (4.1). The programme was found to facilitate improvements in employees' lifestyle habits, morale and the company's public image. The major weaknesses were its moderately low profile even in actively participating workplaces and a lack of sustainability without on-going support [124]. According to the Irish Heart Foundation, this programme is still being implemented in workplaces in a similar manner but further improvements to the programme are planned (2015).

### 2.8.4. Workplace dietary interventions within the global context: lessons learned

Dietary consumption occurs within a complex ecological system of human behaviour [125]. In addition to biological, cultural and psychological factors, an individual's dietary behaviour is greatly influenced by social norms and subtle cues in their eating environments and furthermore by their attitude towards weight [126, 127]. A study found that 35% more calories are consumed by people when dining with a friend and 96% more calories are consumed if dining with a group of 7 people when compared to eating alone [126]. This evidence shows the importance of the environment regarding dietary behaviour [91]. The findings can be further illustrated with another study that focused on expatriate populations that had transferred from one environment to another. British expats who had settled in Abu Dhabi had much higher diabetes prevalence rates (18%) when compared with a baseline prevalence of 8% in the United Kingdom [128].

Given the importance of each environment, to improve dietary behaviour, workplace dietary interventions should be targeted towards employees, employers and the workplace environment as the process of eating at work is complex and determined by multiple factors and multiple levels [129]. To explain, employees may purchase their daily food choices from the workplace canteen or vending machines or they may bring their food in from home. These food choices are influenced by multiple factors including personal preferences, habits, food availability, cost, nutrition knowledge and daily working schedules (i.e. time to eat) [129]. Therefore, given the complex process of food consumption at work (multiple levels and multiple factors), workplace dietary interventions should be developed using a complex framework [125].

This section will provide a brief overview of the available evidence regarding workplace dietary interventions. Maes et al. conducted a systematic review (Jan 1990-Oct 2010) which examined the effect of European intervention studies that focused on promoting a healthy diet solely and in combination with increasing physical activity at the workplace [130]. Findings showed that 17 studies focused on the promotion of a healthy diet and of these, 8 were educational, 1 used worksite environmental change strategies and the remaining 8 studies combined education and environmental change. The quality of the interventions was assessed using the criteria of the European Network for Workplace Health Promotion (ENWHP) which considers: prior analysis of the needs of the workplace; involvement of all stakeholders; improvement of the quality of working life and conditions; behaviour change of the individual employee; engagement of the activities in the management practices and daily working life of the workplace. An additional measure was added for 'theory based intervention development' [115].

None of the included interventions were rated as 'strong', 7 were of 'moderate' quality and 10 were of 'weak' quality. There was a moderate positive effect on dietary behaviour in 13 of the studies (9 educational and 4 combined education and environmental change). However, based on a standardised tool for measuring the quality of quantitative studies, 10 of these studies were of 'weak' methodological quality and 3 were rated as being of 'moderate' quality [131]. Due to an absence of data, the review could not conclude if any of the interventions caused an effect on body composition. Overall, the evidence was inconclusive and Maes suggested that future workplace health promotion interventions would be improved if they complied with established quality criteria [130].

Mhurchu et al. conducted a systematic review (1995-2009) to assess the effects of workplace interventions on employee diets [132]. A total of 16 studies were included in the review and 8 of these studies used education strategies only while the other 8 studies used environmental modification either alone or in combination with nutrition education. Similar to the respective findings by Goetzel et al. [118] and Engbers et al. [133], the findings suggested that worksite interventions may be effective in improving dietary behaviour but the effect sizes were generally small even though reductions of up to 9% in total dietary fat and increases of up to 16% in daily fruit and vegetables were observed. However, the methodological quality of the included studies was generally weak as many study designs did not include suitably matched control groups, dietary outcomes were usually measured using self-reported measures and the studies were poorly reported.

The authors of this review recommended that such interventions should be targeted to intervene at multiple levels of the workplace environment [132]. Additionally, the authors suggested that it is necessary to improve the quality and reporting of these intervention studies to accurately determine their effectiveness. The studies should be evaluated using objective outcomes, appropriately matched control groups, long periods of follow-up to examine the effects on employee health, productivity and absenteeism and comprehensive qualitative process evaluations [132].

The findings from the above reviews showed that there is limited evidence available regarding the effectiveness of these interventions. These intervention studies need to be developed and evaluated within an established complex framework and should be reported in a standardised manner to enable researchers to collate the data and compare the effectiveness of these studies. Chapter 3 of this thesis presents a more specific systematic review that evaluates the effectiveness of workplace dietary modification interventions alone or in combination with nutrition education.

#### 2.8.5 Understanding the relationship between nutrition knowledge, diet quality and blood pressure in a working population

Many workplace dietary interventions have depended on nutrition education strategies alone to improve employees' nutrition knowledge, dietary behaviours and health status. These behavioural change strategies included group nutrition sessions, individual nutrition counselling, food labelling, supervised shopping tours and information emails. Evidence is limited regarding the effectiveness of these strategies but there is some evidence that these strategies can moderately increase fruit and vegetable consumption [130, 132, 134]. Nutrition knowledge has been identified as a partial mediator between socio-economic status (education attainment used as a proxy) and diet quality in other populations and has also been associated with a lower prevalence of obesity [135-137].

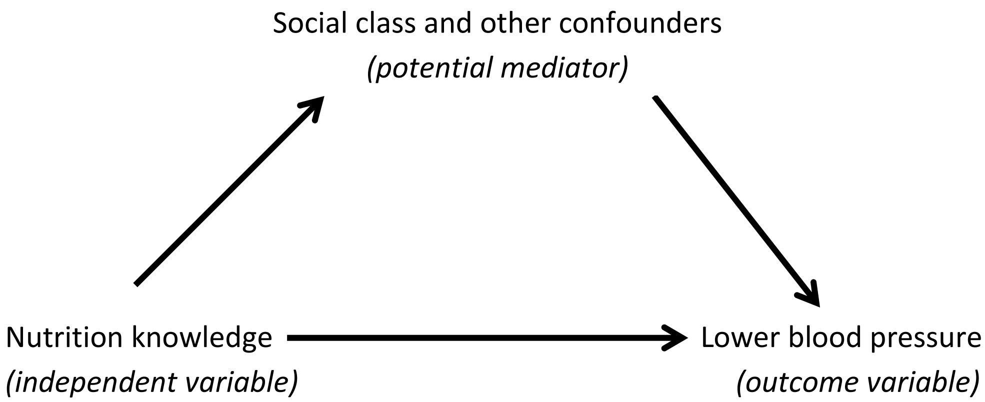
Uncertainty exists regarding the relationship between nutrition knowledge, diet quality and blood pressure. Previous research has indicated that individuals with greater nutrition knowledge may consume healthier diets [137-139]. However, this relationship between nutrition knowledge and diet quality has been contradicted by evidence suggesting that nutrition knowledge alone is not enough to influence healthy dietary behaviours [140-142]. Nutrition knowledge could be a good measure of social class and higher nutrition knowledge maybe associated with better cardiovascular risk outcomes (e.g. blood pressure) through mechanisms that do not depend on improved dietary intakes.

Given this ambiguity, the candidate examines the hypothesis that higher nutrition knowledge predicts better diet quality (DASH score) and lower blood pressure and that the relationship between nutrition knowledge and blood pressure is largely explained by diet quality (Chapter 6). This is the first time that this relationship has been investigated in an educated working manufacturing population using validated measures for nutrition knowledge and diet quality [47, 137]. Baron and Kenny's approach to mediation analyses has been used to assess if diet quality (DASH score) is a mediator. If an association between the independent and outcome variable exists, a variable is recognised as a mediator if the following conditions are met: 1) a significant association is found between the independent and the mediator variable, 2) a significant association exists between the mediator and outcome variable, and 3) when 1 and 2 are controlled, the direct association between the independent and outcome variable is reduced [136, 143].

Higher nutrition knowledge will not cause a lowering of blood pressure. However, there are two paths that may explain this relationship. These paths are explained below and examined in chapter 6:

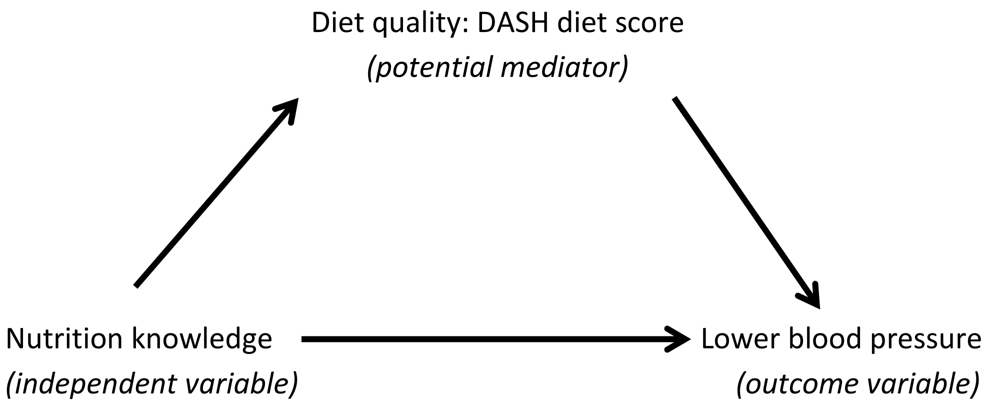
**Path 1: Confounding**

The relationship between nutrition knowledge and blood pressure may be attenuated when adjusted for social class and other confounders (not the DASH score).



**Path 2: Mediation**

The relationship between nutrition knowledge and blood pressure may be attenuated when adjusted for the DASH score (not for social class and other confounders).




2.8.6. The role of behavioural science theory in dietary interventions

Many social, cultural, environmental and economic factors can contribute to the development, maintenance and modification of health behaviour patterns [144]. For example, no independent factor or group of factors accurately clarifies the reasons why people make the food choices they do [129]. However, individual determinants of dietary behaviour such as knowledge, attitudes, awareness of health status, presence of stress and motivation are important to consider. Other factors such as families, social relationships, socioeconomic status, culture, workplace structure and geographical location also influence dietary behaviour [129].

An overall understanding of some of the key elements and models for understanding behaviours and behaviour changes can provide the basis for well-informed dietary interventions and can facilitate researchers to develop the interventions around the most prominent factors [129]. Health promotion interventions that are based on appropriate behavioural science theory have been shown to be more effective than interventions that are lacking a theoretical foundation [129]. Furthermore, intervention strategies that amalgamate multiple theories have been found to have even larger effects when compared to intervention studies that are based on one theory [145, 146].

It is important to develop a theoretical understanding of the expected process of change in workplace dietary interventions based on available evidence and theory. Although, there is no definite theory that dominates the existing research regarding workplace dietary interventions, Painter et al. found that the three most commonly used theories in health behaviour research were the health belief model, the transtheoretical model/stages of change and the social cognitive theory [129, 147]. These theories will be described in this section.

Health belief model

The health belief model (HBM) was one of the first theories of health behaviour [129]. The HBM describes that an individual's readiness to take action is influenced by their beliefs about whether they are at risk of developing a disease or health issue and their perceived benefits of taking action to avoid it [148]. The fundamental constructs of HBM include perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action and self-efficacy [149]. The HBM has been applied to early cancer detection, hypertension screening and to interventions to reduce cardiovascular disease risk factors. The health belief model would not provide a suitable theoretical framework for a workplace dietary intervention as working populations are generally healthy and therefore the perceived risk of developing a diet-related disease may be low [129, 150].

Transtheoretical model/stages of change

The transtheoretical model (TTM) explains that all individuals are at different stages of readiness to adopt health behaviours [151]. This model is a heuristic model. It explains a sequence of steps that can cause successful behaviour change: pre-contemplation (no interest in change or no need recognised for change), contemplation (considering change), preparation (planning for change), action (adopting new practices) and maintenance (sustainable practice of new healthy behaviour) [151]. The TTM theorises that individuals do not proceed through the stages of change in a linear sequence and can commonly repeat some stages (e.g. individuals may relapse to a previous stage depending on their motivation). The stages of change model has been shown to be useful in understanding mediators of workplace health promotion effectiveness [152]. Changes in the stages of change were associated with reductions in dietary fat intakes and increases in fibre, fruits and vegetable intakes [152].

Social cognitive theory

Social cognitive theory (SCT) is the cognitive formulation of social learning theory. SCT describes human behaviour as a “three-way, dynamic, reciprocal model where personal factors, environmental influences and behaviour continually interact“ [153, 154]. An underlying principle of SCT is that individuals’ learn from their own experiences but also from observations of those who surround them [154]. The main concept of SCT is that an individual can be an agent for change and react to change in their environment [129]. Therefore, environmental dietary modifications in the workplace may have the ability to promote healthy dietary behaviours among employees [129]. This core construct is also fundamental to social ecological models [129].

Social ecological model

The social ecological model (SEM) highlight multiple levels of influence that can include individual, organisational (i.e. workplace), community and public policy levels. This model also explains that behaviours are formed by the surrounding social environment [117]. The principles of the SEM are comparative with the SCT concepts which propose that developing conducive environments to support change are important to enable the adoption of healthy behaviours [129, 154]. Owing to the increasing prevalence of obesity in many countries, researchers are examining the effects of environmental modification in communities by reducing high calorie foods and by decreasing the price of healthy food products in workplace environments [155, 156] (see section 2.10 of the background for additional detail on the social ecological model).

### 2.9. Complex intervention framework

Before workplace dietary interventions can be implemented with confidence on a global level, more high quality research is required [157]. Workplace dietary intervention studies need to test practical environmental and nutrition education strategies using a complex intervention framework which incorporates all organisation levels including employees, workplace stakeholders (decision makers) and the workplace environment [4, 5, 158]. These interventions should also be guided by population based public policy [127]. Recommended intervention frameworks that acknowledge the complexity of these interventions and the need to intervene at multiple levels are required to increase the effect on employees dietary behaviours and health [159]. The standardised MRC framework is a valuable example and it can be used to guide development, implementation, evaluation and reporting of these interventions [160].

For the following reasons, it is clear that workplace dietary interventions need to be developed within a complex intervention framework to influence positive dietary change because there [160]:

-Are a number of interacting components within these interventions (i.e. several behavioural strategies).

-Are a few organisational levels that will be targeted by these interventions (employees, workplace stakeholders (caterers, occupational health and human resources managers)).

-Are various outcomes to accurately measure the effect (e.g. employees' dietary data, nutrition knowledge and health status, employees' absenteeism data and food sales data).

-Is a level of tailoring of these interventions necessary when applying the intervention to different workplace environments (context dependent).

## 2.10. Applying the MRC framework to complex workplace dietary interventions: how these interventions might work?

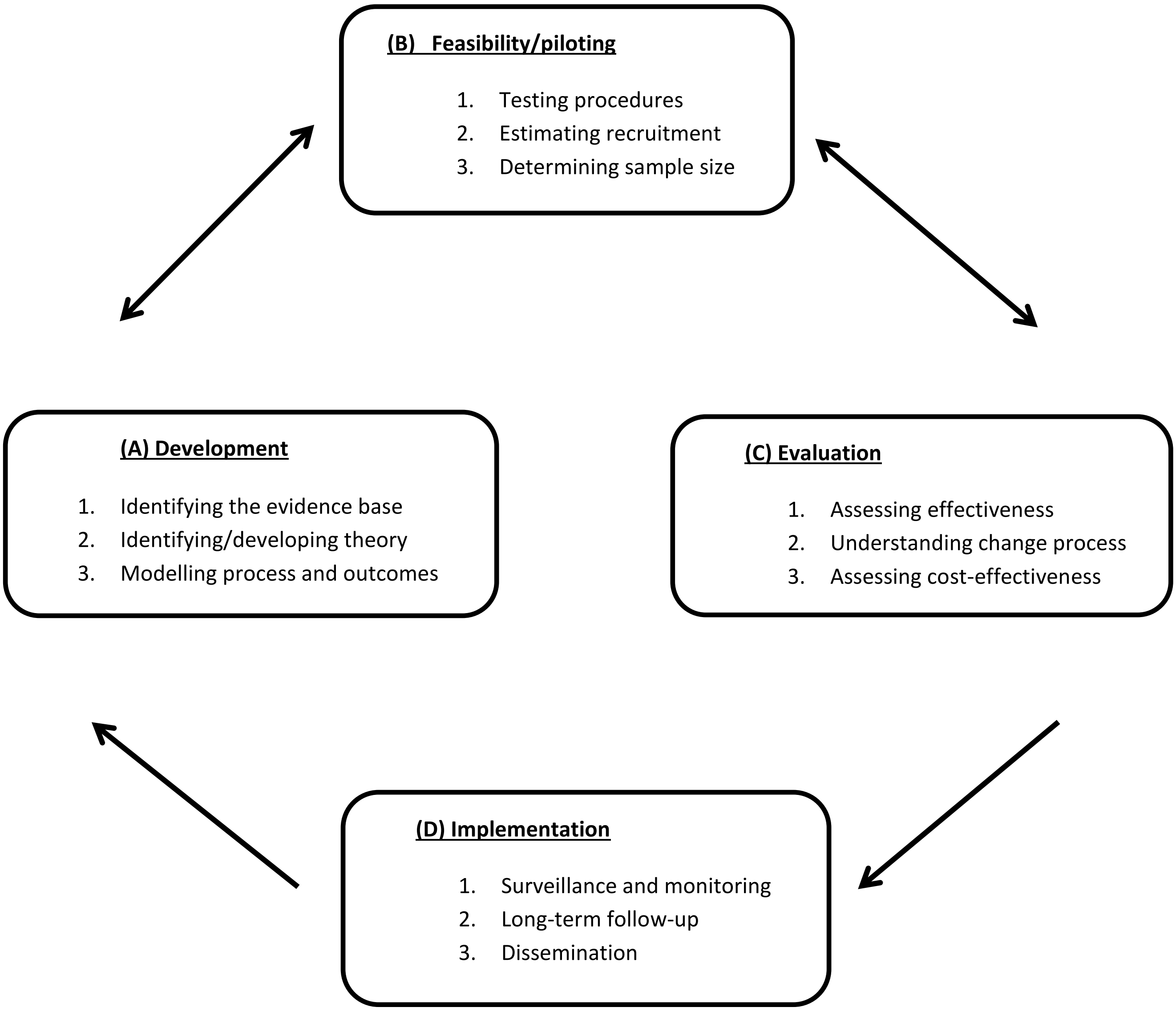
Workplace dietary interventions should be developed, implemented and evaluated within a complex framework according to the MRC framework for developing and evaluating complex interventions [160]. In this section, the components of this framework will be explained in detail. The candidate will also show how the MRC framework can be used to guide the development of complex workplace dietary interventions. The MRC framework was initially published in 2000 and was later updated in 2008 to assist researchers and funders to adopt and recognise appropriate methods for the development of these interventions [160].

### 2.10.1. The phases of the MRC framework

The MRC guidelines explain that complex interventions should be developed systematically with the highest quality of available evidence and appropriate theory. Following development, these interventions should be tested using a phased approach commencing with a detailed pilot phase that is focused on all of the main study design concerns. A comprehensive evaluation should be conducted next to measure the effects of these interventions along with careful monitoring of the process of implementation. All findings should also be widely disseminated [160].

The MRC's framework comprises of four main phases that include: development, feasibility/piloting, evaluation and implementation. These phases do not necessarily have to follow a linear or cyclical sequence and the arrows in figure 5 show the main interactions between the phases [161]. Reporting is not included in the framework as the MRC guidelines note that it should be a key component of each phase in the process. Evaluations of complex interventions should be reported in a standardised manner with the use of appropriate established guidelines [160] (CONSORT for RCTs [162] and TREND statement for non-randomised designs [163]).

**Figure 5. MRC framework: key elements of the development and evaluation process**



2.10.2. (A) Development phase

A complex intervention should be developed to a level where it is expected to have a worthwhile effect. The following three stages should be adhered to:

1. **Identifying the evidence base:** If a recent high quality systematic review is not available regarding the intervention of interest, a systematic review should be conducted by the researchers developing the intervention. However, it can be challenging to review and combine data from other complex interventions owing to heterogeneity between the studies with varied modes of intervention delivery, study designs and outcomes [164] (see chapter 3 for additional detail).

2. **Identifying/developing appropriate theory:** There are two similar theoretical perspectives that can explain the likely process of change of complex workplace environmental dietary interventions and these are the social ecology theory and the nudge theory (choice architecture) [160].

*a. Social ecology theory:* The social ecology theory offers a theoretical underpinning that explains how environmental workplace interventions can positively influence employees dietary behaviours [165, 166]. Social ecology theory suggests that individuals and their environment connect on multiple levels that include personal, organisational and community systems (micro, meso and macro societal levels)

[167]. These levels can influence food choice. The theory identifies that although individuals are capable of influencing their environment, the environment can similarly limit or support individual's choice and behaviour [168]. While it is assumed that individual behaviour is mainly affected by the immediate environment (i.e. home or workplace), community and/or cultural influences from the extended environment can also limit or enable behaviour [117]. The theory also recognises that the effectiveness of workplace (organisational) interventions can also depend on local community initiatives or national policies that support healthy eating external to the workplace [117].

Social ecology theory has been positively applied to workplace-based smoking cessation programmes that included blue collar workers, a group that have been shown to be particularly reluctant to participate in workplace health promotion initiatives/interventions [169, 170]. This theory acknowledges that employees' dietary behaviours are influenced by the organisational structure of the workplace environment. For example, if portion control was implemented by catering employees in a workplace, employees would consume less calories. Also, if traffic-light menu labelling was displayed daily at the entrance of a workplace canteen, employees would have the opportunity to choose a lower calorie or healthier food choice at work [117]. *b. Nudge theory (choice architecture):* As the social ecology theory also acknowledges, social and physical environments have an impact on individuals health related behaviours (e.g. diet, physical activity, smoking, alcohol consumption) and consequently modifications within these environments can lead to change [3]. Choice architecture (also referred to as 'nudging') is a technique where an environment is purposively modified to change individuals' health behaviours in foreseeable ways. This valued method has been of interest among psychological and behavioural scientists for many years [171]. However, since Thaler's publication of 'Nudge: improving decisions about health, wealth and happiness' in 2008, the technique has been recognised among policy makers as a potential method to influence health behaviours [172, 173].

Choice architecture has been primarily applied to health related interventions within micro-environments (i.e. buildings such as restaurants and workplaces) to improve health behaviours [171, 172, 174, 175]. Within these suitable environments, individuals are located for a particular reason (e.g. work) and are likely to practice health behaviours such as daily food choice [159]. Examples of choice architecture environmental dietary modifications within a workplace canteen such as changing plate size or ingredient changes in meals (reduction of fat, salt and sugar) may reduce portion sizes and/or increase the consumption of healthy foods by employees [176]. These modifications require minimal conscious engagement by employees and are usually conducted via automatic or unconscious psychological processes. Thus, these modifications are less dependent on employees self-regulatory skills [171, 177, 178]. Interventions of this kind can simultaneously influence the dietary behaviours of many people and are not focused on individuals [2].

**3. Modelling process and outcomes:** It is important to model a complex intervention before a full scale evaluation is conducted as it provides evidence of the need for the evaluation. Regarding the development and testing of complex workplace dietary interventions, formal guidelines such as the National Institute for Health and Clinical Excellence (NICE) guidance on the development and evaluation of behaviour change interventions should be utilised [12].

### 2.10.3. (B) Feasibility/piloting phase

Evaluations of complex interventions are generally of low-quality given the difficulties with acceptability, compliance, mode of delivery, intervention compliance, determination of sample size, recruitment, attrition and small effect sizes [160, 179]. A feasibility study is imperative in order to anticipate and understand the above uncertainties, the context of the environment where the intervention will be implemented and the data collection process (e.g. length of appointments).

### 2.10.4. (C) Evaluation phase

The evaluation of complex health promotion interventions is a contentious issue in the existing literature [125]. The RCT is the classical study design used to test effectiveness in health promotion and public health. However, many health behaviours interventions consist of multiple components and the effects of these interventions cannot be adequately tested using an RCT [125, 180]. There is an increasing need to develop specific workplace health promotion interventions within a complex intervention framework and to develop appropriate and sensible methods of evaluation that accomplish the rigour of the RCT design but can be applied within the context of everyday settings [130, 160, 181]. Appropriate study designs should be chosen to evaluate complex interventions depending on the research questions asked and the type of intervention being tested.

**1. Assessing effectiveness:** An experimental study design (e.g. randomised controlled trial (RCT), cluster randomised trials) that includes randomisation should initially be considered as it is the most robust method to avoid selection bias of participants. However, randomisation may not be feasible if the intervention applies to the entire population, if it cannot be reversed or if implementation is already underway. In addition, it is challenging to combine academic rigour with the practicalities of delivering a multi-level workplace dietary intervention that must take into account the high intensity of the intervention, the workplace structures and the needs of the workplace stakeholders and employees. Nonetheless, it is important that rigorous, independent, comprehensive and long-term evaluations are undertaken to achieve definitive conclusions about the effects on employees (dietary behaviours and health) and employers [130, 157]. However, as non-randomised designs introduce biases to a study, researchers need to consider these biases in the study design and adjust for them using appropriate statistical analysis i.e. regression modelling [160].

**2. Understanding change process:** A process evaluation should also be conducted when testing a complex intervention along with an outcome evaluation as it can provide researchers with knowledge regarding the elements that led to the success or failure of the intervention. Process evaluations can also assess the quality of implementation, compliance to and fidelity of the interventions, identify causal mechanisms and highlight contextual factors that may be associated with a difference in the outcomes [182, 183].

**3. Assessing cost-effectiveness:** An economic evaluation should also be completed when testing a complex intervention. If the intervention is a success, it is more likely to be adopted by decision makers and policy makers if economic considerations were included in the development of the intervention [184].

#### 2.10.5. (D) Implementation phase

Academic dissemination of findings is essential in peer-reviewed academic journals. However, to have a complex intervention implemented into routine practice, it is necessary to translate study findings using ways that are accessible to decision makers and policy makers. If an intervention is adopted into a wider population, effect sizes are likely to decrease but it is still necessary to observe and monitor the intervention closely. Long-term follow-up of complex interventions is uncommon but necessary and would be helpful to future researchers and policy makers [160, 185].

### 2.11. Background summary

NCDs cause unnecessary morbidity and mortality. The most common NCDs are cardiovascular diseases, cancers, chronic respiratory diseases and diabetes. As a result of changing environments, the prevalence of NCDs and the burden associated with these diseases is increasing. In particular, obesity is one of the main drivers for the increasing prevalence of NCDs. This is a major global public health concern as it poses a threat to human sustainability. NCDs have a negative impact on all individuals despite age, gender and socio-economic status.

Aside from tobacco use, physical activity and alcohol consumption, the promotion of a healthy diet is key to the prevention of NCDs. The promotion of diets that are low in fat, saturated fat, sugar and salt were among the priority cost-effective interventions highlighted at the UN High Level Meeting on NCDs in September 2011. The surrounding environments in which people live and work influences their dietary behaviours. Modifying these environments in addition to nutrition education are potential mechanisms for diet improvements.

The workplace has been recognised by the WHO as a priority environment to influence dietary behaviours given that individuals can spend a large proportion of their waking hours in their workplaces. Evidence is limited regarding the effectiveness of workplace dietary interventions as previous interventions were of low-intensity with sub-optimal study designs. As dietary behaviour occurs within a complex ecological system, there is a need to develop workplace dietary interventions within a complex intervention framework and to develop appropriate and practical methods of evaluation to understand the effect of these interventions.

In this thesis, the candidate will assess the existing evidence regarding these interventions and will measure the comparative effectiveness of a workplace environmental dietary modification intervention and an educational intervention both alone and in combination against a control workplace. The interventions will be developed, implemented and evaluated using the MRC's recommended framework for ‘developing and evaluating complex interventions’. The interventions will comply with a soft paternalistic “nudge” theoretical perspective and a social ecological perspective. The information presented in this thesis will provide scientists and policy makers with critical evidence on the effectiveness of complex workplace dietary interventions on employees dietary behaviours, nutrition knowledge and health status. An intervention related sub-study will also be discussed to show the relationship between nutrition knowledge, diet quality and hypertension.

## 3. THE EFFECTIVENESS OF WORKPLACE DIETARY MODIFICATION INTERVENTIONS: A SYSTEMATIC REVIEW

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THIS PAPER WAS PUBLISHED IN PREVENTIVE MEDICINE IN 2013 (SEE APPENDIX 4)

**3.1. Abstract**

**Objective**

To evaluate the effectiveness of workplace dietary modification interventions alone or in combination with nutrition education on employees dietary behaviour, health status, self-efficacy, perceived health, determinants of food choice, nutrition knowledge, co-worker support, job satisfaction, economic cost and food-purchasing patterns.

**Methods**

Data sources included Pubmed, Medline, Embase, Psych Info., Web of Knowledge and Cochrane Library (November 2011). This review was guided by the PRISMA statement. Studies were randomised controlled trials and controlled studies. Interventions were implemented for at least three months. Cochrane Collaboration's risk of bias tool measured potential biases. Heterogeneity precluded meta-analysis. Results were presented in a narrative summary.

**Results**

Six studies conducted in Brazil, USA, Netherlands and Belgium met the inclusion criteria. Four studies reported small increases in fruit and vegetable consumption (≤ half serving/day). These studies involved workplace dietary modifications and three incorporated nutrition education. Other outcomes reported included health status, co-worker support, job satisfaction, perceived health, self-efficacy and food-

purchasing patterns. All studies had methodological limitations that weakened confidence in the results.

**Conclusion**

Limited evidence suggests that workplace dietary modification interventions alone and in combination with nutrition education increase fruit and vegetable intakes. These interventions should be developed with recommended guidelines, workplace characteristics, long-term follow-up and objective outcomes for diet, health and cost

### 3.2. Introduction

The increasing prevalence of diet-related diseases including obesity and cardiovascular disease is largely driven by the interlinked problems of poor diet, calorie excess and physical inactivity. This global epidemic continues to endanger population health and the sustainability of healthcare systems worldwide [186]. Obesity in adults accounts for up to 6% of direct health costs in the EU and more than 12% in indirect costs including shortened lives, reduced productivity and lowered incomes [187]. CVD accounts for nearly half of all deaths in Europe and 35% of all premature deaths (before the age of 65). CVD costs the EU economy €192 billion representing a per capita annual cost of €391 [188].

There is a need to develop and evaluate dietary interventions in suitable environments to investigate if these interventions can improve dietary behaviours and reduce diet-related disease risk [12, 189]. The workplace is regarded as an ideal environment to promote healthy dietary behaviours because some individuals can spend up to two-thirds of their waking hours at work [5, 106, 186, 190]. Uncertainty remains regarding the effectiveness and cost-effectiveness of workplace dietary interventions.

Employees depend on their workplace to provide many of their daily meals [191, 192]. Individual, environmental and societal factors can affect food choices [186]. Dietary interventions focused on improving employees dietary patterns need to surpass individual nutrition education and intervene at multiple levels of the workplace environment including food choice modifications and nutrition education [157]. Effective workplace health promotion is complex and multi-dimensional. Each workplace is uniquely defined by its employee organisation and structure; history and culture; and social, economic and political circumstances [193]. The effectiveness of complex dietary interventions may be enhanced if they incorporate environmental modifications, are designed using established guidelines, take into account the needs and characteristics of the workplace and its employees and have the support of all relevant stakeholders [193].

Previous reviews have reported that workplace environmental and education interventions including diet, physical activity and other lifestyle factors modestly improve dietary quality [130, 157]. This review differs from previous reviews because it focuses on dietary modification interventions only or in conjunction with nutrition education where the food choice offered has changed in the work environment during the intervention. There is some evidence to suggest that such interventions influence and may improve dietary behaviour [133, 157, 194]. The objective of this review is to evaluate the effectiveness of workplace dietary modification interventions alone or in combination with nutrition education on employees dietary behaviour, clinical health status, self-efficacy, perceived health, determinants of food choice, nutrition knowledge, co-worker support, job satisfaction, economic cost and food-purchasing patterns.

## 3.3. Methods

### 3.3.1. Data sources and searches

This systematic review was guided by the PRISMA statement [195]. Following an initial scoping search (4th November 2011, Appendix 1), a full search strategy was developed for PubMed which included a Cochrane highly sensitive search filter for controlled trials [196]. This search strategy was modified for all databases including Medline (1951-November 2011), Embase (1974-November 2011), Psych Info. (1967-November 2011), Web of Knowledge (1900-November 2011) and the Cochrane Library (1972-November 2011), all of which were searched for English language publications (16th-17th November 2011, Appendix 1). Reference lists of all included studies were hand searched. An advanced search was conducted in Google Scholar and the WHO website.

### 3.3.2. Study outcomes

Studies were included in the review if they reported the effects of workplace dietary modification interventions on any of the primary and secondary outcomes that were specified in the protocol for the review. The primary outcome of interest was a change in dietary behaviour. It was assessed using 24-hr dietary recall measures, food diaries, weighed food records, FFQs or other dietary assessment methods.

Secondary outcomes considered in this review included:

1. Clinical health status outcomes such as BMI, waist and hip ratio measures, serum cholesterol levels (individual/employee level outcomes).
2. Self-efficacy (individual/employee level outcome).
3. Perceived health (individual/employee level outcome).
4. Nutrition knowledge (individual/employee level outcome).
5. Determinants of food choice outcomes including attitudes to food and food habits (individual/employee level outcomes).
6. Co-worker support (individual/employee level outcome).
7. Job satisfaction (individual/employee level outcome).
8. Economic cost outcomes including absenteeism, productivity, healthcare costs and profit margins (wider employer/worksite level outcomes).
9. Food purchasing patterns (wider employer/worksite level outcomes).

These outcome measures were selected to show the impact of these interventions on the employees and the workplace. The primary outcome was a change in dietary behaviour as these interventions were focused on dietary modification. The secondary outcomes measured the effectiveness of these interventions at the individual/employee level and the employer/worksite level. The mediating mechanisms affecting the impact of the intervention were also of interest (i.e. co-worker support and job satisfaction).

### 3.3.3. Study selection

All published articles from each database were imported into Endnote X3 2009 and any duplicates were removed. The titles and abstracts of the remaining studies were reviewed. Any full text articles retrieved were independently screened for eligibility by three review authors who were not blinded to authors' names, journal title or publication date. Any disagreements regarding study inclusion were resolved by discussion and consensus (Table 1).

Stronger study designs including randomisation, controlled studies and comparable control groups were selected for this review to ensure in so far as is possible that the reported effects were attributed to the interventions. Randomised controlled trials (RCTs) with full and quasi-randomisation, by individual and workplace clusters were included. Controlled trials that did not use appropriate randomisation strategies and controlled before and after studies were also included. A controlled before and after study was defined as a non-randomised study design where a control population of similar characteristics and performance as the intervention group was identified and where data were collected before and after the intervention in both the control and intervention groups [197]. Participants were adults (>18 years) in paid employment in public, voluntary or private organisations. Studies including selected groups of employees with pre-existing medical conditions or co-morbidities (e.g. diabetes, high cholesterol, high blood pressure, obesity) were excluded.

Interventions implemented for at least 3 months were included to measure sustainable changes in dietary behaviour and to compare with the selection criteria of previous systematic reviews [198, 199]. Interventions were included if they involved any one or more of the following dietary modifications in the workplace or workplace canteens or other 'on-site' workplace food service establishments (e.g. on-site newsagents or vending machines):

1. Changes in dietary content of available foods/meals as a result of modified food preparation practices (e.g. reduction in salt, sugar or fat content, increase in fruit, vegetables or fibre content).
2. Changes in portion size.
3. Changes in the food choices available to employees by increasing the availability of healthy options (e.g. addition of healthy foods to canteen menus, special cost offers with healthy food choices) or reducing the availability of unhealthy options or simultaneously increasing the availability of healthy options and decreasing the availability of 'unhealthy' options.

Studies where the workplace food modification intervention was delivered in conjunction with an education intervention were included. Studies where the workplace food modification intervention was delivered in conjunction with a co-intervention (besides an education intervention) were only included if the workplace food modification intervention (and/or education intervention) could be directly compared to the control group (if the co-intervention was not delivered to participants in the control group).

Studies were excluded if the workplace intervention:

1. was delivered to "employees" and "non-employees" of the same workplace (e.g. an intervention in a University that affected both University staff and University students) and where data obtained from employees and non-employees were combined thereby precluding evaluation of the intervention effect on employees.
2. included selected groups of employees with pre-existing medical conditions or co- morbidities (e.g. diabetes).
3. focused on the individual only rather than the organisation/environment (e.g. if a study implemented individual diet programmes only rather than changes to the workplace).
4. did not modify food choice for employees.
5. only involved the delivery of nutritional advice/education to employees.
6. was a computer only tailored dietary intervention.
7. did not include a control group in the study design.

Data extraction and risk of bias assessment

A standardised data extraction form was created, piloted and then used to abstract the available data for the outcomes. Data on participants, intervention design, setting and duration, outcome and outcome measures were extracted independently from all studies by three reviewers. Potential biases in included studies were assessed independently by three review authors using the Cochrane Collaboration's risk of bias tool [197]. The 'risk of bias' tool included six domains: sequence generation, allocation concealment, blinding (of participants, personnel and outcome assessors), incomplete outcome data, selective outcome reporting and other sources of bias. Study authors for all included studies were contacted to clarify the allocation concealment method and the blinding method for participants and personnel. All authors reached a consensus regarding potential bias in all included studies.

#### 3.3.4. Data synthesis and analysis

Heterogeneity is investigated by examining the methodological and clinical characteristics of the included studies. The heterogeneity of all included studies precluded meta-analysis and therefore we presented a narrative summary of the results in each study.

### 3.4. Results

Searches generated 785 relevant references (Figure 6). After screening titles and abstracts, 762 non-relevant articles were excluded. Of the remaining 23 articles, six studies (reported in 12 articles) met the selection criteria (Table 2). The reasons for excluding the remaining 11 articles are provided in Table 1. The included studies were conducted in private and public workplace settings including companies focused on manufacturing, food processing, finance/legal, education, government, research, health and community health care. The studies were conducted in USA (three studies) [200-202], Brazil (one study) [203], Netherlands (one study) [204] and Belgium (one study) [205]. Study sizes ranged from 391 to 2,800 employees and from four to 29 workplaces. Five studies recruited both male and female employees and one study enrolled males only. The duration of follow-up was three months in two studies [200, 205], six months in two studies [203, 204], 19.5 months in one study [202] and 24 months in one study [201].

A variety of workplace dietary modification interventions were introduced in the six studies. These modifications included workplace cafeteria changes with menu modification [201, 203, 205], alterations in food presentation [203] and increased availability and accessibility of fruit and vegetables [200, 202, 204] (Table 2). Two studies increased fruit and vegetable options in the staff vending machines [200, 202] and two studies used point-of-choice labelling for fruit and vegetables [202, 203]. One study also increased the availability of low-fat products, fruit and vegetables [204] while another study offered taste tests [201]. Five studies also introduced nutrition education programmes that focused on group education only or group and individual education [201-205]. Group education methods included menu planning, educational materials (napkins, posters and videos), group information sessions (presentations) and multimedia (newsletters). Individual education methods included individual nutrition counselling and personal advice.

The theoretical model underpinning the intervention was described in two studies. One study followed the stages of change model [201] while the other study based their intervention on an ecological model [203]. None of the workplace dietary modification interventions were designed in accordance with established guidelines for developing, evaluating and implementing complex interventions. Employee advisory boards (EABs) assisted in the development and implementation of the interventions in two studies and monitored project activities [201, 202].

All included studies reported on changes in dietary behaviour which was the primary outcome of interest. Dietary intake was measured using self-reported methods. Four studies used FFQs [200-202, 204] while one study analysed one day food records [205] and another study included a survey to calculate portions of fruit and vegetables consumed at work [203].

Five studies focused on fruit and vegetable consumption and the intakes were reported separately in one study [204] and combined in the other studies [200-203] (Table 2). Fruit and vegetable intake was measured in servings per day in four studies [200, 202, 204, 206] and grams per day in one study [203]. In four studies, implementation of the workplace intervention was associated with small but statistically significant increases in fruit and vegetable consumption (Table 3).

Three of these studies were dietary modification and nutrition education interventions [201-203] and one study was a dietary modification intervention only [200]. No study reported an effect size greater than one half serving increase in intake per day. In one study, no significant differences in fruit and vegetable consumption were reported between the environmental interventions and the education interventions or between the environmental interventions and the control groups ($p \geq 0.16$) [204] .

Changes in fat intake were reported in three studies. In one study, following adjustment for baseline differences, there was a statistically significant difference between the intervention and control groups for percentage of energy obtained from total fat (-1.56% [95% CI -2.98, -0.13], $p<0.05$) and polyunsaturated fat (-0.81% [95% CI -1.49, -0.13], $p<0.05$) [205]. In another study, the difference in total fat intake between the intervention and control group was non-significant, (-4.27% [95% CI -10.20, 1.66], $p>0.05$) [203]. In the remaining study, there was no statistically significant difference in mean fat intake between the study groups ($p \geq 0.16$) [204]. A number of studies also showed other positive dietary changes. In one study, following adjustment for baseline differences, the difference between the intervention and control groups showed a statistically significant reduction in energy intake (-142 kcal/day [95% CI -276, -8.83], $p<0.05$), an increase in protein intake (0.79% [95% CI 0.161, 1.43], $p<0.05$) and carbohydrates intake (0.81% [95% CI 0.51, 2.18], $p<0.05$) [205].

Changes in clinical health status outcomes were reported in one study. Following adjustment for baseline differences, the difference between the intervention and control groups reported a statistically significant increase in BMI in the intervention group (0.258 $kg/m^2$ [95% CI 0.128, 0.389], $p<0.001$) and a statistically significant reduction in mean serum high density lipoprotein (HDL) cholesterol in the intervention group (-0.06 mmol/l [95% CI -3.63, -1.21], $p<0.001$). The differences between the intervention and control groups were non-significant for mean serum total cholesterol levels (0.07 mmol/l [95% CI -1.13, 6.73], $p>0.05$) and waist and hip ratio measures (0.004 [95% CI -0.0016, 0.011], $p>0.05$) [205].

Self-efficacy was reported in one study [200]. There was a statistically significant increase in self-efficacy towards eating 2 daily servings of fruit in the intervention groups (slope coeff. 0.18, SE 0.09 ($p< 0.03$)) compared with the control groups but there was a non-significant difference in self-efficacy towards eating 3 daily servings of fruit (slope coeff. 0.11, SE 0.08 ($p>0.05$)), job satisfaction (slope coeff. 0.05, SE 0.06 ($p>0.05$)) and perceived health (slope coeff. 0.04, SE 0.05 ($p>0.05$)) [200]. Changes in nutrition knowledge were recorded in one study and the mean score (score/10) was significantly greater in the intervention group when compared with the control group and adjusted for baseline differences (1.34/10 [95% CI 1.09, 1.59], $p<0.001$) [205]. Co-worker support was assessed in one study. It was measured according to six items, each measured on a 4-point scale (never, seldom, sometimes and often). The self-reported measure was completed by the participants (employees). During analysis, the six items were combined so that a low score revealed low perceived co-worker support and a high score revealed high perceived support. There was a statistically significant intervention effect on reported co-worker support ($p<0.009$) between the worksite intervention group, worksite and family intervention group and the control group when adjusted mean values at baseline and final assessments were controlled for worksite [202].

Two studies evaluated the effect of the workplace interventions on food purchasing patterns. In one study [200], there was a statistically significant increase in self-purchasing of fruit (slope coeff. 0.16, SE 0.05, $p<0.01$) and family purchasing of vegetables (slope coeff. 0.14, SE 0.05, $p<0.01$) in the intervention groups compared to the control groups. However, there was a non-significant difference reported for self-purchasing of vegetables (slope coeff. 0.08, SE 0.05, $p>0.05$) and family purchasing of fruit (slope coeff. 0.08, SE 0.05, $p>0.05$). In another study, the sales proportions of low-fat products were measured and there were no findings reported comparing the food supply program plus educational program (dietary modification intervention), educational program and the control groups [204].

3.4.1. Assessment of quality of evidence

The assessment of the quality of included studies was impeded by incomplete reporting and consequently an 'unclear risk of bias' judgement was frequently reached for domains in the 'risk of bias' tool (Figure 7). The risk of selection bias was judged to be acceptable in two studies for random sequence generation as one study used statistical software and the other study used a method of closed tickets. The remaining studies did not provide sufficient information on random sequence generation. For allocation concealment, the risk of selection bias was judged to be adequate in one study as closed tickets were used to randomly assign the condition to the groups. The method of allocation concealment was not described or was described in insufficient detail in the other studies.

The risk of performance bias was judged to be high in one study as the participants were aware of the intervention and unclear in the remaining studies as there was inadequate information provided to determine whether the study participants and personnel were blinded to group allocation. The risk of detection bias was unclear in all included studies as there was insufficient information to decide if the outcome measures were determined without knowledge of group assignment. Attrition bias was judged to be low in three studies as two studies imputed missing data using appropriate statistical methods. The remaining study reported a low attrition rate and the characteristics of the responders were not different to the non-responders. The risk of reporting bias was judged to be low in one study as the study protocol was available with preliminary results and the outcomes were reported in the pre-specified way. The remaining five studies provided inadequate detail to permit a judgement. All included studies were judged to be free of other sources of bias (Table 4).

## 3.5. Discussion

### 3.5.1. Main findings

This systematic review sought to evaluate the effects of workplace dietary modification interventions used either alone or in combination with nutrition education. Six studies that varied in duration from 3 to 24 months with 8443 participants were included. The methodological and clinical heterogeneity of the studies precluded meta-analysis and therefore a narrative summary of the results of each study was presented.

In one study, the intervention focused on dietary modification only [200]. In the remaining studies dietary modification was combined with nutrition education [201-205]. Only two studies based their intervention designs on a theoretical understanding including the stages of change model [201] and an ecological model [203]. None of the included studies complied with established guidelines to develop and evaluate complex interventions. Only two studies used Employee Advisory Boards (EAB) to involve employees in the development, implementation and monitoring of worksite interventions [201, 202].

All included studies measured a change in dietary behaviour from baseline to follow-up using self-reported dietary assessments [200-205]. In four studies, the interventions improved employees' fruit and vegetable consumption. In three of these studies, food modification was combined with nutrition education [201-203] and in the remaining study the intervention consisted of dietary modification only [200]. Due to the limited duration of the studies it is unclear if these modest dietary improvements can be sustained over a long period of time. Three studies measured the change in fat intake. One study reported a statistically significant difference between the intervention and control groups for percentage of energy obtained from total fat and polyunsaturated fat while the other two studies found non-significant differences for total fat intake [203, 204]. Some studies showed additional positive dietary changes including a statistically significant reduction in energy intake and a statistically significant increase in protein and carbohydrate intakes [205].

Clinical health status outcomes were reported in one study and showed a statistically significant increase in BMI and a statistically significant reduction of serum HDL cholesterol in the intervention group. The differences between the intervention and control groups were non-significant for mean serum total cholesterol levels and waist and hip ratio measures [205].

In a combined dietary modification and nutrition education intervention study, nutrition knowledge was significantly better in the intervention group when compared to the control group [205]. There was a statistically significant intervention effect on reported co-worker support when the worksite intervention group, worksite and family intervention group and the control group were compared [202]. Self-efficacy towards eating two daily servings of fruit significantly increased in the dietary modification intervention groups when compared to the control groups but there was no significant difference reported in self-efficacy towards eating 3 daily servings of fruit, job satisfaction and perceived health [200]. The same study found a statistically significant increase in self-purchasing of fruit and family purchasing of vegetables [200]. Another study investigated the intervention effect on the sales proportions of low-fat products but no findings were reported comparing the dietary modification intervention with the nutrition education or control groups [204]. However, isolated findings from individual studies require confirmation in additional studies.

### 3.5.2. Strengths and limitations

This systematic review was conducted in accordance with the PRISMA statement [195]. The risk of bias in included studies was rated using the Cochrane Collaboration's risk of bias tool [197]. There was limited ability to draw conclusions due to the heterogeneity of interventions and outcomes and the limited quality of included studies. The instruments used to record dietary data varied between studies and there may have been differences in the accuracy with which dietary data were recorded in different studies. No conclusions can be drawn about the effects of workplace dietary modification interventions on attitudes, food habits, determinants of food choice, absenteeism, productivity, healthcare costs and profit margins as no studies reported these outcome measures. The review was confined to studies that included a control group in the study design, were published in the

English language and indexed in selected electronic databases. It is therefore possible that relevant published studies without a control group, unpublished studies, non-English language publications and studies indexed in other electronic databases may have been overlooked.

#### 3.5.3. Comparisons with other reviews

Several reviews have evaluated the effectiveness of workplace interventions designed to promote healthy nutrition [130, 133, 157, 198, 199]. These reviews differ significantly from each other and from this review in terms of the types of study designs included, the type of interventions evaluated and the types of outcome variables included. Despite these differences, some common themes emerge from these reviews in relation to issues such as the limited quality of the available evidence on the effectiveness of interventions and the inability to conduct formal meta-analyses of the results of included studies due to the heterogeneity of study designs, interventions and outcomes [130, 133, 157, 198, 199].

The findings of this review and previous reviews have reported that nutrition education and multi-component workplace dietary interventions have a moderate positive effect on dietary behaviour [130] in particular regarding fruit and vegetable consumption [133, 157]. Another review noted that workplace interventions focused on increasing fruit and vegetable intakes were most effective among participants at a higher risk of disease [199]. There is a consensus that workplace health promotion needs to surpass the realm of education and intervene at multiple levels of the worksite environment to have a sufficient influence on dietary behaviour [133, 157].

### 3.5.4. Study implications

The quality of future trials evaluating the effects of workplace dietary modification interventions can be enhanced if the following key concepts are applied. Researchers should comply with the MRC recommended guidance for developing and evaluating complex interventions [160]. Future studies of this kind should be reported using standardised guidelines like the TREND statement [163]. The TREND statement recommends the measurement of standard outcomes and probes researchers to consider methods to control for bias and confounding. Standardised reporting will improve the quality of these studies and reduce the heterogeneity of future studies regarding study design, intervention design and outcomes.

The follow-up period needs to be extended to over a year to accurately measure the long-term impact on dietary behaviour and to allow for dietary change due to seasonal variability. Outcomes such as employee absenteeism, productivity, healthcare costs and workplace profit margins should be measured to facilitate analyses of the cost-effectiveness of these workplace dietary modification interventions. Objective outcomes such as nutrient analysis of foods at workplaces, blood cholesterol, resting blood pressure and 24-hr urinary analysis are important outcomes for future studies evaluating the effects of these interventions.

Intervention studies should also include assessment of dietary patterns outside the workplace to measure the true impact on dietary behaviour and investigate if other health compensatory behaviours are evident away from the work environment. The evaluation of the effects of these interventions could be enhanced by using mixed methods to examine not only 'what' changes using quantitative measures but also'how' and 'why' these changes take place using qualitative measures (i.e. interviews). Detailed process evaluations using qualitative measures may facilitate the identification of critical elements in the success or failure of these interventions.

The implementation of future multi-level dietary interventions should also consider improving the physical, social and organisational environments in the workplace to allow maximum impact [207]. The WHO Concepts of Health Promoting Workplaces and the WHO Global Healthy Work Approach, outlines that key stakeholders that influence working life and employee participation are pivotal for effective development and implementation of workplace health promotion strategies [106]. Additional work factors can also potentially affect dietary behaviour such as rotating work schedules, work-related stress, rest breaks, overtime and shift patterns [207, 208].

### 3.6. Conclusion

There is limited evidence to suggest that workplace dietary modification interventions alone or in combination with nutrition education can increase fruit and vegetable consumption. It would be premature to recommend implementation of these interventions as the size of the effect is small. Ambiguity exists including the long-term effect on dietary behaviour, the absence of information on determinants of food choice, clinical health status and economic cost outcomes and the limited quality of existing research. Future complex dietary modification interventions should be designed using recommended guidelines, reported in a standardised manner, developed according to the context of the study workplaces, have long-term follow-up periods and include objective measures for diet, health status and cost.

**Table 1. Characteristics of excluded studies (ordered by study ID)**

| Study | Reason for exclusion |
|---|---|
| **Baer, 1993** | No food modification intervention. |
| **Barratt et al. 1994** | No food modification intervention and only selected groups of employees with co-morbidities included. |
| **Beresford et al. 2010** | Only worksites without on-site cafeteria services were recruited. |
| **Dejoy et al. 2011** | Different outcomes assessed. |
| **Engbers et al. 2006** | Study recruited only selected groups of employees with increased CVD risk. |
| **Lassen et al. 2007, Lassen et al. 2011** | Control groups implemented intervention changes during the intervention period. |
| **Lowe et al. 2010** | No control group. |
| **Sorensen et al. 1992** | No worksite food modification involved in the intervention design[a]. |
| **Thorsen et al. 2010** | No control group. |
| **Williams et al. 2007** | No worksite food modification involved in the intervention design. Different outcomes, primary outcome was change in BMI and did not measure dietary behaviour. |
| a. A modest disagreement regarding exclusion of a study was resolved by discussion and consensus. It was agreed that the study did not meet the inclusion criteria (Sorensen et al. 1992). | |

## Table 2. Characteristics of included studies

| Included Study | Study Design | Participants | Intervention | Outcomes |
|---|---|---|---|---|
| ***Beresford, 2001*** (Beresford et al. 2001) | Cluster RCT | A total of 28 worksites (educational, medical and other) randomised to intervention (n=14) or control (n=14) arms on completion of baseline data collection. Intervention group recruited 1169 participants and control group recruited 1226 participants. All worksites with 250 to 2000 employees, located in the metropolitan area of Seattle, USA and had food serving cafeterias were eligible for the study. | -Based on the stages of change model.<br>-Focused on changes in the work environment and individual behaviour.<br>-In each worksite, an employee advisory board (EAB) implemented the intervention, guided the project activities and complied with a protocol that specified minimum activities.<br>-Environmental elements included training for the cafeteria workers, new company catering policies, modified selections in vending machines and a nutrition resource kiosk was provided. Individual elements aimed to improve consciousness on healthy eating using posters, napkins, a self-evaluation brochure, cooking demonstrations and taste testings.<br>-Control group, minimal intervention focused on increasing fruit and vegetable consumption using posters, newsletters, food demonstrations and a self-help manual.<br>-Final follow-up was at 24 months. | Fruit and vegetable consumption (servings/day) |
| ***Backman 2011*** **(**Backman et al. 2011) | Prospective, randomised block experimental design | Convenience sample of 391 low-wage employees in 6 intervention work sites and 137 low-wage employees in 3 control work sites in Los Angeles, CA | -Fresh fruit deliveries with enough for 1 serving per employee, 3 days a week for 12 consecutive weeks.<br>-The control work sites did not receive the fruit deliveries. | Participants' fruit and vegetable consumption, fruit and vegetable purchasing habits, self-efficacy, job satisfaction and overall health. |
| ***Bandoni 2010*** (Bandoni et al. 2010) | Randomized controlled study | 29 companies of Sao Paulo (intervention and control), Brazil with 2510 workers | -The intervention focused on change in the work environment and was based on an ecological model for health promotion.<br>-Included menu planning, food presentation, point-of-choice labelling and motivational strategies to encourage the consumption of fruit and vegetables.<br>-Intervention duration 6 months. | Change in availability of fruits and vegetables (in grams) served to each customer at lunch, consumption of fruit and vegetables in the workplace by workers, availability of energy, macronutrients and fibre. |
| ***Braeckman 1999*** (Braeckman et al. 1999) | Quasi-experimental design | Study conducted in 4 work sites in Belgium ranging from 250-500 workers with a predominantly male, blue-collar and Caucasian workforce. All male employees aged 35-69 years were recruited. Baseline characteristics were similar for the 2 control groups and 2 intervention groups. Employees were pooled into 1 control group (n=366) and 1 intervention group (n=272). | -Short-term and low-intensity nutrition intervention.<br>-Consisted of an individualized health risk appraisal, group sessions, education, mass media activities and environmental changes.<br>-Intervention duration 3 months. | BMI, blood lipids, nutrition knowledge and dietary changes. |
| ***Steenhuis 2004*** (Steenhuis et al. 2004) | A cluster randomised pre-test-post-test experimental design | 17 worksite cafeterias (1013 respondents) of large Dutch companies and governmental organizations with mainly white collar workers were recruited through the head of catering organizations. | -4 conditions: the educational program; the food supply program plus educational program; the labelling program plus educational program; and a control group.<br>-In the educational program, determinants of eating less fat and more fruit and vegetables were targeted.<br>-Food supply program plus educational program included an increased availability of low-fat products, fruit and vegetables.<br>-Labelling program plus educational program: low-fat products in the 6 food categories (butter/margarine, milk, cheese, meat products, desserts and snacks) were labelled with a sign in front of the product.<br>-Intervention duration was 6 months. | Changes in dietary behaviour (total fat, fruit + vegetable intake) during lunch in the worksite cafeteria. Sales data for some targeted product categories including milk, butter, cheese, meat products and desserts. |
| ***Sorensen 1999*** (Sorensen et al. 1999) | Cluster RCT | 22 community health centres were randomly assigned to a minimal intervention, worksite intervention or worksite plus family intervention. No. of participants, n=1359. No details regarding age. | -3 intervention arms:<br>1. Control arm: minimal intervention (offered to all groups, included national 5-a-day media campaign, 5-a-day slide presentation and taste test) (8 sites).<br>2. The worksite intervention: employee advisory boards, individual behaviour change (media campaign per year, presentations, videos, group sessions and individual advice) and environmental change (increase in fruit and vegetables in vending machines, taste-tests and point-of-choice labelling of fruit and vegetables) (7 sites).<br>3. The worksite plus family intervention incorporated family-focused interventions into the worksite program, including a learn-at-home program, newsletter, family festival and materials mailings (7 sites).<br>-Follow-up was at 19.5 months. | Fruit and vegetables servings/day, co-worker and household support for healthy eating, employee participation and changes in awareness. |

## Table 3. Fruit and vegetable consumption

| Study ID | Gender | Intervention setting | Intervention duration | Outcome measure | Baseline | | Final follow-up | | Effect Size |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Intervention [I] | Control [C] | Intervention [I] | Control [C] | |
| Backman, 2011 | Men | Los Angeles, CA (USA) workplaces – manufacturing + food processing. | 3 months | Fruit + Veg: Mean servings/day (FFQ) | N/A[a] | N/A[a] | N/A[a] | N/A[a] | Slope coefficient 0.13 (p<0.01) SE 0.04[b] |
| Bandoni, 2010 | Men and women | Workplaces -companies of Sao Paulo, Brazil | 6 months | Fruit + Veg: Mean g/day (worker survey portions consumed at lunch converted into grams) | n = 651<br>104.85 g/d<br>(95% CI 98.71,110.99) | n = 645<br>102.1g/d<br>(95% CI 94.89,109.31) | n = 630<br>123.03g/d<br>(95% CI 117.14,128.93) | n = 584<br>109.65g/d<br>(95% CI 103.28,116.02) | 11.75g/d (2.73, 20.77)[c] increase in consumption in the intervention group controlling for control group consumption |
| Steenhuis, 2004 | Men and women | Netherlands, Dutch companies | 6 months | Fruit: Mean servings/day (FFQ) | N/A[d] | N/A[d] | N/A[d] | N/A[d] | Effect sizes not reported.<br>No significant differences between study groups (all p-values ≥0.16)[e] |
| | | | | Vegetables: Mean servings/day (FFQ) | N/A[d] | N/A[d] | N/A[d] | N/A[d] | |
| Beresford, 2001 | Men and women | Seattle (USA) workplaces – manufacturers, healthcare, finance/legal, education, research, other) | 24 months | Fruit + Veg: Mean servings/day (abbreviated FFQ) | n = 1342<br>3.68<br>(SD not reported) | n =1400<br>3.63<br>(SD not reported) | n = 1169<br>4.18<br>(SD not reported) | n =1126<br>3.84<br>(SD not reported) | 0.3 servings; p <0.05[f]<br>difference in change from baseline scores between intervention and control groups |
| Sorensen, 1999 | Men and women | Boston, community health centres. | 19.5 months | Fruit + Veg: Mean servings/ day (7-item 'screener' FFQ) | WI[h] + FI[h] (n = not reported)<br>2.55<br>(SD not reported)<br>WI[h] (n = not reported)<br>2.73<br>(SD not reported) | MI[h] (n = not reported)<br>2.66<br>(SD not reported) | WI[h] + FI[h] (n = not reported)<br>2.96<br>(SD not reported)<br>WI[h] (n = not reported)<br>2.81<br>(SD not reported) | MI[h] (n = not reported)<br>2.62<br>(SD not reported) | WI[h] + FI[h] = 16% increase (approx. 0.4-0.5 servings) versus 2% decrease in Control [p<0.05 versus control][g]<br><br>WI[h] = 3% increase (approx. 0.1 servings) versus 2% decrease in Control [p>0.05 versus control][g] |

a. Data on mean consumption at baseline and follow-up were not provided. There were 391 participants in the intervention and 137 in the control worksites. Participants were allowed to enter the study at any of the four assessment periods. Of the 528 participants, 175 completed the baseline questionnaire, 221 completed the week 4 questionnaire, 251 the week 8 questionnaire; 328 the week 12 questionnaire.
b. Intervention effect estimated using Growth Curve Analysis with hierarchical linear modeling. The slope co-efficient indicates change over the 4 assessments between the study groups.
c. Estimate obtained from linear regression model for the difference (change from baseline) in the intervention group, adjusted for fruit and vegetable consumption in the control group and for sex, education and age of workers.
d. Data on mean consumption at baseline and 6 months follow-up were not provided. There were three intervention groups 1) LP +EP [n=215] 2) FSP + EP [n=290] 3) EP [n=293] and one control group NP [n=215].
e. In a regression analysis using persons as unit of analysis, there were no significant differences at 1 month follow-up between study groups correcting for baseline consumption and educational level, BMI and shopping behaviour. These analyses were repeated with consumption scores months after the start of the intervention as the dependent variable (n = 621). There were no significant differences for all comparisons between intervention groups and between intervention and control groups.
f. Mixed model regression with fixed treatment arm, random pair and pair by arm effects adjusted for baseline, age, gender, education, autonomy, time between end of intensive intervention and follow-up evaluation.
g. Percentages of change adjusted for gender, education, occupation, race/ethnicity, co-worker support.
h. WI = worksite intervention (7 sites), FI = worksite plus family intervention (7 sites) and MI = minimal intervention (8 sites).

**Figure 6. Study flow diagram: search strategy**

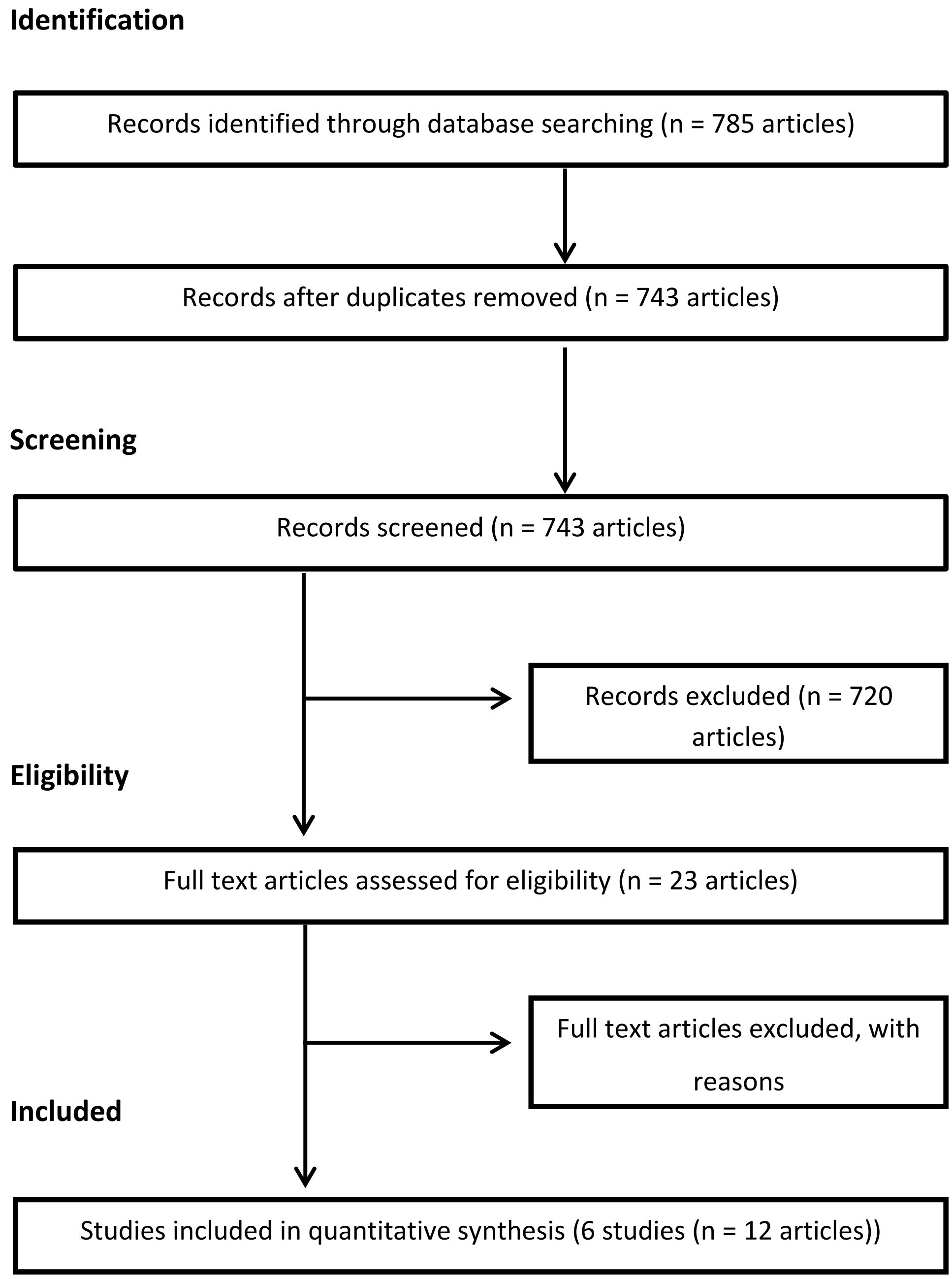

**Figure 7. Risk of bias summary: review authors' judgements about each risk of bias item for each included study**

| | Random sequence generation (selection bias) | Allocation concealment (selection bias) | Blinding of participants and personnel (performance bias) | Blinding of outcome assessment (detection bias) | Incomplete outcome data (attrition bias) | Selective reporting (reporting bias) | Other bias |
|---|---|---|---|---|---|---|---|
| Backman 2011 | ? | ? | ? | ? | + | ? | + |
| Bandoni 2010 | + | ? | ? | ? | ? | ? | + |
| Beresford 2001 | ? | ? | − | ? | ? | + | + |
| Braeckman 1999 | ? | ? | ? | ? | + | ? | + |
| Sorensen 1999 | ? | ? | ? | ? | ? | ? | + |
| Steenhuis 2004 | + | + | ? | ? | + | ? | + |

Low risk of bias + Unclear risk of bias ? High risk of bias −

## Table 4. Methodological quality of included studies: risk of bias tables

### Beresford 2001 (Beresford et al. 2001)

| Bias | Authors' judgement | Support for judgement |
|---|---|---|
| Random sequence generation (selection bias) | Unclear risk | "A total of 28 worksites were randomized to intervention (n=14) or control (n=14) arms of the study, on completion of baseline surveys". No information provided about sequence generation. |
| Allocation concealment (selection bias) | Unclear risk | No information provided about allocation concealment. |
| Blinding of participants and personnel (performance bias) | High risk | "To the extent that participants were aware of the intervention". The participants were not blinded to the intervention. No information provided about blinding of personnel. |
| Blinding of outcome assessment (detection bias) | Unclear risk | No information provided on blinding of outcome assessment. Participants were aware of the intervention. Participants completed four self-reported measures: a modified FFQ (primary outcome measure); the Fat-and Fibre-related diet behaviour questionnaire (FFB); multiple 24-hr dietary recalls; and a modified usual-day intake or checklist. The authors acknowledge in the text that "self-reported dietary behaviours may be reactive, and unobtrusive measures are valuable adjuncts to confirming self-reports" so they included two indicators to improve inter-observer reliability. Study proctors (study investigators) observed the employees plates at the check-out lines and during randomly chosen lunch times. Plate observation at cafeteria checkout lines reported a differential change of 0.16 servings of fruit and vegetables for one meal in one day when the intervention group was compared to the control group. This was consistent with the differential change of 0.30 servings of fruit and vegetables measured by the self-reported FFQ for the whole day when the intervention group was compared to the control group. It is not known if the study proctors or the participants were blind to the group assignment so it is difficult to permit a judgement. |
| Incomplete outcome data (attrition bias) | Unclear risk | The response rate to the baseline survey was 80% (63-93%). During the study, one of the intervention worksites closed, reorganized as a different type of company and relocated. At follow-up, the average response rate was 71% (apart from one intervention site with a low response rate of 38% at follow-up, the range was 58-85%). The distribution of demographic characteristics of respondents to the baseline survey was similar in the intervention and control groups. From baseline to two-year follow-up, lost to follow-up was similar in the intervention (173 participants) and control (174 participants) groups. No additional information provided on participants lost to follow-up e.g. reasons provided for missing data. |
| Selective reporting (reporting bias) | Low risk | The study protocol was available with preliminary results and the outcomes were reported in the pre-specified way. |
| Other bias | Low risk | The study appears to be free of other sources of bias. |

## Backman 2011 (Backman et al. 2011)

| Bias | Authors' judgement | Support for judgement |
|---|---|---|
| Random sequence generation (selection bias) | Unclear risk | "The 9 participating work sites had a wide variation in the total number of employees and therefore were divided into 2 equally sized groups to ensure that an equal number of employees were exposed to the intervention and control conditions. The investigators randomly assigned these two groups to the intervention or control group". No information provided about sequence generation. |
| Allocation concealment  (selection bias) | Unclear risk | No information provided about allocation concealment. |
| Blinding of participants and personnel (performance bias) | Unclear risk | "Research team explained that they were interested in understanding employees' dietary habits" and "employees in both the control and intervention groups were not told that fruit deliveries were part of the evaluation". Given the nature of the intervention, bias may have been introduced as the employees (participants) may have related the fruit deliveries with the intervention. No information provided about blinding of personnel. |
| Blinding of outcome assessment (detection bias) | Unclear risk | The participants were the outcome assessors. Participants self-completed a questionnaire including an FFQ that assessed both frequency and portion size and questions regarding self-efficacy, workers satisfaction and perceived general health. There is inadequate information to judge if the outcome measures were determined without the knowledge of the group assignment. |
| Incomplete outcome data (attrition bias) | Low risk | Extreme imbalance from baseline to follow-up. "Of the 528 employees who provided usable data for the study, 175 completed baseline data, 221 completed the questionnaire at week 4, 251 completed at week 8 and 328 completed the questionnaire after week 12". However, intervention and control groups were demographically similar. The authors note that "the response rate in the control worksites was low". The specific response rate was not reported. Reasons for missing data were provided including new hires joining the study after its commencement and absence of employees on the days that the questionnaires were distributed. Missing data was addressed with hierarchical linear modelling (statistical analysis software for missing data using a weighted estimate). |
| Selective reporting (reporting bias) | Unclear risk | Insufficient information to permit judgement. |
| Other bias | Low risk | The study appears to be free of other sources of bias. |

## Bandoni 2010 (Bandoni et al. 2010)

| Bias | Authors' judgement | Support for judgement |
|---|---|---|
| Random sequence generation (selection bias) | Low risk | Additional information from the main author (Bandoni et al. 2010): "The sample was randomised at the company level. Companies were invited to participate in the study and after accepting they were randomly assigned to intervention and control groups using statistical software to randomly select the companies as intervention or control". Adequate information provided as statistical software used to randomly select the workplaces to intervention or control. |
| Allocation concealment (selection bias) | Unclear risk | Inadequate information provided about allocation concealment. |
| Blinding of participants and personnel (performance bias) | Unclear risk | Additional information from the main author (Bandoni et al. 2010): "Due to the nature of the behavioural intervention, the research team (personnel) was aware of the companies in each group (control or intervention) but the companies themselves did not know there were two study groups". The personnel were not blinded and it is unclear if the companies were blinded to the intervention in their own company. |
| Blinding of outcome assessment (detection bias) | Unclear risk | Participants (outcome assessors) self-completed individual worker surveys to measure the consumption of fruit and vegetables in the workplace. Although the companies were not aware that there were two studies groups, there is insufficient information to determine if the participants were blinded to their group assignment. Changes in availability of fruits and vegetables served to each customer at lunch were measured by study researchers (outcome assessors) using the food service managers' reports and energy and nutrient data. The study researchers were aware of the group assignment. |
| Incomplete outcome data (attrition bias) | Unclear risk | Insufficient reporting of attrition/exclusions to permit judgement. Number of participants lost to follow-up was not reported in each group. |
| Selective reporting (reporting bias) | Unclear risk | Insufficient information to permit judgement. |
| Other bias | Low risk | The study appears to be free of other sources of bias. |

## Braeckman 1999 (Braeckman et al. 1999)

| Bias | Authors' judgement | Support for judgement |
|---|---|---|
| Random sequence generation (selection bias) | Unclear risk | "Male workers from two work sites were randomly assigned to the intervention programme; men from the other work sites were allocated to the control group". No information provided about sequence generation. |
| Allocation concealment (selection bias) | Unclear risk | Additional information from study author: "We contacted companies and those who were willing to participate were matched (number of workers, economic activity...) and then one workplace was assigned as intervention and the other as control". Insufficient information provided about allocation concealment. |
| Blinding of participants and personnel (performance bias) | Unclear risk | No information provided on blinding of participants. Additional information from main author (Braeckman et al. 1999): "For the data collection and analysis, it was not always possible to blind researchers". |
| Blinding of outcome assessment (detection bias) | Unclear risk | Dietary habits were measured using 24-hour dietary recalls. Inadequate detail as to whether the dieticians (outcome assessors) were blinded to knowledge of group allocation when carrying out the 24-hour dietary recalls. Inadequate information as to whether objective outcome measurements including venous blood samples, BMI, waist to hip ratio were blinded to group assignment. |
| Incomplete outcome data (attrition bias) | Low risk | Baseline characteristics were similar in the intervention and control groups. "83% of all eligible subjects were screened at baseline (n=770) and follow-up measures were obtained for 82%". Attrition rate was low (10% at 3-month follow-up) and it was noted that the employees who did not complete the follow-up questionnaire were not different from the employees who did. |
| Selective reporting (reporting bias) | Unclear risk | Insufficient information to permit judgement. |
| Other bias | Low risk | The study appears to be free of other sources of bias. |

## Steenhuis 2004 (Steenhuis et al. 2004)

| Bias | Authors' judgement | Support for judgement |
|---|---|---|
| Random sequence generation (selection bias) | Low risk | Additional information from study author: "the worksites were randomly assigned to a group (by means of closed tickets; first one in group one, second one in group two, and so on)". Adequate sequence generation method. |
| Allocation concealment (selection bias) | Low risk | Additional information from study author: "a condition was randomly assigned to the groups (also by means of closed tickets)". Adequate information on allocation concealment. |
| Blinding of participants and personnel (performance bias) | Unclear risk | No information provided on blinding of participants and personnel. |
| Blinding of outcome assessment (detection bias) | Unclear risk | Total fat, fruit and vegetable intake was assessed with a self-reported FFQ for participants. Intake during lunch was measured by asking participants to record the food items they had purchased during their last lunch in the cafeteria. Sales data for some targeted product categories were also collected by study investigators. Insufficient information is provided to determine if outcome assessors (participants and researchers) were blinded to group assignment. |
| Incomplete outcome data (attrition bias) | Low risk | Total response varied from 30.1% at the first time point, 76.4% at the second time-point and 61.3% at the third time-point. Data from the respondents was used in the analysis of the effects on total fat, fruit and vegetable consumption after 6 months. The attrition analysis showed that gender, age, level of education and fat, fruit and vegetable consumption were not significantly associated with attrition. |
| Selective reporting (reporting bias) | Unclear risk | Insufficient information to permit judgement. |
| Other bias | Low risk | The study appears to be free of other sources of bias. |

## Sorensen 1999 (Sorensen et al. 1999)

| Bias | Authors' judgement | Support for judgement |
|---|---|---|
| Random sequence generation (selection bias) | Unclear risk | "Worksites were stratified into blocks based on size and ethnic composition and randomized by block to achieve balance in size and ethnicity across conditions". No information provided about sequence generation. |
| Allocation concealment (selection bias) | Unclear risk | No information provided about allocation concealment. |
| Blinding of participants and personnel (performance bias) | Unclear risk | No information provided on blinding of participants and personnel. |
| Blinding of outcome assessment (detection bias) | Unclear risk | Fruit and vegetable intake was measured with a self-reported "7-item screener that assessed the frequency and number of servings of orange and grapefruit juice; other fruit juices; green salad; French fries or fried potatoes; baked, boiled or mashed potatoes; vegetables other than salad or potatoes; and fruit, not counting juices". A self-reported FFQ assessed changes in total diet. Co-worker support was measured using a self-reported survey. Worker characteristics were assessed using self-reported standard items like gender, age, education and income. Insufficient information is provided to determine if outcome assessors (participants) were blinded to group assignment. |
| Incomplete outcome data (attrition bias) | Unclear risk | "The mean worksite response rate was 87% (range, 68%-100%; n=1359). The follow-up survey, conducted at the conclusion of the intervention (May-July 1996), used the same sampling techniques as at baseline and resulted in a mean worksite response rate of 76% (range, 56%-100%; n=1306). The 2 samples were independently selected at the 2 time points; about half (47%) of the respondents at baseline also responded at follow-up". Insufficient information provided on missing data. Specific results presented were restricted to those without missing data and there was inadequate detail about how these results differed from the complete data. |
| Selective reporting (reporting bias) | Unclear risk | Insufficient information to permit judgement. |
| Other bias | Low risk | The study appears to be free of other sources of bias. |

## 4. EFFECTIVENESS OF COMPLEX WORKPLACE DIETARY INTERVENTIONS ON DIETARY BEHAVIOURS' AND DIET-RELATED DISEASE RISK: STUDY PROTOCOL FOR A CLUSTER CONTROLLED TRIAL.

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## 4.1. Abstract

**Background**

Dietary behaviour interventions have the potential to reduce diet-related disease. Ample opportunity exists to implement these interventions in the workplace. The overall aim is to assess the effectiveness and cost effectiveness of complex workplace dietary interventions that are focused on environmental dietary modification and/or nutrition education in large manufacturing workplace settings on employees dietary behaviours, nutrition knowledge and health status.

**Methods/Design**

A cluster controlled trial involving four large multi-national manufacturing workplaces in Cork will be conducted. The complex intervention design has been developed using the MRC framework and the NICE guidelines and will be reported using the TREND statement for the transparent reporting of evaluations with non-randomised designs. It will draw on a soft paternalistic “nudge” theoretical perspective. Nutrition education will include three elements: group presentations, individual nutrition consultations and detailed nutrition information. Environmental dietary modification will consist of five elements: (a) restriction of fat, saturated fat, sugar and salt, (b) increase fibre, fruit and vegetables, (c) price discounts for whole fresh fruit, (d) strategic positioning of healthier alternatives and (e) portion size control. The workplaces will be allocated to control, nutrition education alone (Education), environmental dietary modification alone (Environment) and nutrition education and environmental dietary modification (Combined intervention). A total

of 448 participants aged 18 to 64 years will be selected randomly. All permanent, full-time employees, purchasing at least one main meal in the workplace daily will be eligible. Changes in dietary behaviours, nutrition knowledge and health status will be recorded with measurements obtained at baseline, 3-4 months, 7-9 months and 20-23 months. A process evaluation and cost-effectiveness economic evaluation will also be undertaken.

**Discussion**

A 'Food Choice at Work' toolbox (concise teaching kit to replicate the intervention) will be developed to inform and guide future researchers, workplace stakeholders, policy-makers and the food industry.

Trial registration: Current Controlled Trials: ISRCTN3510823

## 4.2. Background

Altering people's health related behaviours can have a substantial impact on the main causes of mortality and morbidity [12]. Behavioural interventions can modify current patterns of disease [12]. Diet-related disease is a major public health concern and it continues to endanger our population health and the sustainability of our healthcare systems [209]. Dietary intakes of fat (especially saturated fat and trans fat), sugar and salt play a critical role in the development of hypertension, obesity, type 2 diabetes and cardiovascular disease [210].

Given the complicated intricacies of dietary behaviour, there is a need to develop effective complex behavioural interventions to promote dietary change in the population. Complex or multilevel interventions have several interacting components and should be developed systematically with appropriate evidence and theory [12, 189]. These interventions should be piloted carefully and the process of implementation should be monitored [160].

The workplace is an ideal setting to implement these complex interventions as most adults spend a large proportion of their waking hours at work [211]. This controlled environment can tolerate the interacting components of these interventions and provides access to a relatively homogenous population for which the interventions can be tested on [180]. Relevant reviews agree that these interventions may be more effective if they are of high intensity, developed within a complex framework and comply with a robust study design [125, 130, 133, 157, 180, 199].

However, there are substantial gaps in the current evidence base [130, 133, 157, 180, 198, 199]. Although a moderate positive effect on dietary behaviour has been reported particularly with fruit and vegetable intakes [130, 133, 157, 199], workplace dietary intervention studies have been of low-intensity with sub-optimal study designs [130, 133, 157, 198, 199]. These interventions mainly focused on information provision and failed to examine environmental approaches such as food modification and real incentives e.g. price discounts [180]. Inconsistent reporting of previous studies has also precluded meta-analysis. Therefore, the impact of complex workplace dietary interventions is still unknown.

The aim of this study is to assess the effectiveness and cost effectiveness of complex workplace dietary interventions that are focused on environmental dietary modification and/or nutrition education in large manufacturing workplace settings on employees dietary behaviours, nutrition knowledge and health status. The study design is informed by the findings of a systematic review conducted by the authors [212].

#### 4.2.1. Study hypothesis

Complex workplace dietary interventions that combine environmental dietary modification and nutrition education are more effective and cost-effective than nutrition education interventions alone or environmental dietary modification interventions alone when considering positive changes in employees dietary behaviours, nutrition knowledge and health status.

#### 4.2.2. Study objectives

The key objectives for this study are the following:

1. To develop high intensity complex workplace dietary interventions that are focused on environmental dietary modification and/or nutrition education in large manufacturing workplace settings.
2. To assess at 3-4 months, 7-9 months and 20-23 months follow-up the comparative effectiveness of a workplace environmental dietary modification intervention and an educational intervention both alone and in combination versus a control workplace on employees dietary behaviours, nutrition knowledge and health status.
3. To conduct a process evaluation to define critical elements of the success or failure of these interventions.
4. To measure the extent to which the impact of these interventions are influenced by the employees food choice motives and eating behaviours.
5. To evaluate and compare the alternative interventions in terms of their costs and consequences.

## 4.3. Methods

The complex intervention design has been developed and will be evaluated using the MRC framework for 'Developing and evaluating complex interventions: new guidance' [160]. The four phases of the framework include (A) development, (B) feasibility and piloting, (C) evaluation and (D) implementation and are illustrated in figure 6 in chapter 2 of this thesis.

### 4.3.1. (A) Intervention development

This phase focuses on (1) identifying the evidence base, (2) identifying/developing a theoretical understanding and (3) modelling the process and outcomes for the complex intervention.

1. Identify the evidence base

We conducted a systematic review on the impact of workplace dietary modification interventions alone or in combination with nutrition education (Chapter 3) [213]. The review was guided by the PRISMA statement [195]. Although there was evidence that some interventions can moderately increase fruit and vegetable consumption, results shows that uncertainty remains regarding the long-term effects on dietary behaviour, health status and economic cost. The systematic review findings informed the intervention design.

2. Identifying/developing theory

This intervention design will comply with a soft paternalistic "nudge" theoretical perspective and a social ecological perspective [165, 166, 168, 172, 214]. The intervention will create positive reinforcement with indirect suggestions for healthy food choices to try to improve dietary behaviour. Environmental engineering approaches will be guided by choice architecture that will include food modification, relocation of healthy food options and price discounts.

3. Modelling process and outcomes

This complex intervention design is guided by the detailed principles and recommendations of the NICE guidelines [12]. The study focuses on two potential methods to improve long-term dietary behaviour in the workplace including environmental dietary modification and nutrition education. Both methods will be measured independently and collectively in purposively selected workplaces. The workplaces will be allocated to control, nutrition education alone (Education), environmental dietary modification alone (Environment) and nutrition education and environmental dietary modification (Combined intervention). The intervention design has been developed by the research team (nutritionists, dieticians, public health and health promotion researchers) with advice from catering stakeholders in Ireland (catering managers association of Ireland (CMAI) representatives), workplace stakeholders (catering managers, human resources managers, occupational health managers) and the target population i.e. manufacturing employees. Figure 8 illustrates the Food Choice at Work Trial design.

The primary study outcomes will include changes in employees' dietary intakes of salt and BMI at 7-9 months follow-up. Secondary outcomes will include changes in dietary intakes (total fat, saturated fat, total sugars and fibre), diet quality (as measured by the DASH score), nutrition knowledge and health status (weight, midway-waist circumference and resting blood pressure) at 7-9 months follow-up. A cost-effectiveness economic evaluation will also be conducted and absenteeism trends will be recorded during the study period. A cost-effectiveness economic evaluation will be undertaken in each workplace following a previous framework developed by Drummond et al. [215]. Very few studies have used cost-effectiveness techniques to evaluate workplace interventions. Recently, Sacks et al. found that the traffic light nutrition labelling offered excellent value for money as an obesity-prevention measure [216]. Absenteeism trends will also be monitored before and after the intervention to measure differences in labour productivity (Appendix 3, publication 4).

Interventions

Each workplace will have a research workplace leader that will be based on-site for the duration of the study. The workplace leader will collaborate with the workplace stakeholders to co-ordinate the study and monitor daily adherence to the interventions.

Nutrition education strategies:

Nutrition education strategies will include three components: 1. group presentations, 2. individual nutrition consultations and 3. detailed nutrition information.

1. Group presentations: monthly 'lunch and learn' group nutrition sessions (30 minutes per session) will be delivered to all employees. These sessions will concentrate on portion control, reading food labels, general healthy eating, reducing sugar, salt and fat dietary intakes. Sessions will be repeated a number of times per month so all participants in all shifts will have the opportunity to attend. Peer support and group discussion will allow for more effective learning.

2. Individual nutrition consultations:

    (i) Individual nutrition consultations: Individual dietary counselling (20 minutes per session) with a nutritionist or dietician will be conducted with each participant at baseline, follow-up at 3-4 months, 7-9 months and 20-23 months. The nutritionist/dietician will provide advice on how to follow a healthy diet, reach/maintain a healthy BMI and achieve/maintain a healthy resting blood pressure. The individual consultation will be based on the participant's individual lifestyle, their health status results (weight, BMI, waist circumference) and dietary recall assessments. The 'Food Choice at

Work' healthy eating booklet will be offered to each participant at the end of their first consultation. The booklet will support the nutritional advice given during the consultations.

(ii) The 'healthy eating chat table' will be situated outside the canteen during break-times twice a month. All employees will have the opportunity to sit and ask a nutritionist or dietician questions about healthy eating.

3. Detailed nutrition information will be offered throughout the duration of the intervention using six key methods:

(a) Posters and leaflets will be displayed throughout the workplace and will be based on the theme of the 'lunch and learn' monthly nutrition sessions. This information will be replaced monthly.

(b) Monthly emails will be disseminated to all employees using the workplace intranet to inform the employees of the scheduled activities for that month.

(c) A unique healthy eating traffic light coding system will be applied to the daily menus in the employees' canteens and vending machines on site. The coding system will display the number of calories and traffic lights will show the amount of fat, saturated fat, total sugars and salt per portion size of the meal/food item. The traffic lights will also be displayed in words for employees that are colour blind (Figure 9).

All traffic light threshold values will be based on the Irish nutrient goals from the Food Safety Authority of Ireland (FSAI) and the Food and Drug Administration (FDA) labelling system. The Irish nutrient goals have been developed on the basis of a caloric intake of 2000 kilocalories (Kcal) per day [217]. The recommended percentage intake for fat is >20 to ≤35% (<80g), for saturated fat is <10% (≤20g), for total sugar is ≤20% (≤90g) and for salt is ≤6g [217]. A green light will be applied if the food/meal does not exceed 5% of the recommended percentage intake. An amber light will be applied to a food/meal that contains between 5-20% of the recommended percentage intake. A red light will be applied if the food/meal exceeds the limit of 20% of the recommended percentage intake.

(d) Food Choice at Work quiz: Two short quizzes focused on the traffic light displays and the 'lunch and learn' group nutrition sessions will be distributed to all employees each month. Randomly selected winners will receive free lunches.

(e) Pocket-sized food choice shopping cards will be offered after baseline assessments. These cards will provide guidance on how to select healthy food choices when purchasing food at work or outside of work using our own unique traffic light coding system.

(f) Pocket-sized personal measurement cards will be offered after baseline assessments to allow participants' to log and follow their progress throughout the study regarding their health status. Individual dietary advice from the nutrition consultations will also be recorded on the card.

Environmental dietary modification strategies:

The menus in environment and combined workplaces will be nutritionally analysed using NetWISP software (Weighed Intake Software Program; Tinuviel Software, Warrington, UK) before the study commences. The workplace stakeholders and the research team will discuss and reach a consensus on all future environmental dietary modifications in the workplace canteens and vending machines. Taste testing will be conducted by the workplace stakeholders and the research team before the implementation of any modifications. All catering staff will be trained before and during the intervention period so there is high compliance with the specific dietary modifications and portion control.

Five environmental dietary modifications will be recommended including (a) restriction of fat, saturated fat, sugar and salt, (b) increase fibre, fruits and vegetables (c) price discounts for whole fresh fruit, (d) strategic positioning of healthier alternatives and (e) portion size control.

(a) For the restriction of fat, saturated fat, sugar and salt: All menus need to be modified. Stock and bouillon should be removed from all recipes and replaced with a recommended low-salt stock. Salt should be eliminated from all cooking processes. Fresh herbs, spices and garlic should be introduced to develop additional flavour. High salt, saturated fat and fat savoury options should be restricted (e.g. sausage rolls, croissants) and replaced with low-fat/low-salt options. High salt products (gravy mixes, stock cubes), processed meats (bacon, corned beef) will be reduced and replaced where possible with low salt options (turkey, chicken, fish). Fresh herbs, spices and garlic will be introduced to develop additional flavour.

Ready-made meals will be removed and replaced with freshly cooked options. Full-fat dairy products (i.e. milk, cream, cheese and butter) will be replaced with low-fat options where possible. Cheese and cream will not be used as a garnish on meals. Cheddar cheese will be reduced in all dishes. Cooking methods with oil such as deep-fat frying will be limited and replaced with methods of boiling, poaching, grilling, steaming and baking where possible. Only plant oils will be used in cooking (i.e. rapeseed, olive, canola and other plant oils). Full-fat mayonnaise will be replaced with low-fat mayonnaise in sandwiches and other lunch options.

No sauces or accompaniments will be added to any meals unless the employee requests. Chips/french fries will be removed from the menus two days a week and replaced with different potato options e.g. baked potato. Pizzas will be removed from the menus three days a week. All desserts will be fruit-based. Soft carbonated drinks will be restricted and replaced with water, milk and unsweetened fruit juice options.

(b) To increase fibre, white pasta, rice and bread will be replaced with wholegrain alternatives. Fruit and vegetables will be added into rice, pasta, soup and meat dishes. A buffet style fresh salad bar will be available to accompany any dish daily. Fresh whole fruit will be available throughout the day.

(c) Portions of whole fruit will be offered at discount prices.

(d) Healthier alternatives will be strategically positioned: healthy snacks such as whole fresh fruit, dried fruit, natural nuts, wholegrain and/or wholemeal sandwiches, brown soda bread and seeds will be positioned at eye-level at the entrance of the canteen and in the vending machines. Chocolate, sweets, biscuits, crisps will be restricted and replaced where possible with healthy snacks in the canteen and in the vending machines located in the canteen. Full size chocolate bars will be replaced with smaller options. Salt will be removed from the tables and will be replaced with sachets.

(e) To introduce portion size control, workplaces will be recommended to comply with the FSAI guidance on portion size[128, 218]. Training will be provided to all catering staff regarding strict portion size control. Standard serving tools will be used by caterers and employees to control portion size at mealtimes.

4.3.2. (B) Feasibility and piloting

The second phase includes (1) testing procedures, (2) estimating recruitment and (3) determining an appropriate sample size.

1. Testing procedures

In 2009, the authors of the 'Food Choice at Work Study' carried out an observational cross-sectional comparison pilot study in two public hospitals in Cork, Ireland; one of which had implemented a long-term (2 years) catering intervention designed to reduce dietary fat, saturated fat, sugar and salt intakes. All menus were modified. High-salt products (gravy mixes, stock cubes) and processed meat (bacon, corned beef) were replaced with low-salt options (turkey, chicken and fish). Fresh herbs, spices and garlic were introduced. Salt was removed in cooking. Salt cellars were removed from the tables in the canteen but small salt sachets were available at the service counter. Nutrition information was displayed in the canteen area. No sauces were added to any meals without the employee's consent. All desserts were fruit-based. Staff members were encouraged to consume extra salad and vegetable options at no extra cost. Cooking methods with oil were reduced. No catering changes were implemented in the second hospital.

A total sample of 100 random employees aged 18-64 years (50 from each hospital) who consumed at least one main meal in the hospital staff canteen daily took part in the study. Dietary intakes and socio-demographic characteristics were assessed. Reported mean intakes of total sugars, total fat, saturated fat and salt were significantly lower in the intervention hospital when adjusting for age and gender. Estimated average salt intake in the intervention hospital (5.6g/day) did not exceed the tolerable upper limit of 6g/day vs. a mean salt intake of 6.7g/day in the non-intervention hospital.

The study findings, published in the Journal of Public Health Nutrition [219] (Appendix 4) suggest that a structured catering initiative sustained over a relatively long period may influence long-term positive food choices at work and at home. Although these findings should be interpreted cautiously given the small sample size, many of the proposed dietary environmental modification and nutrition education components of the 'Food Choice at Work' study have been shown to be acceptable and feasible in a workplace setting.

Validation study

One of our research team will carry out a validation study assessing the accuracy of the study's 24-hour dietary recalls for estimations of dietary salt intake in comparison to the 24- hour urinary sodium excretion method, spot urine samples and FFQs (Appendix 4).

2. Estimating recruitment

A four week period in each workplace will be allocated to estimate recruitment. The time taken to schedule employees and conduct baseline data collection appointments will be recorded to inform the other stages of data collection.

3. Determination of sample size

A decrease in BMI by 1 $kg/m^2$ (1 unit) and a 2g average fall in dietary salt intake would have population health significance and clinical significance in terms of the risk of diet-related disease. To detect this difference in BMI between the control and intervention groups at 7-9 and 20-23 months follow-up and assuming a common standard deviation of 3.77, it is estimated that a sample size of 448 (112 per workplace) would have 80% power at the 5% significance level (findings from a previous study show that a 1 $kg/m^2$ difference was independently associated with 13% higher risk for hypertension) [220, 221]. The study will also be adequately powered (80% power at the 5% significance level) to detect a fall in dietary salt intake between the control and intervention groups at 7-9 and 20-23 months follow-up using a standard deviation of 4.2.

4.3.3.(C) Evaluation

The third phase is concerned with assessing the (1) effectiveness of the interventions, (2) understanding the change process and (3) assessing the cost-effectiveness of the complex intervention.

1. Effectiveness of the interventions

Study design

Effectiveness of the interventions will be evaluated using a cluster controlled trial design in four large manufacturing multi-national workplaces based in Cork in the Republic of Ireland with a representative sample of employees.

Study duration

The total study duration is 23 months. The interventions will be delivered over a 9-month period.

Unit of analysis

While the data will be collected at the individual level, the primary unit of analysis will be at the workplace level.

Recruitment

A list of Cork based manufacturing companies will be obtained from the industrial development authority website and will be systematically contacted in alphabetical order. A total of 20 potentially suitable companies will be contacted based on size and staff profile. The four most suitable workplaces will be purposively selected based on face to face meetings with individual workplace stakeholders (i.e. HR manager, catering manager). Only workplaces and employees that meet the specified selection criteria will be recruited.

Inclusion criteria:

**Workplace level:** Any manufacturing multi-national workplace that employs more than 250 employees and has a daily workplace canteen for employees can be included in the study. The workplace must be located in Cork, represented on the IDA website and able to commit to all components of the complex intervention for the duration of the study.

**Individual level:** Any permanent, full-time employee who is contracted to work for the duration of the study period and purchases and consumes at least one meal in the main canteen daily will be eligible to participate in the study.

Exclusion criteria:

**Workplace level:** All non-manufacturing multi-national workplaces that employ less than 250 employees or do not have a workplace canteen; are not represented in the IDA website; not located in Cork or not able to commit to the intervention design for the study period will be excluded.

**Individual level:** employees will be excluded if they:

1. Have a part-time contract.
2. Do not have contracts to work during the study period or are temporary contractors.
3. Do not work in the workplace full-time (for example work from home 2 days a week).
4. Travel regularly for work (more than once a month).
5. Do not purchase and consume a main meal from the staff canteen daily.
6. Are medically advised not to participate in the study/on long term sick leave or pregnant.
7. Are likely to leave the company during the study (i.e. retirement).
8. Are involved in an on-going diet programme external to work (for example the Weight Watchers programme).

Lists of permanent, full-time employees will be obtained from the human resources manager in each workplace. Employees will be randomly selected to participate using random number generation software and will be screened for eligibility over the phone by the research team.

Data collection methods.

All data collection will take place during paid working hours (excluding employees' breaks). Data will be collected in four stages using questionnaires, dietary and physical assessments and face to face semi-structured interviews. Baseline assessments will be conducted prior to implementation of the intervention. Follow-up assessments will be carried out at 3-4 months, 7-9 months and 20-23 months.

**Questionnaire instruments**

Four questionnaires will be self-completed by each participant electronically primarily or in a hard copy format. All questionnaires are based on validated, pre-tested questionnaires and will be completed at various study time-points.

I. The Health, Lifestyle and Food Questionnaire (HLFQ) (Appendix 2) is organised into ten different sections (A-J): Sections A, B, and C relate to the participant (gender, age, ethnicity, education) and include details of their work life (permanent/temporary, job arrangement) and general health status (self-rated health, health conditions and self-rated weight) [222]. Sections D, E and F relate to the participants usual dietary patterns at home and at work. Sections G, H and I investigate the participant's usual lifestyle patterns including physical activity (using the International Physical Activity Questionnaire (IPAQ)), smoking and alcohol questions [222]. Section J will focus on the participant's nutrition knowledge using the General Nutrition Knowledge Questionnaire (GNKQ) [223]. The questionnaire will take approximately 25 minutes to complete.

II. The Food Motives Questionnaire (FMQ) (Appendix 2) will investigate the motives underlying the selection of food [224]. It consists of nine scales including health, mood, convenience, sensory appeal, natural content, price, weight control, familiarity and ethical concern. This questionnaire will take five minutes to complete.

III. The Dutch Eating Behaviour Questionnaire (DEBQ) (Appendix 2) is a validated eating behaviour scale that assesses restrained, emotional and external eating behaviours [225]. The questionnaire will take three minutes to complete.

IV. The EuroQol-5D (EQ-5D) (Appendix 2) is a standardised instrument. Applicable to a wide range of health conditions and treatments, the EQ-5D health questionnaire provides a simple descriptive profile and a single index value for health status [226]. EQ-5D is primarily designed for self-completion by participants and is ideally suited for use in on-line surveys and face-to-face interviews.

**Dietary assessments**

24-hour dietary recall

The 24-hour dietary recall method will measure current nutrient intake over a period of 24 hours including the workplace and the home environment. Little burden is placed on the participant as this method requires short-term memory only but it fails to measure habitual diet.

The 24-hour dietary recall method will be a modified version of the validated UK 24-hour dietary recall method [227]. Two dietary recalls will be collected within one week to examine on-duty (while employee is at work) and off-duty (while employee is outside of work) dietary patterns at baseline and follow-up periods at 3-4 months, 7-9 months and 20-23 months.

The 3-step method outlines what the participant had to eat and drink in the previous 24 hour period as follows:

Step 1: Quick list**,** participants will be asked to report everything that they had to eat or drink the day before their appointment (12 midnight-12 midnight).

Step 2: The nutritionist/research assistant will collect detailed information on items named in the quick list (consumption time, place of consumption, brand and recipe), foods likely to be eaten in combination (milk in coffee) and the quantity consumed and any leftovers or second helpings.

Step 3: Recall review, participants will have an opportunity to provide additional information or to refer to foods forgotten in the quick list.

Finally, the interviewer will ask the participants about their consumption of water and food supplements. All information gathered will be recorded on a food consumption record. Specific prompts to measure salt and oil consumption will also be included. Each 24 hour dietary recall data collection will take approximately 20 minutes to complete. Finally, there is an interviewer evaluation to be completed by the nutritionist/ research assistant. Each food, drink and portion size will be coded according to the 24 hour coding instructions based on the validated UK method. Food and nutrient analysis will be calculated using NetWISP4© (Weighed Intake Software Program; Tinuviel Software, Warrington, UK) [228, 229].

FFQ

The FFQ tool is used to measure habitual dietary intake. It is a quantitative instrument and the most commonly used dietary assessment method in large scale epidemiologic surveys.

The FFQ will be self-completed by each participant electronically primarily or in a hard copy format (Appendix 2) at baseline and follow-up at 7-9 months and 20-23 months. The FFQ is an adapted version of the European Prospective Investigation of Cancer (EPIC) FFQ [230]. It has been used extensively in the Irish population including the Irish Surveys of Lifestyle, Attitudes and Nutrition [222], the original Cork and Kerry baseline study in 1998 [231] and the baseline phase II Cork and Kerry study in 2010 [232]. The FFQ is designed to assess the whole diet and includes 150 food items arranged into the main food groups. Respondents will be asked to record their average frequency of consumption of each food item over the last year. Typical weights, portion sizes and nutrient intake will be based on recommendations established by the Food Standards Agency (2002) [233] and

McCance and Widdowson's Food Composition Tables [234, 235]. A precisely designed programme will convert dietary information to food quantities and nutrient values i.e. NetWISP4© (Weighed Intake Software Program; Tinuviel Software, Warrington, UK) [228, 229].

**Physical assessments**

Each participant will be asked to participate in a physical assessment where measures of BMI, (mid-way) waist circumference, waist hip ratio and resting blood pressure will be assessed.

BMI

Weight will be measured using an electronic TANITA weighing scales and height will be measured using a Seca Leicester height measure. BMI will be calculated $kg/m^2$ [158]. Participants will be classified as underweight (BMI ≤18.49 $kg/m^2$), normal (BMI=18.50-24.99$kg/m^2$), overweight (BMI=25.00-29.99$kg/m^2$) or obese (BMI ≥30.00$kg/m^2$) [158].

Mid-way waist circumference

Mid-way waist circumference will be measured in centimetres using a Seca 200 measuring tape. Participants will be classified as centrally obese if their mid-way waist circumference is recorded at ≥94cm for men and ≥80cm for women [236].

Resting blood pressure

BP measurements will be obtained using the Omron M7 Digital BP monitor. The monitor is a compact, fully automatic BP monitor, operating on the oscillometric principle. This method of measurement determines the participant’s blood pressure by measuring the pressure fluctuations caused by the pulse waves. Before the measurement begins, the participant will be seated and as relaxed as possible with both feet parallel and flat on the floor. The researcher will ensure that the participant has not been smoking or participating in any vigorous exercise prior to the measurement. A full bladder also affects a BP reading, so the researcher will give the participant an opportunity to void prior to measurement.

The researcher will instruct the participant to remove any tight clothing covering the upper arms and ensure that the participant has been seated and settled for approximately 5 minutes prior to commencing the procedure. The measurements will be taken on the right arm whenever possible. The participant's arm will rest on a desk so that the antecubital fossa (a triangular cavity of the elbow joint that contains a tendon of the biceps, the median nerve, and the brachial artery) is at the level of the heart and the palm is facing up. The participant must always feel comfortable. The greatest circumference of the upper arm will be measured for a suitable cuff, with the arm relaxed and in the normal BP measurement position (antecubital fossa at the level of the heart), using a non-elastic tape. Three measurements will be taken from each participant one minute apart.

Urine analysis

Spot urine samples will be obtained for analyses of sodium, potassium, urea and creatinine levels. Two spot urine samples will be obtained from each individual at baseline and 7-9 months follow-up (4 spot samples in total per participant). For each stage of data collection, each participant will provide one sample from the evening before their on-duty 24-hour dietary recall and their second sample will be the first sample voided on the morning of their dietary recall. The urine samples will be taken approximately 12 hours apart e.g. 8pm and 8am.

A sub-sample of participants from each workplace will be asked to complete a 24-hour urine collection the day before their on-duty 24-hour dietary recall at baseline and 7-9 months follow-up. The 24- hour urinary sodium excretion method is considered the gold standard method for estimating dietary salt intake. It is estimated that between 90 per cent and 95 per cent of dietary salt intake is excreted in urine. Para-aminobenzoic acid (PABA), a biologically inert substance which is rapidly excreted in urine, will be administered to all participants on the day of urine collection to validate the completeness of the 24-hour collection sample. To estimate total sodium excretion in the spot urines, the sodium content will be corrected for total 24-hour urine volumes calculated from the validated 24-hour urine samples collected.

Statistical analysis

Data manipulation and statistical analyses will be conducted using StataIC 12 (StataCorp, College Station, TX, US). Primary analysis will examine the effects of the interventions by measuring changes in dietary behaviour, health status outcomes and nutrition knowledge.

Data regarding individual and environmental factors that may influence the effectiveness of the dietary complex interventions will be collected during baseline and follow-up. Individual factors will include personal (age, gender, ethnicity, education status, nutrition knowledge), lifestyle (smoking status, alcohol consumption, physical activity) and workplace factors (shift-work patterns, work status e.g. production worker, work schedule). Environmental factors will include the employees (gender breakdown and age profile) and the workplace structure (number of employees in workplace, canteen arrangement e.g. opening hours, employee structure e.g. percentage of employees working in production).

Paired t-tests will be performed to calculate the mean differences within each workplace from baseline to follow-up. Analysis of covariance (ANCOVA) will be used to compare the control and the intervention groups at follow-up and will be 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. A mixed effects model will examine subject variation in the longitudinal trends in dietary behaviour. It will explore associations between trends in dietary behaviour, nutrition knowledge and health status over time in the workplaces and adjust for the potential confounding effect of other factors such as age, gender and shift work patterns. The cost effectiveness economic evaluation will be completed using a similar framework to Drummond et al. [215] and Roberts et al. [237].

Planned subgroup analysis

Secondary analysis will investigate external factors that may be associated with the effects of the interventions. Subgroup analysis will look for possible differential effects in different employee disciplines (i.e. production employees versus management) and work groups (i.e. shift workers versus day workers). Analysis will be conducted across workgroup-strata and education level will act as a proxy measure of social class. Dietary pattern analysis will be conducted using latent class analysis (LCA) [238]. It will identify mutually exclusive subgroups within different dietary classes. LCA will estimate each participant's probability of belonging to a particular dietary class. A change in these subject-level probabilities is evidence of changes in dietary behaviour and preference. Changes in dietary preferences will be compared in all workplaces and associations with clinical and behavioural outcomes will be examined.

(2) Understanding change process: process evaluation

The implementation of the intervention will be monitored with a detailed process evaluation throughout the intervention period. A sub-sample of key workplace stakeholders from each workplace will be invited to attend semi-structured interviews. Workplace stakeholders (catering managers, human resources managers, occupational health managers and employee representatives) will include individuals that have been exposed to the intervention either by participation or have been involved in the development of the study design.

Semi-structured interviews will be conducted with participants for one hour at baseline and follow-up at 7-9 and 20-23 months. The researchers tasked with implementing the study, will also be involved in the on-going process evaluation. They will participate in focus groups and document study activities on a weekly basis.

The process evaluation will explore opinions on effective strategies to promote healthy eating at work, determine participants' perceptions of the implementation of the interventions in their workplace settings and examine the workplace stakeholders' awareness of changes in the workplace and changes in their dietary patterns for the duration of the intervention.

The process evaluation plan will be directed by Steckler and Linnan's conceptual framework [239]. The topic guide will be based on the following 6 components: fidelity, dose delivered, dose received, reach, recruitment and context. With informed participant consent, the interviews and focus groups will be digitally recorded, transcribed and analysed in NVIVO software (QSR International Pty Ltd.). A framework approach will be used for data analysis [240]. This method is appropriate given that the study has pre-specified objectives but it will also allow for unexpected themes to emerge [241]. Although outside the scope of her thesis, the candidate is co-author for one of the process evaluation papers. The aim of the publication is to examine barriers to and facilitators of implementing the complex FCW interventions, from the perspectives of key workplace stakeholders and researchers implementing the intervention (Appendix 3, publication 3).

(3) Assessing cost-effectiveness: economic evaluation

A seven step framework similar to that described by Drummond et al. [215] and Roberts et al. [237] will be used to measure the cost-effectiveness of each intervention as follows:

a. Each alternative intervention will be described and will include its components and potential benefits.
b. State the perspective from which the programmes will be analysed. The principal costs of the interventions are the advice by the nutritionists and the toolbox (resources used for implementation of interventions: training, equipment). If these costs are borne by the businesses, then the perspective

will be that of the business and their staff (the business benefits from lower sick days, the staff from better health). If the health service bears these costs, then the perspective is that of the health service (it bears the costs, but sees an improvement in population health), which is the primary objective of the health service. Thus the perspective adopted will depend on who is bearing the costs and reaping the benefits.

c. Identify, measure and value the costs of the alternatives. Identification will involve the listing of all resources used; measurement captures the resources used in physical units and valuation puts prices on these physical resources. We will also measure sick days for each employee the year before the intervention and the year after the intervention and compare the two results to measure whether there is a difference.
d. Identify, measure and value the outcomes of the alternatives. The primary outcome will be quality of life as measured using EQ-5D. A secondary outcome will be BMI.
e. Future costs and outcomes will be discounted at the appropriate discount rate. In Ireland this is taken at 3.5% and in the UK it is 5%.
f. Decision Analytical Modelling will be used to assess parameter uncertainty and heterogeneity. For instance, quality adjusted life years (QALYs) will be calculated based on a combination of the quality of life scores emerging from the EQ-5D measurement and the number of life years saved, based on extrapolation of the changes in BMI. The uncertainty surrounding these QALY estimates will be appropriately modelled.

g. Incremental Cost Effectiveness Ratios (ICERs) will be calculated for each of the alternatives and analysis of relative value for money will be reported. This and other measures of value for money, such as Net Benefit, will be presented in a Decision Analytical Framework.

4.3.4.(D) Implementation

The fourth phase concentrates on (1) surveillance and monitoring, (2) long-term follow-up and (3) dissemination.

1. Surveillance and monitoring

As the workplace leaders will be based in the workplace during the study period, they will observe and enforce all components of the intervention and record a weekly log of the intervention activities. The workplace leaders will meet with the workplace stakeholders on a weekly basis. The workplace leaders will inform the 'Food Choice at Work' logistics committee.

The FCW logistics committee will meet monthly in each workplace to monitor the efficiency of day-to-day data collection, harmonise communication, discuss concerns relating to the study design and data, discuss training of the research team and participant or stakeholder safety. Members will include the project manager, lead investigator (FG), workplace leader, human resources representative, occupational health and safety manager, employee representative and catering managers from each workplace.

The steering and data monitoring committee will meet once every two months. Members will include the lead investigator, principal investigator, co-investigators (with expertise in nutritional science, behavioural science, health economics, epidemiology, public health and biostatistics), the project manager and workplace leaders. The committee will monitor the study; oversee day-to-day ethical, data and administrative management; monitor compliance with the intervention and discuss dissemination. Quarterly progress reports relating to budget forecasts and fieldwork progress will be signed off.

An oversight committee will meet quarterly to review study deliverables and outputs, ensure that accurate, timely and appropriate reporting and problem solving occurs. Financial management will also be discussed. Members will include the principal investigator (IJP), lead investigator (FG), project manager, representative from the office of research and innovation and the finance Department in the University of College, Cork, Republic of Ireland.

2. Long-term follow-up

The complex interventions will be implemented over a 9-month period and follow-up will take place at 3-4 months, 7-9 months and 20-23 months (12 months post-intervention). A follow-up at 23 months is necessary to measure the sustainability of changes in dietary behaviour.

3. Dissemination

Future academic dissemination will occur through a range of academic international peer reviewed journals. National and international conferences will be attended to disseminate research findings using posters and oral presentations. Employees in the included studies will be informed of overall study findings by email. Noteworthy findings will be published in future press release to inform the public, food industry and public health policy-makers. A 'Food Choice at Work' toolbox (concise teaching kit to replicate the intervention) will be developed to inform and guide future researchers, relevant stakeholders and policy makers.

**4.4. Side-effects reporting and quantification**

Reporting will adhere to the TREND guidelines [160, 163]. No adverse events are envisaged for participants. The field work will be carried out in compliance with a detailed Standard Operating Procedures (SOP) manual. All field research employees will receive formal training for dietary and physical assessments at baseline and re-training before the follow-up periods to ensure standardisation of processes and procedures. All scales, tape measures and automated BP monitors will be calibrated and recorded at the start of the study and recalibrated monthly in accordance with the SOP.

Urine samples (24-hour urine collections and spot urine samples) will be assayed for electrolytes in an accredited hospital laboratory. The SOP explains in specific detail the standard duty of care for abnormal blood pressure and urine results. The first priority will always be the health and wellbeing of the participant. A physician working with the Department of Epidemiology and Public Health, University College Cork, Republic of Ireland will oversee all 24-hour urine collection results and advise accordingly.

### 4.5. Discussion

The FCW study is the first high-intensity, complex dietary intervention study to measure the effectiveness and cost-effectiveness of environmental modification and/or nutrition education over a long-term period in similarly structured controlled manufacturing workplaces. This unique study will be developed and evaluated according to an established academically rigorous framework and has the potential to improve dietary behaviour, nutrition knowledge and reduce the risk of diet-related disease.

#### 4.5.1. Strengths and limitations

The strengths of the FCW study are (1) the systematic theory and evidence base used to develop the study, (2) the participatory approach (inclusion of catering and workplace stakeholders in the study design and evaluation), (3) the study has been developed and evaluated according to the TREND statement (an academic framework recommended by the MRC and NICE guidelines) [160, 163], (4) complex 'high intensity' intervention design including a unique traffic light coding system based on recommended portion size, (5) thorough process evaluation, (6) extensive cost-effectiveness economic evaluation (7) triangulation of methods. The dietary, health status and knowledge assessments will provide descriptive and contextual data on changes due to the intervention while the semi-structured interviews will deepen our understanding of the process of the implementation according to the perspectives of key stakeholders within the intervention workplaces, (8) no risk of contamination as all employees work in different companies located in different geographical areas (9) various outcome measures to assess changes in dietary behaviour and health status (objective and self-reported measures). Objective measurements include BMI, resting blood pressure and urine analysis (24-hr urine collection and spot urine samples). Self-reported measures include the completion of questionnaires (HLFQ, FFQ, FMQ, DEBQ and EQ-5D). (10) Intensive training will be provided for the research team and caterers (environment and combined workplaces) and (11) study progress will be monitored by the logistics committee in all workplaces and the steering committee.

The limitations of the study include:

(1) The non-randomised study design: However, the characteristics of each workplace will be similar including work schedules (shift patterns), company-type (production and office based), skilled and educated workforces. Demographic information from the questionnaires will determine further comparison between worksites. The sample will also be randomly selected from the employee lists.

(2) No allocation of concealment: The workplaces will be purposively selected to ensure that all components of the interventions can be implemented successfully.

(3) Lack of blinding: Given the nature of the workplace interventions (nutrition consultations and/or environmental change), it is not possible to adequately blind personnel or participants. Participants will be masked to the study hypothesis.

(4) Selection bias: healthy employees may be more likely to participate but demographic variables of non-responders will be examined to ensure the participants are representative of the general workforce.

(5) Recall bias and social desirability bias may be evident given that both dietary measurements (FFQ and 24-hour dietary recall) are self-reported. Dietary data may be over- or underestimated. The FFQ will be completed by the participant without the presence of the researcher. The 24-hour dietary recall method is clearly structured with specific food prompts so recall bias may be prevented.

#### 4.5.2. Implications for research and practice

The Food Choice at Work interventions may improve the included employees' dietary behaviours and reduce their diet-related disease risks. This study will provide critical evidence on the effectiveness of complex workplace interventions in the promotion of healthy dietary behaviours in the manufacturing working population. It may assist in the development of future guidelines to improve dietary behaviours in the workplace and will inform future researchers. It may influence national and international catering stakeholders, policy-makers and motivate the food industry to provide healthier food choices. If the findings are positive, it may reduce diet-related disease development and the burden on the healthcare system in the Republic of Ireland.

### 4.6. Ethics

Ethical approval was granted by the Clinical Research Ethics Committee of the Cork Teaching Hospitals in the Republic of Ireland in May 2012 and was amended in March 2013. Permission has been granted by the managing directors and catering managers in all workplaces. Informed consent will be obtained from all participants prior to participation in the study.

### 4.7. Funding sources

This work is supported by the HRB Centre for Health & Diet Research grant (HRC2007/13) which is funded by the Irish Health Research Board and by the Department of Agriculture, Fisheries and Food. Student bursaries have been awarded from the Irish Heart Foundation and the Nutrition and Health Foundation to students involved in the study.

**Figure 8. FCW trial design**

**Cluster controlled trial**

Unit of delivery: **workplace**

Enrolment: Large workplaces assessed for eligibility

Final workplaces selected (n=4)

Allocation of workplaces

**Baseline data collection**

Physical assessments: BMI, WC, BP, urine analysis
Two 24-hr dietary recalls (within 1 week)
Process evaluation
Food frequency questionnaire (FFQ)
Health, lifestyle + food questionnaire (HLFQ)
Economic evaluation (EQ-5D)

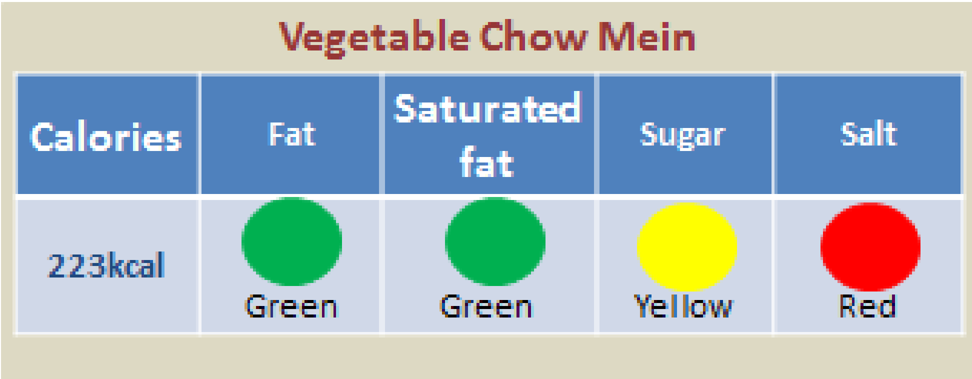
**Implementation of complex dietary interventions**

| Control | Education | Environment | Combined |
|---|---|---|---|
| No changes to be implemented | 1.Monthly group presentations<br><br>2.Individual nutrition consultations (healthy eating booklet and healthy eating chat tables)<br><br>3.Detailed nutrition information:<br>-Monthly posters and leaflets<br>-Monthly emails<br>-Healthy eating traffic light coding system<br>-Quizzes<br>-Shopping card<br>-Personal measurement card | 1.Restriction of fat, saturated fat, sugar and salt.<br><br>2.Increase fibre, fruits and vegetables.<br><br>3. Price discounts for whole fresh fruit.<br><br>4. Strategic positioning of healthier alternatives.<br><br>5. Portion size control. | 1.Restriction of fat, saturated fat, sugar and salt<br><br>2.Increase fibre, fruits and vegetables<br><br>3.Price discounts for whole fresh fruit<br><br>4.Strategic positioning of healthier alternatives<br><br>5.Portion size control<br><br>6.Provide nutrition education (all the elements of the education workplace) |

**Follow-up 3-4 months**: Physical assessments (BMI, WC, BP), two 24-hr dietary recalls (within 1 week), Food motives questionnaire (FMQ), Dutch Eating Behaviour Questionnaire (DEBQ)

**Follow-up 7-9 months + 20-23 months**: All baseline assessments repeated

**Figure 9. Traffic light display**



Geaney, F. 2015. The effect of complex workplace dietary interventions on employees dietary behaviours, nutrition knowledge and health status. PhD Thesis, University College Cork.

Please note that Chapter 5 (pp.149-180) is unavailable due to a restriction requested by the author.

# 6. NUTRITION KNOWLEDGE, DIET QUALITY AND HYPERTENSION IN A WORKING POPULATION

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THIS PAPER WAS PUBLISHED IN PREVENTIVE MEDICINE REPORTS IN 2014 (SEE APPENDIX 4)

## 6.1. Abstract


**Objective**

To examine if employees with higher nutrition knowledge have better diet quality and lower prevalence of hypertension.

**Method**

Cross-sectional baseline data were obtained from a complex workplace dietary intervention trial. Participants included 828 randomly selected employees (18-64 years) recruited from four multinational manufacturing workplaces in Ireland, 2013. A validated questionnaire assessed nutrition knowledge. A FFQ measured diet quality from which a DASH score was constructed. Standardised digital BP monitors measured hypertension.

**Results**

Nutrition knowledge was positively associated with diet quality after adjustment for age, gender, health status, lifestyle and socio-demographic characteristics. The odds of having a high DASH score (better diet quality) were 6 times higher in the highest nutrition knowledge group compared to the lowest group (OR=5.8, 95%CI 3.5 to 9.6). Employees in the highest nutrition knowledge group were 60% less likely to be hypertensive compared to the lowest group (OR=0.4, 95%CI 0.2 to 0.87). However, multivariate analyses were not consistent with a mediation effect of the DASH score on the association between nutrition knowledge and blood pressure.

### Conclusion

Higher nutrition knowledge is associated with better diet quality and lower blood pressure but the inter-relationships between these variables are complex.

## 6.2. Introduction

Hypertension remains a global public health challenge. An estimated 26% of all adults worldwide have hypertension [250]. Hypertension is the primary cause of CVD and 13% of deaths are associated with CVD, 62% of strokes and 49% of ischemic heart disease events are attributable to raised blood pressure [251].

It is possible to reduce the prevalence of hypertension by improving individuals' diet quality [210, 252]. Adherence to the Mediterranean diet has been shown to decrease the risk of cardiovascular diseases [135]. The DASH dietary pattern has significantly reduced blood pressure among both normotensive and hypertensive adults. This pattern promotes low intakes of fat, sodium and processed foods with high intakes of fruit and vegetables [47].

Ambiguity exists regarding the relationship between nutrition knowledge and diet quality. Previous research has indicated that individuals with greater nutrition knowledge are more likely to consume healthier diets [137-139]. Yet, this suggested relationship between nutritional knowledge and diet quality is negated by research advocating that nutritional knowledge alone is not sufficient to influence healthy dietary behaviours [140-142].

The workplace is a suitable setting to promote healthy dietary behaviours [32, 207]. Some workplace dietary interventions focus on behavioural change techniques, such as nutrition education methods alone to improve employees' dietary behaviours. These behavioural change approaches including group and individual nutrition counselling, supervised shopping tours and weekly emails have shown a moderate positive effect on fruit and vegetable consumption [130, 134, 157]. However, the value of these methods is uncertain as many of these studies failed to measure changes in nutrition knowledge. Furthermore the extended effect of nutrition knowledge on specific diet-related diseases like hypertension remains unknown [253]. The study aim was to measure if employees with high nutrition knowledge have better quality diet and lower prevalence of hypertension than those with low nutritional knowledge. We hypothesised that higher nutrition knowledge would predict better diet quality and lower blood pressure and that the relationship between nutrition knowledge and blood pressure would be largely explained by diet quality [135, 137].

## 6.3. Methods

### 6.3.1. Study design

Cross-sectional baseline data were obtained from a large cluster controlled trial, The FCW study [243] . It was a study of the effectiveness and cost-effectiveness of complex dietary interventions that were focused on environmental dietary modifications alone or in combination with nutrition education in four multinational manufacturing workplace settings (See chapter 4 for additional details).

### 6.3.2. Study population

A random sample of 828 participants aged 18-64 years were recruited from the selected workplaces; Control: 100 (70% response rate), Education: 224 (70% response rate), Environment: 112 (91% response rate), Combined: 392 (60% response rate). The number of employees recruited per workplace reflected the difference in company size. The sample was powered to detect a decrease in BMI by 1 $kg/m^2$ and a 2g average fall in dietary salt intake between the control and intervention groups post-delivery of the interventions. Eligible employees were permanent, full-time employees who purchased and consumed at least one daily meal at work. A wide variety of hot and cold meal options were available for employees during working hours. Many food options were served using a buffet-style so employee’s managed the frequency and quantity of their own food items.

### 6.3.3. Data collection

Participants were asked to complete FFQ's, nutrition knowledge questionnaires and demographic questionnaires. Physical assessments were conducted by trained research assistants as per the SOP manual [245]. All data were collected during work hours in the individual workplaces. Participants who did not complete all assessments were excluded from analysis. No incentives were provided to employees participating in the study.

### 6.3.4. Dietary assessments

#### Food frequency questionnaire

The FFQ is an adapted version of the European Prospective Investigation of Cancer (EPIC) FFQ [230] and has been validated for use in the Irish population [222, 246, 254]. Full details of the FFQ have been published elsewhere [222] (Appendix 2). Participants recorded their average frequency of consumption of each food item over the previous year. The FFQ assessed the whole diet and included 150 food items arranged into the main food groups. Frequency of consumption of a medium serving was reported for each food item and later converted into quantities (mg/g) using standard portion sizes. A medium serving was based on recommendations established by the Food Standards Agency and McCance and Widdowson's Food Composition Tables [233]. A specifically designed nutrition software programme, NetWISP4© (Weighed Intake Software Program; Tinuviel Software, Warrington, UK), converted the dietary information to food quantities and nutrient values (see chapter 4 for additional details).

Dietary approaches to stop hypertension (DASH) score

Diet quality was investigated using the DASH score which was constructed based on standard food groups within the FFQ [47] (see chapter 5 for additional details). An overall DASH score was calculated for each participant and was also divided into quintiles. Participants in quintile 5 had the highest DASH score and best diet quality.

### 6.3.5. Socio-demographic and lifestyle indicators

Health, lifestyle and food questionnaire

Socio-demographic (gender, age, ethnicity, education, marital status and work life) and lifestyle characteristics (smoking, alcohol consumption and physical activity) were recorded (see chapter 5 for additional details). Consumption of food supplements, salt usage and self-rated health was also reported.

### 6.3.6. Nutrition knowledge score

Nutrition knowledge (NK) was assessed using the well validated general nutrition knowledge questionnaire (GNKQ) [223]. Participants were asked to complete all questions. Each correct answer scored 1. Incorrect and missing values scored 0. Sub-scale scores were calculated for each domain. The sum of the four sections was calculated to give an overall score with a maximum potential score of 116 (see chapter 5 for additional details).

6.3.7. Physical assessment

All participants underwent one physical assessment where BMI, midway-waist circumference and resting blood pressure were measured. BMI was calculated as kg/m² [158]. Mid-way waist circumference was measured using a Seca 200 measuring tape (see chapter 4 for additional details).

Urinary sodium

Spot urine samples were obtained for analyses of sodium excretion [50]. Each participant provided one early morning sample and one evening sample, taken approximately 12 hours apart e.g. 8am and 8pm. Daily average salt intakes were estimated based on the average between both samples and compared to the upper tolerable limit of 6g/day for Irish populations based on the national guidelines [255].

### 6.4. Statistical analysis

Data were analysed using Stata 12 (StataCorp, College Station, TX, US). Internal consistency of the nutrition knowledge score was measured using the Cronbach's alpha statistic. Univariate analyses were performed to assess the relationship between nutrition knowledge, the DASH score and blood pressure. Baron and Kenny's approach to mediation analyses was used to assess the DASH score (diet as a mediator [143]. For the multivariate logistic regression, the DASH score variable was collapsed to an ordinal variable based on the DASH score quintiles. Participants in quintile 5 had the highest DASH score and best diet quality and quintiles 4-1 had lower DASH scores and progressively poorer quality diets. The high DASH score (quintile 5) and hypertension variables were entered into the models as dichotomous, dependent variables. The nutrition knowledge score variable was recoded as an ordinal variable based on the quintiles and entered into all models as an independent variable. Results were adjusted for potential confounding variables including socio-demographic, lifestyle and health characteristics.

## 6.5. Results

6.5.1. Characteristics of study population

Table 9 summarises the socio-demographic characteristics of the study population. The highest proportion of participants were aged 30-44 years (65.9%), were white Irish (90%), male (68.7%) and had a tertiary education (77.3%). Most employees were not in a managerial or supervisory role (78.4%) and usually worked during the day (68.1%). Table 10 shows the lifestyle, physical status and dietary data for men and women. Almost half of the study population had low physical activity levels (45%). A total of 16.7% of employees were classified as current smokers.

A higher proportion of males (13.4%) reported consuming at least 14 units of alcohol/week compared to females (3.1%). Almost half of all employees reported their general health as 'good' (47%) and consumed food supplements (42.4%). Half of participants were overweight (48.6%) and centrally obese (51.2%). Overweight and obesity were higher among males (54.1% and 22.7%) compared to females (36.3% and 19.7%). Similarly, more men (16%) than women (5.8%) were classified as hypertensive and 36.7% of the total study population exceeded the tolerable upper limit of 6g of salt per day according to their urinary sodium intakes (36.7%). A higher proportion of women (52.9%) than men (36%) had a DASH score in the highest quintile, indicating better diet quality (Table 10).

6.5.2. Nutrition knowledge score and DASH score

The internal consistency for the overall nutrition knowledge score was 0.91. It was measured for each domain as follows: advice from the health experts: 0.56; food groups and food sources: 0.89; food choice: 0.39 and diet-disease relationships; 0.74. Cronbach's alpha ranges from 0 to 1 and a score of ≥ 0.7 is adequately reliable [248]. Employees with nutrition related qualifications (n=11 (1.3%)) had a higher mean nutrition knowledge score (men 78.8 (SD 13.9), women 76.8 (SD 17.8)) than employees without these qualifications (men 66.1 (SD 13.4), women 66.6 (SD 16.5)).

The DASH score was tested against variables not included in the original score. Participants who 'always' added salt to food at the table had a lower DASH score (men 20.8 (4.2), women 22.5 (SD 3.6)) than those who reported 'never' adding salt to food (men 25.1 (SD 4.1), women 25.4 (SD 4.5)). According to Cohen's standard effect size cut-off points [256], differences in nutritional knowledge scores of 2.9, 4.6 and 7.4 represented a small, moderate and large effect size, respectively. Changes in DASH scores of 0.85, 2.0 and 3.2 represented a small, moderate and large effect size, respectively.

The unadjusted mean nutrition knowledge scores for men and women are shown in Figure 12. Employees with higher nutrition knowledge scores had a tertiary education (men 67.9 (SD 13.0), women 71.4 (SD 13.3)), were not hypertensive (men

66.7 (SD 13.4), women 67.2 (SD 16.4)), consumed ≤6g/day of salt (men 68.5 (SD 12.4), women 69.3 (SD 15.6)) and were in the highest DASH score quintile (men 71.1 (SD 15.2), women 70.4 (SD 14.7)). The mean nutrition knowledge score for all employees was 66.4 out of a maximum 116. On average, employees scored better in the 'advice from the health experts' (mean score = 8.0 out of 11) and the 'food choice' domains (mean score = 7.2 out of 12). Overall, nutrition knowledge scores were lower for the other domains including food groups and food sources (mean score = 42.0 out of 71) and diet-disease relationships (mean score = 6.7 out of 22).

### 6.5.3. Association between nutrition knowledge, diet quality and hypertension

The relationship between nutrition knowledge and diet quality is evident in figure 13, showing significant positive trends between nutrition knowledge scores and diet quality (DASH score) for each of the four domains ($p<0.001$).

In multivariate analysis adjusted for age, gender and energy intake, employees in the highest nutrition knowledge quintile had a higher overall DASH score (p for trend <0.001) (Table 11). Employees in this quintile only consumed the recommended servings for vegetables (4.82 (SD 2.9), p for trend <0.001) and did not meet the recommendations for whole grains, fruit, legumes and low-fat dairy foods. Nevertheless, employees in this group also had the lowest consumption of red processed meat, sweetened snacks and beverages and salty snacks (p for trend <0.05). All quintiles exceeded the recommended sodium consumption of 2300mg.

Inverse associations with nutrition knowledge and blood pressure were evident in Table 12. Between the lowest nutrition knowledge quintile and the highest quintile, systolic blood pressure and diastolic blood pressure differed by 2.2 mmHg and 2.1 mmHg respectively. The proportion of hypertensive employees also differed by 16.1%.

For the mediation analysis, nutrition knowledge was directly associated with hypertension (β = -0.02 (CI = 0.97-1.0), p<0.05). Nutrition knowledge was positively associated with the DASH score (β= 0.09 (CI = 0.07-0.11), p<0.001). The DASH score was associated with hypertension (β = 0.07 (CI = 0.89-1.0), p<0.05). If the association between nutrition knowledge and hypertension was primarily mediated via diet quality as reflected by the DASH score, one would expect attenuation of this association on the introduction of the DASH score into the model. The findings of the mediation analysis were not consistent with the hypothesis as the β co-efficient increased (albeit statistically insignificant) in the latter analysis (β = -0.05 (CI = 0.89-1.01), p=0.107).

In the multivariate logistic regression analysis, there was a positive association and consistent gradient observed between the high DASH score and nutrition knowledge score when the model was adjusted for age, gender and energy intake (Table 13). The odds of having a high DASH score were 6 times higher in the highest nutrition knowledge group when compared to the lowest group (OR=5.8, 95% CI 3.5

to 9.6). The association remained significant with the sequential addition of each confounding variable (<0.001).

A negative association was observed between nutrition knowledge and hypertension. Employees in the highest nutrition knowledge group were 60% less likely to be hypertensive when compared to the lowest group (OR=0.4, 95% CI 0.2 to 0.87). The association remained significant in the fully adjusted analysis ($p<0.05$). Adjusting for the DASH score did not alter the association between nutrition knowledge and hypertension.

## 6.6. Discussion

### 6.6.1. Principal findings

This study revealed four principal findings. Nutrition knowledge among this working population was relatively low (average of 66.4 out of 116) and employees were lacking knowledge in particular areas including 'food groups and food sources' and 'diet-disease relationships'. Independent of age, gender and energy intake, nutrition knowledge was significantly positively associated with diet quality (DASH score). Adjustment for socio-demographic, health status measures and lifestyle behaviours characteristics did not alter the association. Employees with higher nutrition knowledge had a higher DASH score. Higher nutrition knowledge was associated with lower blood pressure. Employees in the highest nutrition knowledge group were significantly less likely to be hypertensive when compared to those in the lowest knowledge group even after adjustment for potential confounding variables. Conflicting to our original hypothesis, the DASH score did not mediate the relationship between nutrition knowledge and hypertension.

### 6.6.2. Comparison with other studies

Some studies suggest that nutrition knowledge is a distal predictor for diet quality and that ‘simply changing knowledge is unlikely to have the desired effect’ [137, 257]. Conversely, our findings support the existing evidence that nutrition knowledge is significantly associated with diet quality [135-137].

This is the first time that this relationship has been investigated in an educated working population using validated measures for nutrition knowledge [137] and diet quality [47]. Nutrition knowledge has been shown to act as a partial mediator between socio-economic status (education attainment used as a proxy) [135-137] and diet quality in other populations. However, education status did not modify the association between nutrition knowledge and diet quality in our study given that over 80% of the sample had a tertiary education. Nutrition knowledge has also been associated with a lower prevalence of obesity [135] and our findings show a similar relationship with hypertension but with employees with the highest nutrition knowledge only.

#### 6.6.3. Strengths and limitations

Strengths of the study include that all workplaces had similar characteristics as they were all manufacturing workplaces with similar work schedules. Employees had comparable demographics, health status and lifestyle characteristics. BMI, BP, central obesity and urinary sodium were objectively measured by trained research assistants according to the study SOP manual [245]. The use of 24-hour ambulatory BP monitoring would have provided a more accurate measure of the employees BP throughout the day while at work and at home. There was little missing data for all variables besides alcohol consumption but given that this data was collected within the workplace, employees may have been reluctant to report their alcohol intake.

Limitations of the present study include the use of a cross-sectional study design, issues regarding participant recruitment, reliability and measurement error in the assessment of diet quality. We have to be cautious when interpreting the findings of a cross-sectional study but findings are consistent with the published data regarding the relationship between nutrition knowledge and diet quality [137-139]. Although all employees were randomly selected, selection bias cannot be ruled out as healthy employees may have been more likely to participate. The effect of controlled hypertensives is unknown as medication data was unavailable but excluding self-reported hypertensives from the analysis did not alter the results.

The internal consistency values for the overall score (0.91) and for two domains including food groups and food sources and diet-disease relationships were high in this occupational sample (0.89 and 0.74, respectively). Lower values were recorded for the remaining domains (advice from the health experts: 0.56 and food choice: 0.39, respectively). Reliability co-efficients are known to be somewhat dependent on the number of items being measured. Lower Cronbach alpha values were obtained for the two domains with the least number of items. These findings were also evident in previous studies conducted in the UK and Turkey but our findings were more comparable to an Australian study [137, 258, 259]. However, the values for the food choice domain were still lower in the present study when compared to the Australian study (Australian study: 0.55; this study: 0.39). A reason for this could be that there are differences in the recommended healthy eating guidelines between both countries. Nevertheless, the overall questionnaire seems to be a reliable tool for Irish occupational settings but there is a need to review specific items to comply with the Irish healthy eating guidelines.

There is also a possibility of measurement error in the assessment of diet quality. Recall bias may have been introduced as the FFQ was self-reported. Social desirability reporting bias cannot be ruled out as employees with higher nutrition knowledge may have overestimated their intakes of healthy foods. However, employees were masked to the study hypothesis. Residual confounding should also be considered in our interpretation of the associations between nutrition knowledge, DASH score and blood pressure. Specifically, nutrition knowledge is a marker of education attainment and other cognitive skills that were not fully captured in these analyses.

### 6.6.4. Study implications

The study findings will inform future researchers. In particular, the effect of future workplace dietary interventions could be positively improved if the following points are considered. Given the complexities of dietary behaviour, it is important to acknowledge that specific psychological resources like memory, attention and self-control also have an impact on eating behaviours and diet quality. Although some individuals may have adequate nutrition knowledge and may be mindful of the health benefits of a healthy diet, research indicates that there is a gap between good intentions and actual behaviour [260]. Nutrition knowledge and intentions are not enough to guarantee goal directed behaviour [261]. Interventions that also consider individuals psychological resources and environmental factors have been shown to be more effective in promoting healthy dietary behaviours [213, 260].

Furthermore, to increase our understanding of the change process, researchers should also concentrate on the underlying theories that may provide explanations for effective dietary behaviour change. For example, previous studies have suggested that the social cognitive theory may be able to explain how other variables like self-regulation and self-efficacy can help to facilitate the adoption of health eating behaviours among individuals [253, 262].

### 6.7. Conclusion

The findings show that higher nutrition knowledge is associated with better diet quality and lower blood pressure in a manufacturing working population even with adjustment for health status, lifestyle behaviours and socio-demographic characteristics. To the contrary of our original hypothesis, we did not find that the association between nutrition knowledge and hypertension was largely mediated by diet quality (DASH score). While the inter-relations between nutrition knowledge, diet quality and health outcomes such as blood pressure are complex, these findings highlight the value of nutrition education as a component of workplace dietary interventions. In addition to nutrition education, future workplace dietary interventions need to implement and evaluate long-term multi-level complex interventions that consider psychological and environmental factors to reduce the burden of hypertension and other diet-related diseases.

## Table 9. Socio-demographic characteristics for men and women

| | Men n=569 (68.7%) n (%) | Women n=259 (31.3%) n (%) | Total n=828 (100%) n (%) |
|---|---|---|---|
| **Socio-demographic** | | | |
| **Age group (years)** | | | |
| 18-29 | 54 (9.5) | 36 (13.9) | 90 (10.9) |
| 30-44 | 383 (67.3) | 163 (62.9) | 546 (65.9) |
| 45-65 | 132 (23.2) | 60 (23.2) | 192 (23.2) |
| Missing | 0 | 0 | 0 |
| **Ethnicity** | | | |
| White Irish | 516 (90.7) | 229 (88.4) | 745 (90.0) |
| Other[a] | 52 (9.1) | 29 (11.2) | 81 (9.8) |
| Missing | 1 (0.2) | 1 (0.4) | 2 (0.2) |
| **Educational level** | | | |
| None/ primary | 5 (0.9) | 1 (0.4) | 6 (0.7) |
| Secondary | 98 (17.2) | 84 (32.4) | 182 (22.0) |
| Tertiary | 466 (81.9) | 174 (67.2) | 640 (77.3) |
| Missing | 0 | 0 | 0 |
| **Marital status** | | | |
| Married/cohabiting | 420 (73.8) | 149 (57.5) | 569 (68.7) |
| Separated/divorced/ widowed | 18 (3.2) | 16 (6.2) | 34 (4.1) |
| Single/never married | 130 (22.8) | 94 (36.3) | 224 (27.1) |
| Missing | 1 (0.2) | 0 | 1 (0.1) |
| **Job position** | | | |
| Manager | 77 (13.5) | 15 (5.8) | 92 (11.1) |
| Supervisor | 65 (11.4) | 22 (8.5) | 87 (10.5) |
| Non-manager/Non-supervisor | 427 (75.0) | 222 (85.7) | 649 (78.4) |
| Missing | 0 | 0 | 0 |
| **Usual working hours** | | | |
| Day-time (≤8 hours) | 381 (67.0) | 183 (70.7) | 564 (68.1) |
| Night-time (≤8 hours) | 6 (1.1) | 8 (3.1) | 14 (1.7) |
| Shift-work | 182 (32.0) | 68 (26.3) | 250 (30.2) |
| Missing | 0 | 0 | 0 |

[a] Other: Any other white, black or Asian ethnicities including mixed background

## Table 10. Lifestyle, physical status and dietary data for men and women

| | Men n=569 (68.7%) n (%) | Women n=259 (31.3%) n (%) | Total n=828 (100%) n (%) |
|---|---|---|---|
| **Lifestyle** | | | |
| **Smoking status** | | | |
| Never smoked | 307 (54.0) | 130 (50.2) | 437 (52.8) |
| Former smoker | 186 (32.7) | 66 (25.5) | 252 (30.4) |
| Current smoker | 75 (13.2) | 63 (24.3) | 138 (16.7) |
| Missing | 1 (0.2) | 0 | 1(0.1) |
| **Alcohol consumption (units/week)** | | | |
| No drink | 117 (20.6) | 68 (26.3) | 185 (22.3) |
| 1-<7 | 106 (18.6) | 60 (23.2) | 166 (20.0) |
| 7-<14 | 80 (14.1) | 32 (12.4) | 112 (13.5) |
| 14-<21/>21 | 76 (13.4) | 8 (3.1) | 84 (10.1) |
| Missing | 190 (33.4) | 91 (35.1) | 281 (33.9) |
| **Physical activity** | | | |
| Low | 335 (58.9) | 37 (14.3) | 372 (44.9) |
| Moderate | 127 (22.3) | 96 (37.1) | 223 (26.9) |
| High | 104 (18.3) | 124 (47.8) | 228 (27.5) |
| Missing | 3 (0.5) | 2 (0.8) | 5 (0.6) |
| **Health** | | | |
| **BMI ($kg/m^2$)**[a] | | | |
| Underweight / normal weight | 132 (23.2) | 114 (44.0) | 246 (29.7) |
| Overweight | 308 (54.1) | 94 (36.3) | 402 (48.6) |
| Obese | 129 (22.7) | 51 (19.7) | 180 (21.7) |
| Missing | 0 | 0 | 0 |
| **Central obesity**[b] | | | |
| Normal | 298 (52.4) | 106 (40.9) | 404 (48.8) |
| Centrally obese | 271 (47.6) | 153 (59.1) | 424 (51.2) |
| Missing | 0 | 0 | 0 |
| **Hypertension**[c] | | | |
| Not hypertensive | 478 (84) | 243 (93.8) | 721 (87.1) |
| Hypertensive | 91 (16) | 15 (5.8) | 106 (12.8) |
| Missing | 0 | 1(0.4) | 1 (0.1) |
| **Self-reported general health** | | | |
| Excellent | 50 (8.8) | 30 (11.6) | 80 (9.7) |
| Very good | 177 (31.1) | 100 (38.6) | 277 (33.5) |
| Good | 288 (50.6) | 101 (39.0) | 389 (47.0) |
| Fair/ Poor | 53 (9.3) | 28 (10.8) | 81 (9.8) |
| Missing | 1 (0.2) | 0 | 1 (0.1) |
| **Diet** | | | |
| **Consumption of food supplements** | | | |
| Yes | 223 (39.2) | 128 (49.4) | 351 (42.4) |
| No | 334 (58.7) | 127 (49.0) | 461 (55.7) |
| Missing | 12 (2.1) | 4 (1.5) | 16 (1.9) |
| **Daily salt intake (measured from urinary sodium)** | | | |
| ≤6g/day | 347 (61.0) | 173 (66.8) | 520 (62.8) |
| >6g/day | 219 (38.5) | 85 (32.8) | 304 (36.7) |
| Missing | 3 (0.5) | 1 (0.4) | 4 (0.5) |

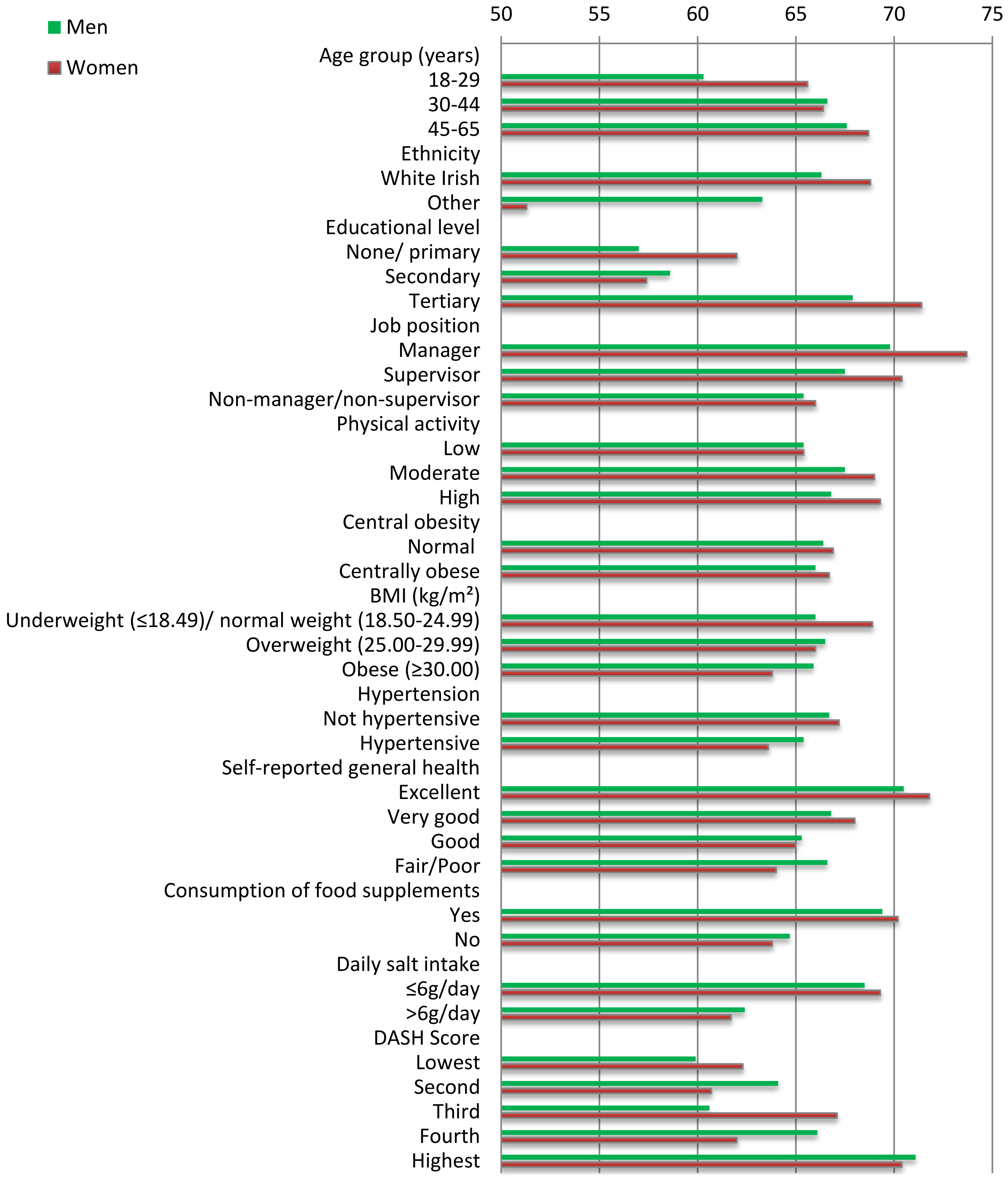
**Table 10. Continued**

| **DASH Score (quintiles)** | | | |
|---|---|---|---|
| Lowest | 63 (11.1) | 8 (3.1) | 71 (8.6) |
| Second | 66 (11.6) | 17 (6.6) | 83 (10.0) |
| Third | 71 (12.5) | 22 (8.5) | 93 (11.2) |
| Fourth | 155 (27.2) | 73 (28.2) | 228 (27.5) |
| Highest | 205 (36.0) | 137 (52.9) | 342 (41.3) |
| Missing | 9 (1.6) | 2 (0.8) | 11 (1.3) |

Abbreviations: BMI, body mass index; DASH, Dietary Approaches to Stop Hypertension.

[a] BMI: underweight = ≤18.49; normal weight=18.50-24.99; overweight=25.00-29.99, obese=≥30.00
[b] Central obesity: average mid-way waist circumference ≥94cm for men or ≥80cm for women
[c] Hypertension: average systolic blood pressure ≥140 mmHg or average diastolic blood pressure ≥90 mmHg

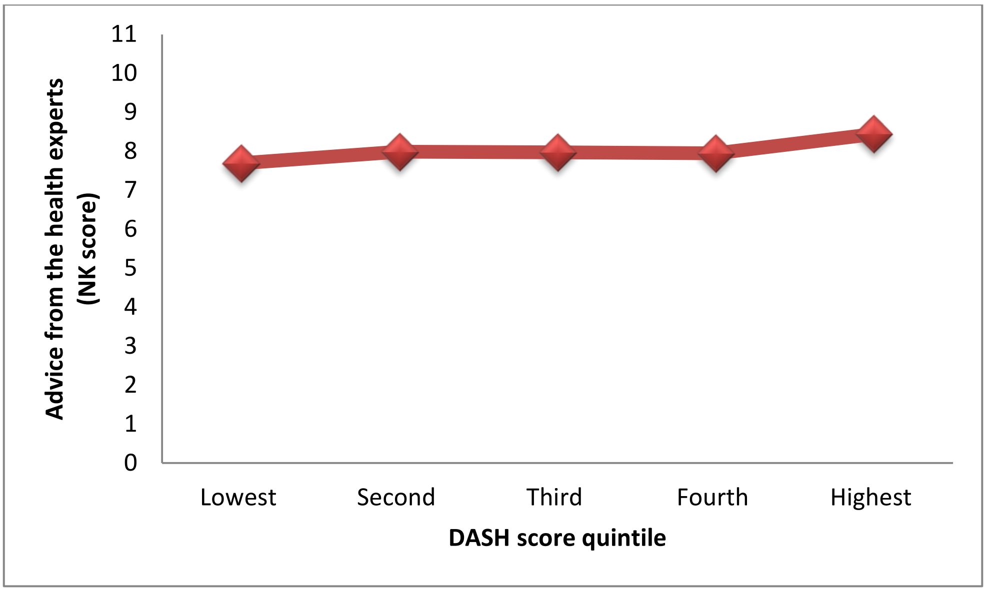
**Figure 12. Unadjusted mean nutrition knowledge scores for men and women**




Abbreviations: BMI, body mass index; DASH, Dietary Approaches to Stop Hypertension.

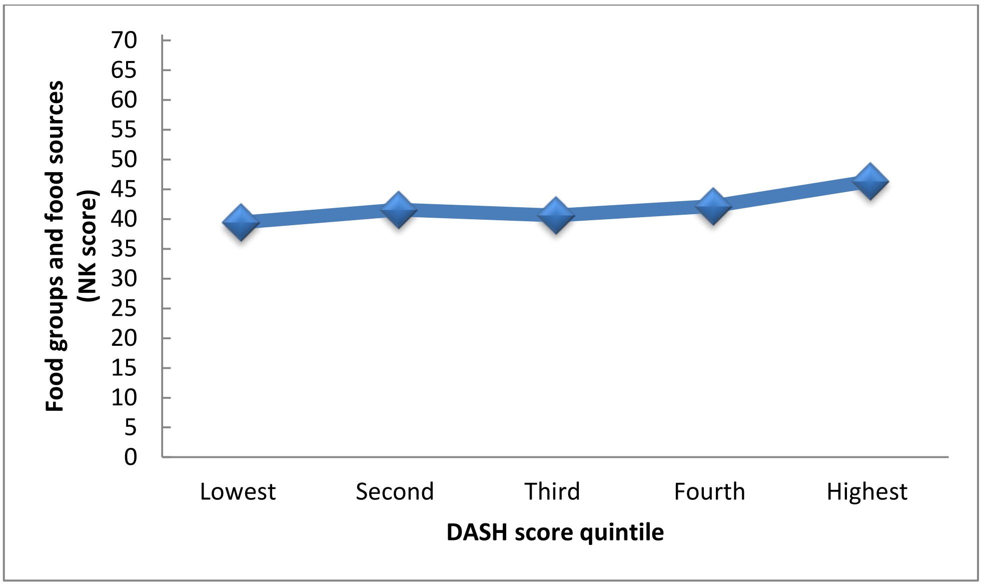
**Figure 13. Comparison of nutrition knowledge score for each domain by DASH score quintile**

(a) Domain 1: advice from the health experts (mean = 8.0, minimum score = 7.7, maximum score = 8.4)



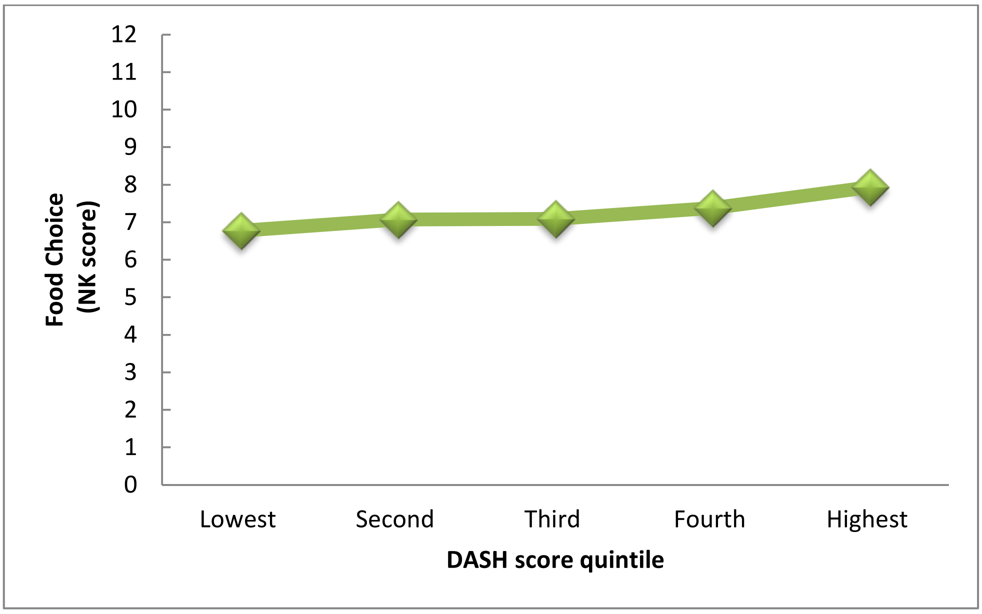

*p* for trend <0.001

(b) Domain 2: food groups and food sources (mean = 42.0, minimum score = 39.4, maximum score = 46.4)



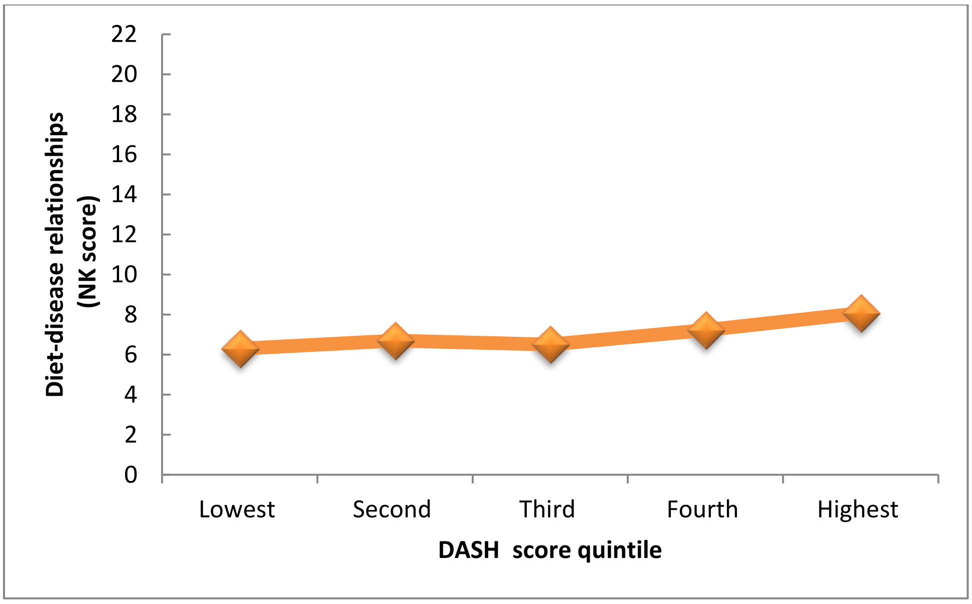

*p* for trend <0.001

(c) Domain 3: food choice (mean = 7.2, minimum score = 6.8, maximum score = 7.9)




*p* for trend <0.001

(d) Domain 4: diet-disease relationships (mean = 6.7, minimum score = 6.3, maximum score= 8.1)




*p* for trend <0.001

**Table 11. Adherence to daily DASH diet recommendations according to nutrition knowledge score**

| Food Group | Recommended daily servings in DASH diet | Nutrition knowledge score quintile [a] Mean (SD) Lowest (≤55) n= 175, 21.1% | Second (56-64) n= 160, 19.3 | Third (65-71) n= 160, 19.3% | Fourth (72-79) n= 182, 22% | Highest (80+) n= 151, 18.2% | *p* trend [b] | *p* trend [c] |
|---|---|---|---|---|---|---|---|---|
| **Whole grains** | 3 | 1.54 (1.4) | 1.59 (1.3) | 2.01 (1.8) | 1.73 (1.3) | 2.19 (1.5) | <0.001 | <0.001 |
| **Fruit** | 4-6 | 1.50 (1.4) | 1.57 (1.3) | 1.76 (1.3) | 1.88 (1.6) | 2.23 (1.5) | <0.001 | <0.001 |
| **Vegetables** | 4-6 | 3.13 (2.4) | 2.99 (2.1) | 3.75 (2.4) | 3.83 (2.5) | 4.82 (2.9) | <0.001 | <0.001 |
| **Legumes** | 0.64 (3-6/week) | 0.33 (0.3) | 0.42 (0.4) | 0.37 (0.4) | 0.50 (0.5) | 0.62 (1.0) | <0.001 | <0.001 |
| **Low-fat dairy foods** | 2-4 | 0.21 (0.3) | 0.19 (0.3) | 0.23 (0.3) | 0.26 (0.4) | 0.30 (0.4) | 0.046 | 0.123 |
| **Red processed meat** | Limited | 1.38 (0.9) | 1.15 (0.7) | 1.01 (0.7) | 1.00 (0.7) | 0.88 (0.5) | <0.001 | <0.001 |
| **Sweetened snacks and beverages** | Limited | 2.86 (2.8) | 2.32 (1.9) | 2.99 (2.8) | 2.36 (2.4) | 2.13 (1.9) | 0.004 | 0.001 |
| **Salty snacks** | Limited | 0.58 (0.6) | 0.63 (0.7) | 0.52 (0.5) | 0.50 (0.4) | 0.46 (0.4) | 0.027 | 0.019 |
| **Na consumption** | 2300 mg | 3099.60 (1410.7) | 3007.77 (1145.4) | 3057.26 (1279.8) | 3013.43 (1169.0) | 3110.51 (1082.1) | 0.912 | 0.558 |
| **Overall DASH score** | | 21.87 (4.2) | 22.63 (4.6) | 23.89 (4.3) | 24.45 (4.4) | 25.83 (4.1) | <0.001 | <0.001 |

Abbreviations: DASH, Dietary Approaches to Stop Hypertension.

[a] Figures are unadjusted
[b] *p* for trend unadjusted
[c] *p* for trend adjusted for age, gender and energy intake

**Table 12. Distribution of blood pressure according to nutrition knowledge score**

| Food Group | Nutrition knowledge score (quintile) Mean (SD) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Lowest (≤55) n= 175 (21.1%)** | **Second (56-64) n= 160 (19.3%)** | **Third (65-71) n= 160 (19.3%)** | **Fourth (72-79) n= 182 (22%)** | **Highest (80+) n= 151 (18.2%)** | ***p* trend [b]** | ***p* trend [c]** |
| **Mean SBP (SD)** | 120.6 (15.5) | 121.1 (13.2) | 120.5 (15.4) | 122.9 (14.8) | 118.4 (14.2) | 0.098 | 0.337 |
| **Mean DBP (SD)** | 75.3 (10.3) | 75.1 (9.2) | 74.4 (9.5) | 75.3 (10.1) | 73.2 (8.0) | 0.240 | 0.114 |
| **Hypertensive [a], n (%)** | 29 (27.4) | 17 (16) | 20 (18.9) | 28 (26.4) | 12 (11.3) | 0.129 | 0.141 |

Abbreviations: SBP, systolic blood pressure; DBP, diastolic blood pressure.

[a] Hypertension defined on blood pressure ≥140/≥90 mmHg
[b] *p* for trend unadjusted
[c] p for trend adjusted age, gender and energy intake

**Table 13. Odds ratios of a high DASH score or being hypertensive according to total nutrition knowledge scores**

| | Model 1 [a] | | | Model 2 [b] | | | Model 3 [c] | | | Model 4 [d] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **High DASH score** [e] | **OR** | **95% CI** | ***p*** | **OR** | **95% CI** | ***p*** | **OR** | **95% CI** | ***p*** | | | |
| *Nutrition knowledge* | | | | | | | | | | | | |
| Lowest | -1- | Referent | - | -1- | Referent | - | -1- | Referent | - | | | |
| Second | 1.5 | (0.89-2.45) | 0.133 | 1.8 | (0.95-3.47) | 0.073 | 1.9 | (0.96-3.57) | 0.066 | | | |
| Third | 2.7 | (1.63-4.34) | <0.001 | 3.0 | (1.62-5.64) | 0.001 | 3.2 | (1.68-6.01) | <0.001 | | | |
| Fourth | 3.2 | (2.00-5.20) | <0.001 | 3.5 | (1.90-6.33) | <0.001 | 3.5 | (1.88-6.52) | <0.001 | | | |
| Highest | 5.8 | (3.48-9.57) | <0.001 | 7.5 | (3.93-14.28) | <0.001 | 7.5 | (3.83-14.6) | <0.001 | | | |
| | | *p* trend <0.001 | | | *p* trend <0.001 | | | p trend <0.001 | | | | |
| **Hypertension** [f] | **OR** | **95%CI** | ***p*** | ***OR*** | ***95% CI*** | ***p*** | ***OR*** | ***95% CI*** | ***p*** | ***OR*** | ***95% CI*** | ***p*** |
| *Nutrition knowledge* | | | | | | | | | | | | |
| Lowest | -1- | Referent | - | -1- | Referent | - | -1- | Referent | - | -1- | Referent | - |
| Second | 0.6 | (0.32-1.19) | 0.152 | 0.5 | (0.21-1.91) | 0.117 | 0.5 | (0.21-1.28) | 0.154 | 0.6 | (0.23-1.39) | 0.213 |
| Third | 0.7 | (0.39-1.37) | 0.324 | 0.6 | (0.24-1.25) | 0.152 | 0.6 | (0.26-1.40) | 0.253 | 0.5 | (0.22-1.34) | 0.185 |
| Fourth | 0.9 | (0.48-1.54) | 0.619 | 0.7 | (0.35-1.49) | 0.380 | 0.9 | (0.39-1.83) | 0.672 | 0.8 | (0.38-1.89) | 0.680 |
| Highest | 0.4 | (0.20-0.87) | 0.020 | 0.3 | (0.09-0.66) | 0.006 | 0.3 | (0.11-0.90) | 0.030 | 0.3 | (0.10-0.89) | 0.029 |
| | | *p* trend <0.001 | | | *p* trend <0.001 | | | *p* trend <0.001 | | | *p* trend <0.001 | |

[a] Model 1: Adjusted for age, gender and energy intake
[b] Model 2: + BMI, mid-way waist circumference, physical activity, smoking, alcohol
[c] Model 3: + ethnicity, job position, marital status and education
[d] Model 4: + DASH (quintile)

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Please note that Chapter 7 (pp.211-229) is unavailable due to a restriction requested by the author.

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# 9. APPENDICES

# Appendix 1. Supplementary tables for chapter 3

## Table 14. Scoping search strategy for systematic review

| **Scoping search strategy: Pubmed** | |
|---|---|
| 1. | (randomised controlled trial[pt] OR controlled clinical trial[pt] OR randomised controlled trials[mh] OR random allocation[mh] OR double-blind method[mh] OR single-blind method[mh] OR clinical trial[pt] OR clinical trials[mh] OR ("clinical trial"[tw]) OR ((singl*[tw] OR doubl*[tw] OR trebl*[tw] OR tripl*[tw]) AND (mask*[tw] OR blind*[tw])) OR ("latin square"[tw]) OR placebos[mh] OR placebo*[tw] OR random*[tw] OR research design[mh:noexp] OR comparative study OR evaluation studies OR follow-up studies[mh] OR prospective studies[mh] OR cross-over studies[mh] OR control OR controls OR prospectiv*[tw] OR volunteer*[tw]) **This complex search string is the Cochrane highly sensitive search filter for controlled trials.** |
| 2. | Controlled Trial OR non-randomised controlled trials OR non-randomised controlled trial |
| 3. | Controlled before and after study OR “before and after study” |
| 4. | Intervention Studies/[major] |
| 5. | Follow-up Studies/ [major] |
| 6. | OR/ 1-5 = 5602065 |
| 7. | Workplace/ [major] |
| 8. | workplace* OR Worksite* OR work location* OR work setting* |
| 9. | OR/ 7-8 |
| 10. | Adult/ |
| 11. | Humans/ |
| 12. | 9 AND 10 AND 11 |
| 13. | 6 AND 12 |
| 14. | Diet/ [Majr] |
| 15. | Diet Records/ [Majr] |
| 16. | Diet Surveys/ [Majr] |
| 17. | Health Knowledge, Attitudes, Practice/[Majr] |
| 18. | Feeding Behavior/ [major] |
| 19. | Food Services/[major] |
| 20. | Food Preferences/[major] |
| 21. | Food Habits/ [major] |
| 22. | OR/14-21 |
| 23. | 13 AND 22 |
| 24. | Health Promotion/ [Majr] |
| 25. | Occupational Health Services/ |
| 26. | Body Mass Index/ |
| 27. | Blood Pressure/ |
| 28. | Waist Circumference/ |
| 29. | OR/ 24-28 |
| 30. | 23 AND 29 |

## Table 15. PubMed search strategy

| | |
|---|---|
| 1. | (randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized controlled trials[mh] OR random allocation[mh] OR double-blind method[mh] OR single-blind method[mh] OR clinical trial[pt] OR clinical trials[mh] OR ("clinical trial"[tw]) OR ((singl*[tw] OR doubl*[tw] OR trebl*[tw] OR tripl*[tw]) AND (mask*[tw] OR blind*[tw])) OR ("latin square"[tw]) OR placebos[mh] OR placebo*[tw] OR random*[tw] OR research design[mh:noexp] OR comparative study OR evaluation studies OR follow-up studies[mh] OR prospective studies[mh] OR cross-over studies[mh] OR control OR controls OR prospectiv*[tw] OR volunteer*[tw]) = 5596551 |
| This complex search string is the Cochrane highly sensitive search filter for controlled trials (Robinson et al. Int J Epidemiol. 2002 Feb;31(1):150-3). | |
| 2. | Controlled Trial OR non-randomised controlled trials OR non-randomized controlled trial = 497430 |
| 3. | Controlled before and after study OR “before and after study” = 105968 |
| 4. | Intervention Studies/[majr] = 246 |
| 5. | Follow-up Studies/ [majr] = 475 |
| 6. | OR/ 1-5 = 5602065 |
| 7. | Workplace/ [majr] = 10540 |
| 8. | workplace* OR Worksite* OR work location* OR work setting*= 28230 |
| 9. | OR/ 7-8 = 28230 |
| 10. | Adult/ = 4879342 |
| 11. | Humans/ = 11868610 |
| 12. | 9 AND 10 AND 11 = 10534 |
| 13. | 6 AND 12 = 6040 |
| 14. | Diet/ [Majr] = 69147 |
| 15. | Diet Records/ [Majr] = 646 |
| 16. | Diet Surveys/ [Majr] = 1622 |
| 17. | Health Knowledge, Attitudes, Practice/[Majr] = 28268 |
| 18. | Feeding Behavior/ [majr] = 49402 |
| 19. | Food Services/[majr]= 7767 |
| 20. | Food Preferences/[majr] = 4341 |
| 21. | Food Habits/ [majr] = 7795 |
| 22. | OR/14-21 = 142883 |
| 23. | 13 AND 22 = 278 |
| 24. | Health Promotion/ [Majr] =43535 |
| 25. | Occupational Health Services/ = 6753 |
| 26. | Body Mass Index/ = 59558 |
| 27. | Blood Pressure/ = 228695 |
| 28. | Waist Circumference/ = 2109 |
| 29. | OR/ 24-28 = 333638 |
| 30. | 23 AND 29 = 90 articles. |

## Table 16. Medline search strategy

| |
|---|
| 1. ( randomized controlled trial OR controlled clinical trial OR randomized controlled trials OR random allocation OR double-blind method OR single-blind method OR clinical trial OR clinical trials OR ("clinical trial") OR (singl* OR doubl* OR trebl* OR tripl*) AND (mask* OR blind*) OR ("latin square") OR placebos OR placebo* OR random* OR research design OR comparative study OR evaluation studies OR follow-up studies OR prospective studies OR cross-over studies OR control OR controls OR prospectiv* OR volunteer* ) = 4254406 |
| This complex search string is the Cochrane highly sensitive search filter for controlled trials (Robinson et al. Int J Epidemiol. 2002 Feb;31(1):150-3). |
| 2. Controlled Trial OR non-randomised controlled trials OR non-randomized controlled trial = 96076 |
| 3. Controlled before and after study OR “before and after study” = 17019 |
| 4. Intervention Studies/[Mesh Heading Phrase (mh)] = 4868 |
| 5. Follow-up Studies/ [mh] = 424409 |
| 6. OR/ 1-5 = 4260603 |
| 7. Workplace/ [mh] = 10426 |
| 8. workplace* OR Worksite* OR work location* OR work setting* = 53408 |
| 9. OR/ 7-8 = 53409 |
| 10. Adult/[mh] = 3 518 888 |
| 11. Humans/[mh] = 11818093 |
| 12. 9 AND 10 AND 11 = 16575 |
| 13. 6 AND 11 = 872 |
| 14. Diet/ [mh] = 157803 |
| 15. Diet Records/ [mh] = 3344 |
| 16. Diet Surveys/ [mh] = 5399 |
| 17. Health Knowledge, Attitudes, Practice/[mh] = 56400 |
| 18. Feeding Behavior/ [mh] = 32446 |
| 19. Food Services/[mh]= 3696 |
| 20. Food Preferences/[mh] = 7800 |
| 21. Food Habits/ [mh] = 16656 |
| 22. OR/14-21 = 258405 |
| 23. 13 AND 22 = 42 articles |

## Table 17. Embase search strategy

| | |
|---|---|
| 1. | (randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized controlled trials[mh] OR random allocation[mh] OR double-blind method[mh] OR single-blind method[mh] OR clinical trial[pt] OR clinical trials[mh] OR ("clinical trial"[tw]) OR ((singl*[tw] OR doubl*[tw] OR trebl*[tw] OR tripl*[tw]) AND (mask*[tw] OR blind*[tw])) OR ("latin square"[tw]) OR placebos[mh] OR placebo*[tw] OR random*[tw] OR research design[mh:noexp] OR comparative study OR evaluation studies OR follow-up studies[mh] OR prospective studies[mh] OR cross-over studies[mh] OR control OR controls OR prospectiv*[tw] OR volunteer*[tw]) = 1310099 |
| This complex search string is the Cochrane highly sensitive search filter for controlled trials (Robinson et al. Int J Epidemiol. 2002 Feb;31(1):150-3). | |
| 2. | Controlled Trial OR non-randomised controlled trials = 3592857 |
| 3. | Controlled before and after study OR “before and after study” = 436 |
| 4. | Intervention = 301389 |
| 5. | Intervention Studies/[majr] = 513 |
| 6. | Follow-up Studies/ [majr] = 8837 |
| 7. | OR/ 1-5 = 4489761 |
| 8. | Workplace/ [majr] = 2249 |
| 9. | workplace* OR Worksite* OR work location* OR work setting*= 24690 |
| 10. | OR/ 7-8 = 24690 |
| 11. | 6 AND 11 = 8072 |
| 12. | Diet/ = 41873 |
| 13. | Diet Records/ = 56364 |
| 14. | Diet Surveys/ = 108040 |
| 15. | Health Knowledge, Attitudes, Practice/ = 376 |
| 16. | Feeding Behavior/ = 58179 |
| 17. | Food Services/[majr]= 2364 |
| 18. | Food Preferences/[majr] = 1302 |
| 19. | Food Habits/ [majr] = 7795 |
| 20. | OR/14-21 = 218422 |
| 21. | 13 AND 22 = 326 |
| Limits: | |
| Adult (18-65 yrs) | |
| Human | |
| Total = 183 articles | |

## Table 18. Psych info search strategy

| | |
|---|---|
| 1. | ( randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized controlled trials[mh] OR random allocation[mh] OR double-blind method[mh] OR single-blind method[mh] OR clinical trial[pt] OR clinical trials[mh] OR ("clinical trial"[tw]) OR ((singl*[tw] OR doubl*[tw] OR trebl*[tw] OR tripl*[tw]) AND (mask*[tw] OR blind*[tw])) OR ("latin square"[tw]) OR placebos[mh] OR placebo*[tw] OR random*[tw] OR research design[mh:noexp] OR comparative study OR evaluation studies OR follow-up studies[mh] OR prospective studies[mh] OR cross-over studies[mh] OR control OR controls OR prospectiv*[tw] OR volunteer*[tw] ) = 22657 |
| This complex search string is the Cochrane highly sensitive search filter for controlled trials (Robinson et al. Int J Epidemiol. 2002 Feb;31(1):150-3). | |
| 2. | Controlled Trial OR non-randomised controlled trials OR non-randomized controlled trial = 17866 |
| 3. | Controlled before and after study OR “before and after study” = 30280 |
| 4. | Intervention/ [Major Subject Heading]/ = 21914 |
| 5. | Followup Studies/ [Major Subject Heading] = 12313 |
| 6. | OR/ 1-5 = 83883 |
| 7. | Work conditions [subject all areas] OR environmental effects / [subject all areas] = 18906 |
| 8. | Employee attitudes [subject all areas] OR Employer Attitudes [subject all areas] = 12120 |
| 9. | workplace* OR Worksite* OR work location* OR work setting*= 24957 |
| 10. | OR/ 7-9 = 48003 |
| 11. | 6 AND 10 = 1117 |
| 12. | Diets/ OR Nutrition/ [subject all areas] = 11505 |
| 13. | Food Intake/ [Major Subject Heading] = 8994 |
| 14. | Eating Attitudes OR Eating Behavior [Major Subject Heading] = 4782 |
| 15. | Food Preferences [Major Subject Heading] = 2468 |
| 16. | Food [Major Subject Heading] = 4844 |
| 17. | Food Habit* = 881 |
| 18. | Diet Record* = 805 |
| 19. | OR/11-18 = 28537 |
| 20. | 11 AND 19 = 39 |

## Table 19. Web of knowledge search strategy

| | |
|---|---|
| 1. | (randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized controlled trials[mh] OR random allocation[mh] OR double-blind method[mh] OR single-blind method[mh] OR clinical trial[pt] OR clinical trials[mh] OR ("clinical trial"[tw]) OR ((singl*[tw] OR doubl*[tw] OR trebl*[tw] OR tripl*[tw]) AND (mask*[tw] OR blind*[tw])) OR ("latin square"[tw]) OR placebos[mh] OR placebo*[tw] OR random*[tw] OR research design[mh:noexp] OR comparative study OR evaluation studies OR follow-up studies[mh] OR prospective studies[mh] OR cross-over studies[mh] OR control OR controls OR prospectiv*[tw] OR volunteer*[tw] ) = 11,247,290 |
| This complex search string is the Cochrane highly sensitive search filter for controlled trials (Robinson et al. Int J Epidemiol. 2002 Feb;31(1):150-3). | |
| 2. | “Controlled Trial” OR “non-randomised controlled trials” OR “non-randomized controlled trial” = 235648 |
| 3. | “Controlled before and after study” OR “before and after study” = 551 |
| 4. | “Intervention” = 634,309 |
| 5. | “Follow-up Studies” = 489,828 |
| 6. | OR/ 1-5 = 11,971,778 |
| 7. | workplace* OR Worksite* OR work location* OR work setting* = 69230 |
| 8. | 6 AND 7 = 23,947 |
| 9. | Diet OR “Diet Records” OR “Diet Surveys” = 857,554 |
| 10. | “Feeding Behavior” OR “Feeding Behaviour” = 64,663 |
| 11. | “Food Services” = 4123 |
| 12. | “Food Preferences” = 11126 |
| 13. | “Food Habits” = 24775 |
| 14. | OR/9-14 = 932421 |
| 15. | 8 AND 15 = 590 |
| 16. | Adult* OR Adulthood OR (18-64yrs) = 5705715 |
| 17. | 15 AND 16 = 268 |
| 18. | “Health Knowledge” OR “Health Attitudes” OR “Health Practice” = 66,500 |
| 19. | “Health Promotion” OR “Occupational Health Services” = 76329 |
| 20. | “Body Mass Index” OR “Blood Pressure” OR “Waist Circumference” = 877517 |
| 21. | OR/ 18-20 = 1,010,237 |
| 22. | 17 AND 21 = 158 |
| 23. | Limit: Only English Language = 144 |

## Table 20. Cochrane library search strategy

| | |
|---|---|
| 1. | ( randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized controlled trials[mh] OR random allocation[mh] OR double-blind method[mh] OR single-blind method[mh] OR clinical trial[pt] OR clinical trials[mh] OR ("clinical trial"[tw]) OR ((singl*[tw] OR doubl*[tw] OR trebl*[tw] OR tripl*[tw]) AND (mask*[tw] OR blind*[tw])) OR ("latin square"[tw]) OR placebos[mh] OR placebo*[tw] OR random*[tw] OR research design[mh:noexp] OR comparative study OR evaluation studies OR follow-up studies[mh] OR prospective studies[mh] OR cross-over studies[mh] OR control OR controls OR prospectiv*[tw] OR volunteer*[tw] ) = 709365 |
| This complex search string is the Cochrane highly sensitive search filter for controlled trials (Robinson et al. Int J Epidemiol. 2002 Feb; 31(1):150-3). | |
| 2. | Controlled Trial OR non-randomised controlled trials OR non-randomized controlled trial = 688769 |
| 3. | Controlled before and after study OR “before and after study” = 57293 |
| 4. | exp Intervention Studies/ = 1549 |
| 5. | exp Follow-Up Studies/ = 36053 |
| 6. | OR/ 1-5 = 709374 |
| 7. | exp Workplace/ = 350 |
| 8. | workplace* OR Worksite* OR work location* OR work setting*= 9215 |
| 9. | exp occupational health services/ = 253 |
| 10. | “organisational interventions” = 44 |
| 11. | employee OR employer |
| 12. | OR/ 7-11 = 10064 |
| 13. | 6 AND 11 = 9980 |
| 14. | exp Diet/ = 9865 |
| 15. | exp Diet Records/ = 430 |
| 16. | exp Nutrition Surveys/ = 227 |
| 17. | exp Diet Surveys/ = 129 |
| 18. | “dietary intake” = |
| 19. | exp Health Knowledge, Attitudes, Practice/= 2729 |
| 20. | exp Feeding Behavior/ = 4567 |
| 21. | exp Food Services/= 195 |
| 22. | exp Food Preferences/ = 336 |
| 23. | exp Food Habits/ = 782 |
| 24. | OR/12-23 = 15636 |
| 25. | 13 AND 24 = 427 articles |

**Appendix 2. Food choice at work questionnaires**

Office Use Only — Self completed Yes ☐ No ☐

Study Number ☐☐☐ ☐☐☐☐

Worksite ☐☐☐

**Confidential**

# Health, Lifestyle and Food Questionnaire

*Thank you for taking the time to complete this questionnaire. Your time and information is greatly valued.*

**The questionnaire is organised into several sections on your general health, your dietary patterns at home and at work, your lifestyle patterns including physical activity, alcohol and smoking, your knowledge of food and your general sense of well-being.**

**Please read the question and instructions carefully and complete each section to the best of your ability.**

**It takes approximately 20-25 minutes to complete.**

**Instructions:**

Please answer the following questions by filling in the appropriate boxes (as per example below) or by writing the answer in the space provided.

Self-completed example: **Are you male or female?** Male ■ Female ☐

*In sections A, B and C we are interested to find out about you, your work life and your general health status.*

## Section A: About You

**A1 Are you male or female?** Male ☐ Female ☐

**A2 What age are you?** _____ years

**A3 In what country were you born?**

Ireland (Republic) ☐ → *Go to A5*
Ireland (NI) ☐
Other UK ☐
Other ☐ please specify________________________________ → *Go to A4*

**A4 If not born in Ireland, when did you first move to Ireland?** _______ **(year)**

**A5 What is your ethnic or cultural background?**

a) White: Irish ☐ Irish Traveller ☐ Any other white background ☐
b) Black or Black Irish: African ☐ Any other black background ☐
c) Asian or Asian Irish: Chinese ☐ Any other Asian background ☐
d) Other including mixed background ☐ Insert own description____________________________

**A6 What is the highest level of education you have completed to date?**

None/ primary not complete ☐
Primary or equivalent ☐
Intermediate/ Junior/ Group Certificate or equivalent ☐
Leaving Certificate or equivalent ☐
Diploma/ Certificate ☐
Primary degree ☐
Postgraduate/ Higher degree ☐

**A7 What is your current marital status?**

Single (never married) ☐ Cohabiting ☐ Married ☐
Separated ☐ Divorced ☐ Widowed ☐

**A8 Are you at present:**

Living alone ☐ Living with other people ☐

**A9 Is your home?**

Owned with mortgage ☐ Rented from local authority ☐ Rented privately ☐
Owned outright ☐ Other ☐

**A10 How many individuals live in your household in each of the following categories?**

Adults (18-65) ______
Adults (65+) ______
Children (14-17) ______
Children (5-13) ______
Children (<5) ______
Total ______ *[INT: TOTAL SHOULD EQUAL SUM OF PEOPLE IN EACH AGE GROUP]*

**A11 How many children do you have?**

None ☐ One ☐ Two ☐ Three ☐ Four or more ☐

**A12 Are you responsible for purchasing the weekly grocery shopping (in general)?**

Yes ☐ No ☐

**A13 Are you responsible for cooking the daily meals in the household (in general)?**

Yes ☐ No ☐

**A14 Do you have any health or nutrition related qualifications?**

Yes ☐ Please specify ________________________________________________
No ☐

## Section B: About Your Work

**B1 Indicate the type of position you hold in the company by filling in one of the following boxes:**

Manager ☐
Supervisor ☐
Not a Manager/Not a supervisor employee ☐

**B2 Indicate the type of job you hold in the company by filling in the box that best describes your position:**

| | | | | | |
|---|---|---|---|---|---|
| Human Resources | ☐ | Finance/Accounting | ☐ | Sales | ☐ |
| Purchasing | ☐ | Planning | ☐ | Quality | ☐ |
| Information Technology | ☐ | Engineering | ☐ | Production | ☐ |
| Maintenance | ☐ | Sanitation | ☐ | Administration | ☐ |
| Catering | ☐ | Other | ☐ | | |

**If other, please specify**______________________________

**B3 How many hours per week do you work (including overtime)?** ________hours

**B4 What hours do you usually work?**

| | | | | | |
|---|---|---|---|---|---|
| Day-time (up to 8 hours) | ☐ | Day-time (12 hour shifts) | ☐ | Night-time (up to 8 hours) | ☐ |
| Night-shift (12 hours) | ☐ | Rotating shifts | ☐ | Other | ☐ |

**If other, please specify**______________________________

**B5 Is your work schedule best described as a regular schedule (roughly the same hours every day), a rotating schedule (e.g. working a shift some days and a night shift other days), or an irregular schedule (e.g., unpredictable hours controlled by situations or workload)?**

Regular schedule ☐ Rotating schedule ☐ Irregular schedule ☐

**B6 Are you an agency or company employee?**

Agency employee ☐ Company employee ☐

**B7 How many years have you been working in your current job for?** ________years

## Section C: General Health

**C1 In comparison with an average person of your age, would you say your health is......?**

Excellent ☐ Very good ☐ Good ☐ Fair ☐ Poor ☐

**C2 Is your daily activity limited by a long term illness, health problem or disability?**

Yes ☐ No ☐

**C3 Have you ever been told by a doctor that you have any of the following?**

| | Yes | No | Didn't visit doctor |
|---|---|---|---|
| High blood pressure | ☐ | ☐ | ☐ |
| High cholesterol | ☐ | ☐ | ☐ |
| Heart Disease/ Angina/ Stroke | ☐ | ☐ | ☐ |
| Osteoporosis | ☐ | ☐ | ☐ |

**C4 Given your age and height, would you say that you are?**

About the right weight ☐ Too heavy ☐ Too light ☐ Not sure ☐

**C5 Are you actively trying to manage your weight?**

Always ☐ Most of the time ☐ Sometimes ☐ Rarely ☐ Never ☐

**C6 If you are actively trying to manage your weight, is it to...?**

Lose weight ☐ Maintain your current weight ☐ Gain weight ☐

**C7 (Women Only) Are you currently pregnant?**
(Please feel free to skip this question if you wish)

Yes ☐ No ☐ Don't Know ☐

*In sections D, E and F we are interested to find out about your usual dietary patterns at home and at work.*

## Section D: Food Life

**D1 Do you follow any of the following diets?** *(Please fill in all boxes that apply to you)*

Vegetarian ☐ Vegan ☐ Diabetic ☐
Gluten free ☐ Weight reducing ☐ Low cholesterol ☐
Do not follow a special diet ☐ *→ Go to D3* Other ☐ ____________

**D2 When did you first follow this/these diets…?**

In the last year ☐ 1-5 years ago ☐ Over 5 years ago ☐

**D3 What type of milk do you use most often?**

None ☐ *→ Go to D5* Whole milk/Full fat ☐
Low fat ☐ Skimmed ☐
Super/fortified ☐ Soya ☐
Other ☐
**If other, please specify**____________________

**D4 How much milk do you drink each day?**

None ☐ Less than half pint ☐ 250ml (half pint) ☐
568ml (one pint) ☐ One litre ☐ More than 1 litre ☐

**D5 How often do you add salt to food while cooking?**

Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never ☐

**D6 How often do you add salt to food while at the table?**

Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never ☐

**D7 Do you take any vitamins, minerals or other food supplements currently?**

Yes ☐ *→ Go to D8* No ☐ *→ Go to D26* Don't know ☐ *→ Go to D26*

**If you take any vitamins, minerals or other food supplements currently, please fill out the table below to outline the type and name of supplement(s) you take, how frequent you take them and when you started taking them:**

| Please tick the supplements you take | | Name of supplement | How often do you take this supplement? (please tick 1): EVERY DAY | MOST DAYS | INFREQUENTLY | When did you start taking this supplement? (please tick 1): IN THE LAST YEAR | 1-5 YEARS AGO | OVER 5 YEARS AGO |
|---|---|---|---|---|---|---|---|---|
| **D8** Cod liver oil and other fish based supplements | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Reason for taking this supplement:** | | | | | | | | |
| **D9** Evening primrose oil type supplements | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Reason for taking this supplement:** | | | | | | | | |
| **D10** Vitamin C only | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Reason for taking this supplement:** | | | | | | | | |
| **D11** Other single vitamins NOT vitamin C | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Reason for taking this supplement:** | | | | | | | | |
| **D12** Vitamins A, C and D only | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Reason for taking this supplement:** | | | | | | | | |
| **D13** Vitamins with iron | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Reason for taking this supplement:** | | | | | | | | |
| **D14** Vitamin B6 and B12 | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Reason for taking this supplement:** | | | | | | | | |
| **D15** Vitamin E | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Reason for taking this supplement:** | | | | | | | | |
| **D16** Calcium | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Reason for taking this supplement:** | | | | | | | | |
| **D17** Chromium | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Reason for taking this supplement:** | | | | | | | | |
| **D18** Magnesium | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Reason for taking this supplement:** | | | | | | | | |
| **D19** Zinc | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Reason for taking this supplement:** | | | | | | | | |
| **D20** Iron only | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Reason for taking this supplement:** | | | | | | | | |
| **D21** Non-prescribed folic acid only | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Reason for taking this supplement:** | | | | | | | | |
| **D22** Multivitamins and Multiminerals | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Reason for taking this supplement:** | | | | | | | | |
| **D23** Multivitamins, NO minerals | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Reason for taking this supplement:** | | | | | | | | |
| **D24** Minerals ONLY; NOT fluoride or iron ONLY | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Reason for taking this supplement:** | | | | | | | | |
| **D25** Other supplements (specify) | ☐ | | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Reason for taking this supplement:** | | | | | | | | |

**D26 For each of the 12 statements, please place an X in one box per statement which best represents your response (as per the example below)**

**Example:**

| **Exercise is something……………………………….** | | | | | |
|---|---|---|---|---|---|
| | **Strongly Agree$_1$** | **Agree$_2$** | **Neither Agree/Disagree$_3$** | **Disagree$_4$** | **Strongly Disagree$_5$** |
| **I do frequently.** | **X** | | | | |

Please complete statements **A – L**:

| **Healthy eating is something……………………………….** | | | | | |
|---|---|---|---|---|---|
| | **Strongly Agree$_1$** | **Agree$_2$** | **Neither Agree/Disagree$_3$** | **Disagree$_4$** | **Strongly Disagree$_5$** |
| A. I do frequently | | | | | |
| B. I do automatically | | | | | |
| C. I do without having to consciously remember | | | | | |
| D. that makes me feel weird if I do not do it | | | | | |
| E. I do without thinking | | | | | |
| F. that would require effort not to do it | | | | | |
| G. that belongs to my (daily, weekly, monthly) routine | | | | | |
| H. I start doing before I realise I'm doing it | | | | | |
| I. I would find hard not to do | | | | | |
| J. I have no need to think about doing | | | | | |
| K. that's typically 'me' | | | | | |
| L. I have been doing for a long time | | | | | |

## Section E: Eating Habits at Work

**E1 Have your eating habits at work changed over the past year?**

Yes ☐ No ☐ → *Go to E4* Don't know ☐ → *Go to E4*

**E2 If yes, are your eating habits:**

Better ☐ Same ☐ → *Go to E4* Worse ☐ → *Go to E4* Don't Know ☐ → *Go to E4*

**E3 If better, are you?**

Eating more fruit ☐
Eating fewer calories ☐
Eating less fat ☐
Eating more fish ☐
Eating more wholegrain/wholemeal products ☐
Consuming less salt ☐
Eating less sugar ☐
Other ☐
***If other, please specify*** ______________________________

**E4 Has your use of salt changed over the past year at work?**

Yes ☐ No ☐ → *Go to E7* Don't know ☐ → *Go to E7*

**E5 If yes, did you:** *(Please fill in all boxes that apply to you)*

Reduce salt added to food at the table ☐
Reduce salt added to food while cooking ☐
Changed to low-salt ☐
Stop adding salt to food at the table ☐
Stop adding salt to food while cooking ☐
Increased salt ☐

**E6 If you reduced/changed your salt intake was this due to:**

Medical Advice ☐ Personal Choice ☐ Not Applicable ☐

**E7 Do your eating patterns at work influence your eating patterns at home?**

Never ☐ Rarely ☐ Sometimes ☐ Most of the time ☐ Always ☐

## Section F: Eating Environment at Work

**F1 Overall how satisfied are you with the canteen food?**

Very satisfied ☐ Satisfied ☐ Neither dissatisfied nor satisfied ☐
Dissatisfied ☐ Very dissatisfied ☐

**F2 For each of the 4 statements, please place an X in one box per statement which best represents your response (as per the example below):**

**Example:**

| At my workplace………………………………. | | | | | |
|---|---|---|---|---|---|
| | Strongly Agree | Agree | Neither Agree/Disagree | Disagree | Strongly Disagree |
| I feel supported | | X | | | |

Please complete statements **A – D**:

| At my workplace………………………………. | | | | | |
|---|---|---|---|---|---|
| | Strongly Agree | Agree | Neither Agree/Disagree | Disagree | Strongly Disagree |
| A. It's difficult to find fruit and vegetables | | | | | |
| B. It is easy to eat a healthy diet | | | | | |
| C. The menu has enough variety for me to choose meals | | | | | |
| D. The meals taste nice | | | | | |

**F3 Do you sometimes have difficulty eating and drinking during work hours, due to inadequate time?**

Never ☐ Rarely ☐ Sometimes ☐ Most of the time ☐ Always ☐

*In sections G, H, and I we are interested to find out about*
*your usual lifestyle patterns including physical activity, alcohol and smoking.*

## Section G: Physical activity

**G1** During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling? (If none, put 0 in box)

☐ Days **If none, put 0 in the box and go to G3**

**G2** If yes, how much time did you usually spend doing vigorous physical activities on one of those days?

☐☐ Hrs ☐☐ Mins Don't know ☐ 9999

**G3** Think about all the moderate activities that you did in the last 7 days. Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? [Do not include walking]. (If none, put 0 in box)

☐ Days **If none, put 0 in the box and go to G5**

**G4** If yes, how much time did you usually spend doing moderate physical activities on one of those days?

☐☐ Hrs ☐☐ Mins Don't know ☐ 9999

**G5** Think about the time you spent walking in the last 7 days. This includes at work and at home, walking to travel from place to place and any other walking that you do solely for recreation, sport, exercise and leisure.

During the last 7 days, on how many days did you walk for at least 10 minutes at a time? (If none, put 0 in box)

☐ Days **If none, put 0 in the box and go to G7**

**G6** If yes, how much time did you usually spend walking on one of those days?

☐☐ Hrs ☐☐ Mins Don't know ☐ 9999

**G7** Which of the following best describes your usual walking pace?
A slow pace ☐ A steady average pace ☐ A fairly brisk pace ☐ A fast pace – at least 4 mph ☐

**G8 Is your job physically demanding?**

Never ☐ Rarely ☐ Sometimes ☐ Most of the time ☐ Always ☐

**G9** The last question is about the time you spent sitting on weekdays during the last 7 days. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

During the last 7 days, how much time did you spend sitting on a week day?

| | | | |
|---|---|---|---|
| | | | |

Hrs Mins Don't know ☐

## Section H: Smoking

**H1 Have you yourself smoked at least 100 cigarettes in your entire life?** *[5 PACKS = 100 CIGARETTES]*
Yes ☐ No ☐ → *Go to SECTION I*

**H2 Do you now smoke?**
Yes ☐ No ☐ → *Go to H4*

If yes, how often do you smoke?
Every Day ☐ Some days ☐

**H3 What do you smoke?** (Please fill in all boxes that apply to you)
Pipe ☐
Cigarettes ☐
Cigars ☐ → *Go to H5*

**H4 How long has it been since you last smoked?**
Within the past month (anytime less than 1 month ago) ☐
Within the past 3 months (1 month but less than 3 months ago) ☐
Within the past 6 months (3 months but less than 6 months ago) ☐
Within the past year (6 months but less than 1 year ago) ☐
Within the past 5 years (1 year but less than 5 years ago) ☐
Within the past 10 years (5 years but less than 10 years ago) ☐
10 or more years ago ☐ → *Go to SECTION I*

**H5 Are you currently?**
Trying to quit ☐
Actively planning to quit ☐
Thinking about quitting but not planning to ☐
Not thinking about quitting ☐

**H6 If I gave up smoking** *(Please fill in all boxes that apply to you)*

| | Yes | No | Unsure |
|---|---|---|---|
| My health would improve in the short term | ☐ | ☐ | ☐ |
| My health would benefit in the long term | ☐ | ☐ | ☐ |
| I would put on weight | ☐ | ☐ | ☐ |
| It would be harder to handle stress in my life | ☐ | ☐ | ☐ |
| I'd feel I had done something worthwhile | ☐ | ☐ | ☐ |

## Section I: Alcohol

**I1 How often do you have a drink containing alcohol?**

| | | |
|---|---|---|
| Never | ☐ | → *Go to SECTION J* |
| Monthly or less | ☐ | |
| 2-4 times a month | ☐ | |
| 2-3 times a week | ☐ | |
| 4 or more times a week | ☐ | |

**I2 How long ago did you last have an alcoholic drink?**

| | | |
|---|---|---|
| During the last week | ☐ | |
| During the last month, but not in the last week | ☐ | |
| Within the last three months, but not in the last month | ☐ | |
| Within the last 12 months, but not in the last 3 months | ☐ | |
| More than 12 months ago | ☐ | |
| Never had alcohol beyond sips or tastes | ☐ | → *Go to SECTION J* |

I3 Considering the last year, how **many drinks containing alcohol do you have on a typical day when you are drinking?** ____________________

*A DRINK IS:*

- *A HALF PINT OR A GLASS OF BEER, LAGER OR CIDER*
- *A SINGLE MEASURE OF SPIRITS (E.G. WHISKEY, VODKA, GIN*
- *A SINGLE GLASS OF WINE, SHERRY OR PORT*
- *BOTTLE OF ALCOPOPS (LONG NECK)]*

**I4 How often do you have 6 or more [standard] drinks on one occasion?**

Never ☐ Less than monthly ☐ Monthly ☐ Weekly ☐ Daily or almost daily ☐

**I5 During the past 7 days how many standard drinks of any alcoholic beverage did you have each day?**

Monday ______ Tuesday ______ Wednesday ______ Thursday ______
Friday ______ Saturday ______ Sunday ______

**I6 How old were you when you started drinking?** ________________

***In section J, we are interested to find out about your knowledge of food.***

## Section J: Your nutrition knowledge

### Advice from the Health Experts

**The first few questions are about what advice you think experts are giving us**

J1 Do you think health experts recommend that people should be eating more, the same amount, or less of these foods? (*fill in one box per food)*

| | More | Same | Less | Not sure |
|---|---|---|---|---|
| Vegetables | ☐ | ☐ | ☐ | ☐ |
| Sugary foods | ☐ | ☐ | ☐ | ☐ |
| Meat | ☐ | ☐ | ☐ | ☐ |
| Starchy foods | ☐ | ☐ | ☐ | ☐ |
| Fatty foods | ☐ | ☐ | ☐ | ☐ |
| High fibre foods | ☐ | ☐ | ☐ | ☐ |
| Fruit | ☐ | ☐ | ☐ | ☐ |
| Salty Foods | ☐ | ☐ | ☐ | ☐ |

J2 How many servings of fruit and vegetables a day do you think experts are advising people to eat? (One serving could be, for example, an apple or a handful of chopped carrots)

.................................................................................................

.................................................................................................

J3 Which fat do experts say is most important for people to cut down on? *(only fill one box)*

a) Monounsaturated fat ☐
b) Polyunsaturated fat ☐
c) Saturated fat ☐
d) Not sure ☐

J4 What version of dairy foods do experts say people should eat? *(only fill one box)*

a) Full fat ☐
b) Lower fat ☐
c) Mixture of full fat and lower fat ☐
d) Neither, dairy foods should be cut out ☐
e) Not sure ☐

### Food Groups and Nutritional Content of Foods

**This section is concerned with food groups and the nutritional content of foods.**

J5 Do you think these foods are *high or low in added sugar*? (*fill in one box per food)*

| | High | Low | Not sure |
|---|---|---|---|
| Bananas | ☐ | ☐ | ☐ |
| Unflavoured yoghurt | ☐ | ☐ | ☐ |
| Ice-cream | ☐ | ☐ | ☐ |
| Orange juice | ☐ | ☐ | ☐ |
| Tomato ketchup | ☐ | ☐ | ☐ |
| Tinned fruit in natural juice | ☐ | ☐ | ☐ |

J6 Do you think these foods are *high or low in fat*? (*fill in one box per food)*

| | High | Low | Not sure |
|---|---|---|---|
| Pasta (without sauce) | ☐ | ☐ | ☐ |
| Low fat spread | ☐ | ☐ | ☐ |
| Baked beans | ☐ | ☐ | ☐ |
| Lunch/sandwich meat | ☐ | ☐ | ☐ |
| (e.g. corned beef) | ☐ | ☐ | ☐ |
| Honey | ☐ | ☐ | ☐ |
| Meat pastry pie | ☐ | ☐ | ☐ |
| Nuts | ☐ | ☐ | ☐ |
| Bread | ☐ | ☐ | ☐ |
| Cottage cheese | ☐ | ☐ | ☐ |
| Polyunsaturated margarine | ☐ | ☐ | ☐ |

J7 Do you think experts put these in the starchy foods group? (*fill in one box per food)*

| | Yes | No | Not sure |
|---|---|---|---|
| Cheese | ☐ | ☐ | ☐ |
| Pasta | ☐ | ☐ | ☐ |
| Butter | ☐ | ☐ | ☐ |
| Nuts | ☐ | ☐ | ☐ |
| Rice | ☐ | ☐ | ☐ |
| Porridge | ☐ | ☐ | ☐ |

J8 Do you think these foods are high or low in salt? (*fill in one box per food)*

| | High | Low | Not sure |
|---|---|---|---|
| Sausages | ☐ | ☐ | ☐ |
| Pasta | ☐ | ☐ | ☐ |
| Kippers | ☐ | ☐ | ☐ |
| Red Meat | ☐ | ☐ | ☐ |
| Frozen vegetables | ☐ | ☐ | ☐ |
| Cheese | ☐ | ☐ | ☐ |
| Tinned Soup | ☐ | ☐ | ☐ |

J9 Do you think these foods are *high or low in protein*? (*fill in one box per food)*

| | High | Low | Not sure |
|---|---|---|---|
| Chicken | ☐ | ☐ | ☐ |
| Cheese | ☐ | ☐ | ☐ |
| Fruit | ☐ | ☐ | ☐ |
| Baked beans | ☐ | ☐ | ☐ |
| Butter | ☐ | ☐ | ☐ |
| Cream | ☐ | ☐ | ☐ |

J10 Do you think these foods are *high or low in fibre/roughage*? (*fill in one box per food)*

| | High | Low | Not sure |
|---|---|---|---|
| Cornflakes | ☐ | ☐ | ☐ |
| Bananas | ☐ | ☐ | ☐ |
| Eggs | ☐ | ☐ | ☐ |
| Red meat | ☐ | ☐ | ☐ |
| Broccoli | ☐ | ☐ | ☐ |
| Nuts | ☐ | ☐ | ☐ |
| Fish | ☐ | ☐ | ☐ |
| Baked potatoes with skins | ☐ | ☐ | ☐ |
| Chicken | ☐ | ☐ | ☐ |
| Baked beans | ☐ | ☐ | ☐ |

J11 Do you think these fatty foods are *high or low in saturated fat*? (*fill in one box per food)*

| | High | Low | Not sure |
|---|---|---|---|
| Mackerel | ☐ | ☐ | ☐ |
| Whole milk | ☐ | ☐ | ☐ |
| Olive oil | ☐ | ☐ | ☐ |
| Red meat | ☐ | ☐ | ☐ |
| Broccoli | ☐ | ☐ | ☐ |
| Sunflower margarine | ☐ | ☐ | ☐ |
| Chocolate | ☐ | ☐ | ☐ |

J12 Some foods contain a lot of fat but no cholesterol

a) Agree ☐
b) Disagree ☐
c) Not sure ☐

J13 Do you think experts call these a healthy alternative to red meat? (*fill in one box per food)*

| | Yes | No | Not sure |
|---|---|---|---|
| Liver pate | ☐ | ☐ | ☐ |
| Lunch/sandwich meat | ☐ | ☐ | ☐ |
| (e.g. corned beef) | ☐ | ☐ | ☐ |
| Baked beans | ☐ | ☐ | ☐ |
| Nuts | ☐ | ☐ | ☐ |
| Low fat cheese | ☐ | ☐ | ☐ |
| Quiche | ☐ | ☐ | ☐ |

J14 A glass of unsweetened fruit juice counts as a helping of fruit

a) Agree ☐
b) Disagree ☐
c) Not sure ☐

J15 Saturated fats are mainly found in: *(only fill one box)*

a) Vegetable oils ☐
b) Dairy products ☐
c) Both a) and b) ☐
d) Not sure ☐

J16 Brown sugar is a healthy alternative to white sugar

a) Agree ☐
b) Disagree ☐
c) Not sure ☐

J17 There is more protein in a glass of whole milk than in a glass of skimmed milk

a) Agree ☐
b) Disagree ☐
c) Not sure ☐

J18 Polyunsaturated margarine contains less fat than butter

a) Agree ☐
b) Disagree ☐
c) Not sure ☐

J19 Which of these breads contain the most vitamins and minerals? *(only fill one box)*
a) White ☐
b) Brown ☐
c) Wholegrain ☐
d) Not sure ☐

J20 Which do you think is higher in calories: butter or regular margarine? *(only fill one box)*
a) Butter ☐
b) Regular Margarine ☐
c) Both the same ☐
d) Not sure ☐

J21 A type of oil which contains mostly monounsaturated fat is: *(only fill one box)*
a) Coconut oil ☐
b) Sunflower oil ☐
c) Olive oil ☐
d) Palm oil ☐
e) Not sure ☐

J22 There is more calcium in a glass of whole milk than a glass of skimmed milk
a) Agree ☐
b) Disagree ☐
c) Not sure ☐

J23 Which one of the following has the most calories for the same weight? *(only fill one box)*
a) Sugar ☐
b) Starchy foods ☐
c) Fibre/roughage ☐
d) Fat ☐
e) Not sure ☐

J24 Harder fats contain more: *(only fill one box)*
a) Monounsaturates ☐
b) Polyunsaturates ☐
c) Saturates ☐
d) Not sure ☐

J25 Polyunsaturated fats are mainly found in: *(only fill one box)*
a) Vegetable oils ☐
b) Dairy products ☐
c) Both a) and b) ☐
d) Not sure ☐

## Food Choice

**The next few items are about choosing foods. Please answer what is being asked and not whether you like or dislike the food!**

For example, suppose you were asked..................
'If a person wanted to cut down on fat, which cheese would be best to eat?'
(a) Cheddar cheese
(b) Camembert
(c) Cream cheese
(d) Cottage cheese
If you didn't like cottage cheese, but knew it was the right answer, you would still fill in the box for cottage cheese.

J26 What is the best choice for a low fat, high fibre snack? *(only fill one box)*
a) Diet strawberry yoghurt ☐
b) Raisins ☐
c) Muesli bar ☐
d) Wholemeal crackers and cheddar cheese ☐

J27 What is the best choice for a low fat, high fibre light meal? *(only fill one box)*
a) Grilled chicken ☐
b) Cheese on wholemeal toast ☐
c) Beans on wholemeal toast ☐
d) Quiche ☐

J28 Which kind of sandwich is healthier? *(only fill one box)*
a) Two thick slices of bread with a thin slice of cheddar cheese filling ☐
b) Two thin slices of bread with a thick slice of cheddar cheese filling ☐

J29 Many people eat spaghetti bolognese (pasta with tomato and meat sauce). Which option is healthier? *(only fill one box)*
a) A large amount of pasta with a little sauce on top ☐
b) A small amount of pasta with a lot of sauce on top ☐

J30 If a person wanted to reduce the amount of fat in their diet, which would be the best choice? *(only fill one box)*

a) Steak, grilled ☐
b) Sausages, grilled ☐
c) Turkey, grilled ☐
d) Pork chop, grilled ☐

J31 If a person wanted to reduce the amount of fat in their diet, but didn't want to give up chips, which one would be the best choice? *(only fill one box)*

a) Thick cut chips ☐
b) Thin cut chips ☐
c) Crinkle cut chips ☐

J32 If a person felt like something sweet, but was trying to cut down on sugar, which would be the best choice? *(only fill one box)*

a) Honey on toast ☐
b) A cereal snack bar ☐
c) Plain digestive biscuit ☐
d) Banana with plain Yoghurt ☐

J33 Which of these would be the healthiest pudding? *(only fill one box)*

a) Baked apple ☐
b) Strawberry yoghurt ☐
c) Wholemeal crackers and cheddar cheese ☐
d) Carrot cake with cream cheese topping ☐

J34 Which cheese would be the best choice as a lower fat option? *(only fill one box)*

a) Plain cream cheese ☐
b) Edam ☐
c) Cheddar ☐
d) Stilton ☐

J35 If a person wanted to reduce the amount of salt in their diet, which would be the best choice? *(only fill one box)*

a) Ready-made frozen shepherd's pie ☐
b) Gammon with pineapple ☐
c) Mushroom omelette ☐
d) Stir fry vegetables with soy sauce ☐

J36 Which one of these would be the right portion size for a serving of cheese? *(only fill one box)*

a) 1 match-box size portion ☐
b) 2 match-box portion ☐
c) Palm of the hand ☐

J37 Which one of these would be the right portion size for a serving of peanut butter? *(only fill one box)*

a) 1 teaspoon (5ml) ☐
b) 2 teaspoons (10ml) ☐
c) 3 teaspoons (15ml) ☐

## Diet and Disease

**This section is about the relationship between diet and health problems or diseases.**

J38.1 Are you aware of any major health problems or diseases that are related to a low intake of fruit and vegetables

a) Yes ☐
b) No ☐
c) Not sure ☐

J38.2 If yes, what diseases or health problems do you think are related to a *low intake of fruit and vegetables?*

..........................................................................................

..........................................................................................

J39.1 Are you aware of any major health problems or diseases that are related to a *low intake of fibre?*

a) Yes ☐
b) No ☐
c) Not sure ☐

J39.2 If yes, what diseases or health problems do you think are related to *a low intake of fibre*?

..........................................................................................

..........................................................................................

J40.1 Are you aware of any major health problems or diseases that are related to *how much sugar* people eat?

a) Yes ☐
b) No ☐
c) Not sure ☐

J40.2 If yes, what diseases or health problems do you think are related to sugar?

..............................................................................................
..............................................................................................

J41.1 Are you aware of any major health problems or diseases that are related to *how much salt or sodium* people eat?

a) Yes ☐
b) No ☐
c) Not sure ☐

J41.2 If yes, what diseases or health problems do you think are related to salt?

..............................................................................................
..............................................................................................

J42.1 Are you aware of any major health problems or diseases that are related to the *amount of fat* people eat?

a) Yes ☐
b) No ☐
c) Not sure ☐

J42.2 If yes, what diseases or health problems do you think are related to fat?

..............................................................................................
..............................................................................................

J43 Do you think these help to reduce the chances of getting certain kinds of cancer? *(answer each one)*

| | Yes | No | Not sure |
|---|---|---|---|
| Eating more fibre | ☐ | ☐ | ☐ |
| Eating less sugar | ☐ | ☐ | ☐ |
| Eating less fruit | ☐ | ☐ | ☐ |
| Eating less salt | ☐ | ☐ | ☐ |
| Eating more fruit & vegetables | ☐ | ☐ | ☐ |
| Eating less preservatives/ additives | ☐ | ☐ | ☐ |

J44 Do you think these help prevent heart disease? (*answer each one*)

| | Yes | No | Not sure |
|---|---|---|---|
| Eating more fibre | ☐ | ☐ | ☐ |
| Eating less saturated fat | ☐ | ☐ | ☐ |
| Eating less salt | ☐ | ☐ | ☐ |
| Eating more fruit and vegetables | ☐ | ☐ | ☐ |
| Eating less preservatives/additives | ☐ | ☐ | ☐ |

J45 Which one of these is more likely to raise people's blood cholesterol level? *(only fill one box)*

Antioxidants ☐
Polyunsaturated Fats ☐
Saturated Fats ☐
Cholesterol in the diet ☐
Not sure ☐

J46 Have you heard of antioxidant vitamins?

a) Yes ☐
b) No ☐

J47 If YES to question J46, do you think these vitamins are antioxidant vitamins? (*answer each one*)

| | Yes | No | Not sure |
|---|---|---|---|
| Vitamin A | ☐ | ☐ | ☐ |
| B Complex Vitamins | ☐ | ☐ | ☐ |
| Vitamin C | ☐ | ☐ | ☐ |
| Vitamin D | ☐ | ☐ | ☐ |
| Vitamin E | ☐ | ☐ | ☐ |
| Vitamin K | ☐ | ☐ | ☐ |

**That is the end of the questionnaire!**

***<u>Your contribution to this research is greatly appreciated.</u>***

## Food Motives Questionnaire

Instructions: **Please circle one number where 1=not at all important, 2=a little important, 3=neither important nor unimportant, 4=moderately important and 5= very important for each question that best represents your response to the statement outlined below 'It is important to me that the food I eat on a typical working day..................' Please read each sentence carefully and remember that there are no right or wrong answers.**

| **It is important to me that the food I eat on a typical working day:** | **Not at all important** | **A little important** | **Neither Important Nor Unimportant** | **Moderately important** | **Very important** |
|---|---|---|---|---|---|
| is easy to prepare | 1 | 2 | 3 | 4 | 5 |
| contains no additives | 1 | 2 | 3 | 4 | 5 |
| is low in calories | 1 | 2 | 3 | 4 | 5 |
| tastes good | 1 | 2 | 3 | 4 | 5 |
| contains natural ingredients | 1 | 2 | 3 | 4 | 5 |
| is not expensive | 1 | 2 | 3 | 4 | 5 |
| is low in fat | 1 | 2 | 3 | 4 | 5 |
| is familiar | 1 | 2 | 3 | 4 | 5 |
| is high in fibre and roughage | 1 | 2 | 3 | 4 | 5 |
| is nutritious | 1 | 2 | 3 | 4 | 5 |
| is easily available in shops and supermarkets | 1 | 2 | 3 | 4 | 5 |
| is good value | 1 | 2 | 3 | 4 | 5 |
| smells nice | 1 | 2 | 3 | 4 | 5 |
| can be cooked very simply | 1 | 2 | 3 | 4 | 5 |
| has a pleasant texture | 1 | 2 | 3 | 4 | 5 |
| is packaged in an environmentally friendly way | 1 | 2 | 3 | 4 | 5 |
| comes from countries I approve of politically | 1 | 2 | 3 | 4 | 5 |
| is like the food I ate when I was a child | 1 | 2 | 3 | 4 | 5 |
| contains a lot of vitamins and minerals | 1 | 2 | 3 | 4 | 5 |
| keeps me awake/alert | 1 | 2 | 3 | 4 | 5 |
| helps me relax | 1 | 2 | 3 | 4 | 5 |
| is high in protein | 1 | 2 | 3 | 4 | 5 |
| takes no time to prepare | 1 | 2 | 3 | 4 | 5 |

| **It is important to me that the food I eat on a typical working day:** | **Not at all important** | **A little important** | **Neither Important Nor Unimportant** | **Moderately important** | **Very important** |
|---|---|---|---|---|---|
| keeps me healthy | 1 | 2 | 3 | 4 | 5 |
| is good for my skin/teeth/hair/nails etc | 1 | 2 | 3 | 4 | 5 |
| makes me feel good | 1 | 2 | 3 | 4 | 5 |
| has the country of origin clearly marked | 1 | 2 | 3 | 4 | 5 |
| is what I usually eat | 1 | 2 | 3 | 4 | 5 |
| helps me to cope with life | 1 | 2 | 3 | 4 | 5 |
| can be bought in shops close to where I live or work | 1 | 2 | 3 | 4 | 5 |
| is cheap | 1 | 2 | 3 | 4 | 5 |
| is satisfying | 1 | 2 | 3 | 4 | 5 |
| makes me feel full | 1 | 2 | 3 | 4 | 5 |

# Dutch Eating Behaviour Questionnaire (DEBQ)

| | | Never | Seldom | Sometimes | Often | Very Often |
|---|---|---|---|---|---|---|
| 1 | When you have put on weight, do you eat less than you usually do? | 1 | 2 | 3 | 4 | 5 |
| 2 | Do you try to eat less at mealtimes than you would like to eat? | 1 | 2 | 3 | 4 | 5 |
| 3 | How often do you refuse food and drink offered because you are concerned about your weight? | 1 | 2 | 3 | 4 | 5 |
| 4 | Do you watch exactly what you eat? | 1 | 2 | 3 | 4 | 5 |
| 5 | Do you deliberately eat foods that are slimming? | 1 | 2 | 3 | 4 | 5 |
| 6 | When you have eaten too much, do you eat less than usual the following day? | 1 | 2 | 3 | 4 | 5 |
| 7 | Do you deliberately eat less in order not to become heavier | 1 | 2 | 3 | 4 | 5 |
| 8 | How often do you try not to eat between meals because you are watching your weight? | 1 | 2 | 3 | 4 | 5 |
| 9 | How often in the evenings do you try not to eat because you are watching your weight? | 1 | 2 | 3 | 4 | 5 |
| 10 | Do you take into account your weight with what you eat? | 1 | 2 | 3 | 4 | 5 |
| 11 | Do you have the desire to eat when you are irritated? | 1 | 2 | 3 | 4 | 5 |
| 12 | Do you have a desire to eat when you have nothing to do? | 1 | 2 | 3 | 4 | 5 |
| 13 | Do you have a desire to eat when you are depressed or discouraged? | 1 | 2 | 3 | 4 | 5 |
| 14 | Do you have a desire to eat when you are feeling lonely? | 1 | 2 | 3 | 4 | 5 |
| 15 | Do you have a desire to eat when somebody lets you down? | 1 | 2 | 3 | 4 | 5 |
| 16 | Do you have a desire to eat when you are cross? | 1 | 2 | 3 | 4 | 5 |
| 17 | Do you have a desire to eat when you are approaching something unpleasant to happen? | 1 | 2 | 3 | 4 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 18 | Do you get the desire to eat when you are anxious, worried or tense? | 1 | 2 | 3 | 4 | 5 |
| 19 | Do you have a desire to eat when things are going against you or when things have gone wrong? | 1 | 2 | 3 | 4 | 5 |
| 20 | Do you have a desire to eat when you are frightened? | 1 | 2 | 3 | 4 | 5 |
| 21 | Do you have a desire to eat when you are disappointed? | 1 | 2 | 3 | 4 | 5 |
| 22 | Do you have a desire to eat when you are emotionally upset? | 1 | 2 | 3 | 4 | 5 |
| 23 | Do you have a desire to eat when you are bored or restless? | 1 | 2 | 3 | 4 | 5 |
| 24 | If food tastes good to you, do you eat more than usual? | 1 | 2 | 3 | 4 | 5 |
| 25 | If food smells and looks good, do you eat more than usual? | 1 | 2 | 3 | 4 | 5 |
| 26 | If you see or smell something delicious, do you have a desire to eat it? | 1 | 2 | 3 | 4 | 5 |
| 27 | If you have something delicious to eat, do you eat it straight away? | 1 | 2 | 3 | 4 | 5 |
| 28 | If you walk past the baker, do you have the desire to buy something delicious? | | | | | |
| 29 | If you walk past a snack bar or cafe, do you have the desire to but something delicious? | 1 | 2 | 3 | 4 | 5 |
| 30 | If you see others eating, do you also have the desire to eat? | 1 | 2 | 3 | 4 | 5 |
| 31 | Can you resist eating delicious foods? | 1 | 2 | 3 | 4 | 5 |
| 32 | Do you eat more than usual, when you see others eating? | 1 | 2 | 3 | 4 | 5 |
| 33 | When preparing a meal are you inclined to eat something? | 1 | 2 | 3 | 4 | 5 |

| **Office Use Only** | Self completed Yes ☐ No ☐ |
|---|---|
| **Study Number** ☐☐☐ ☐☐☐☐ | |
| **Worksite** ☐☐☐ | |

**Confidential**

# EQ-5D Questionnaire

*Thank you for taking the time to complete this questionnaire. Your time and information is greatly valued.*

**The questionnaire is organised into two sections which contain questions on your overall health status. Please read the question and instructions carefully and complete each section to the best of your ability.**

**It takes approximately 5 minutes to complete.**

<u>**Instructions:**</u>

Please answer the following questions by filling in the appropriate boxes (as per example below) or by writing the answer in the space provided.

Self-completed example: **Are you male or female?** Male ■ Female ☐

**Under each heading, please tick the ONE box that best describes your health TODAY.**

**1. Mobility:**
**Please tick only one box.**

I have no problems in walking about ☐
I have slight problems in walking about ☐
I have moderate problems in walking about ☐
I have severe problems in walking about ☐
I am unable to walk about ☐

**2. Self-care:**
**Please tick only one box.**

I have no problems washing or dressing myself ☐
I have slight problems washing or dressing myself ☐
I have moderate problems washing or dressing ☐
I have severe problems in washing or dressing myself ☐
I am unable to wash or dress myself ☐

**3. Usual activities (e.g. work, study, housework, family or leisure activities):**
**Please tick only one box**

I have no problem doing my usual activities ☐
I have slight problems doing my usual activities ☐
I have moderate problems doing my usual activities ☐
I have severe problems doing my usual activities ☐
I am unable to do my usual activities ☐

**4. Pain/discomfort:**
**Please tick only one box**

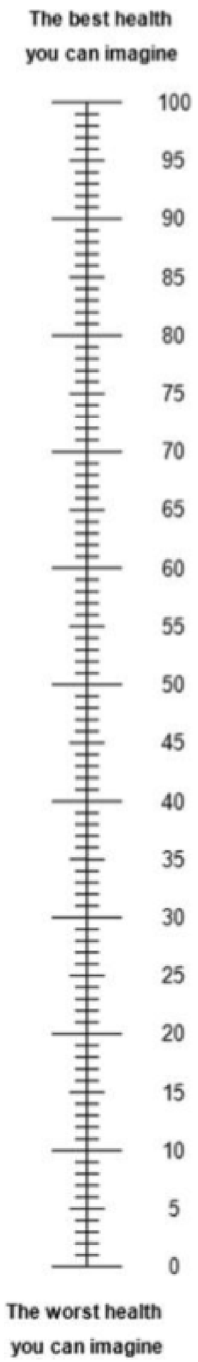
I have no pain or discomfort ☐
I have slight pain or discomfort ☐
I have moderate pain or discomfort ☐
I have severe pain or discomfort ☐
I have extreme pain or discomfort ☐

**5. Anxiety/depression:**
**Please tick only one box**

I am not anxious or depressed ☐
I am slightly anxious or depressed ☐
I am moderately anxious or depressed ☐
I am severely anxious or depressed ☐
I am extremely anxious or depressed ☐

**6. In this section we would like to know how good or bad your health is TODAY. The next question consists of a scale which is numbered 0 to 100. 100 means the best health you can imagine. 0 means the worst health you can imagine.**

Using the picture of the scale to guide you, please choose a value to indicate how your health is today, remembering 100 is the best possible health imaginable and 0 is the worst possible health imaginable.




| | |
|---|---|
| **100-95** | ☐ |
| **95-90** | ☐ |
| **90-85** | ☐ |
| **85-80** | ☐ |
| **80-75** | ☐ |
| **75-70** | ☐ |
| **70-65** | ☐ |
| **65-60** | ☐ |
| **60-55** | ☐ |
| **55-50** | ☐ |
| **50-45** | ☐ |
| **45-40** | ☐ |
| **40-35** | ☐ |
| **35-30** | ☐ |
| **30-25** | ☐ |
| **25-20** | ☐ |
| **20-15** | ☐ |
| **15-10** | ☐ |
| **10-5** | ☐ |
| **5-0** | ☐ |

**7. Now please write the single number you marked on the scale in the box below, e.g. 62, 91, 74.**

Office Use Only | Self completed Yes ☐ No ☐

Study Number ☐☐☐ ☐☐☐☐

Worksite ☐☐☐

**Confidential**

# Food Frequency Questionnaire

*Thank you for taking the time to complete this questionnaire. Your time and information is greatly valued.*

**The questionnaire is organised into 9 different food categories and you will be asked to record your average frequency of consumption of each food item over the last year.**

**YOUR DIET OVER THE LAST YEAR**

For each food there is an amount shown, either what we think is a "medium serving" or a common household unit such as a slice or teaspoon. Please put a tick in the box to indicate how often, on average, you have eaten the specified amount of each food, to the nearest whole number during the past year i.e. from when you receive this questionnaire to the same month the previous year. Please estimate your average food use as best you can. Please answer every question, do not leave ANY lines blank.

**Please read the questions and instructions carefully and complete each section to the best of your ability.**

**It takes approximately 20 minutes to complete.**

**EXAMPLES:**

The following are examples on how to estimate how often and how much bread and potatoes you ate over the past year. Please estimate your food intake for all foodstuffs in the same way. Potatoes: If you have eaten a medium serving of potatoes 3 times per week over the past year put a tick in the box "2-4 per week". If you think you usually eat more or less than a medium serving please try to estimate which box suits best.

| AVERAGE USE LAST YEAR | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Potatoes, Rice and Pasta (medium serving) | Never or less than once per month | 1-3 per month | Once per week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| Boiled, instant or jacket potatoes | ☐ | ☐ | ☐ | ☒ | ☐ | ☐ | ☐ | ☐ | ☐ |

For white bread a medium serving is one medium sized slice. Therefore if you usually eat 1 medium slice 4 or 5 times per day, you should put a tick in the column headed "4-5 per day". If you eat 2 medium slices 4 or 5 times per day, then you should put a tick in the column "6+ per day".

| AVERAGE USE LAST YEAR | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| BREAD AND SAVOURY BISCUITS (One slice or one biscuit) | Never or less than once per month | 1-3 per month | Once per week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| White bread and rolls (including ciabatta and panini bread) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☒ | ☐ |

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| | AVERAGE USE LAST YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MEAT, FISH AND POULTRY (Medium serving – the size of a deck of cards) | Never or less than once per month | 1-3 per month | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| Beef: roast | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Beef: steak | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Beef: mince | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Beef: stew | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Beef Burger (1 burger) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Pork: roast | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Pork: chops | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Pork: slices/escalopes | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Lamb: roast | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Lamb: chops | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Lamb: stew | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Chicken portion or other poultry e.g. turkey: Roast | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Breaded chicken, chicken nuggets, chicken burger | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Bacon | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ham | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Corned beef, Spam, Luncheon meats | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Sausages, Frankfurters (1 sausage) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Savoury pies (e.g. meat pie, pork pie, steak & kidney pie, sausage rolls) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Liver, heart, kidney | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Liver paté | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Fish fried in batter, as in fish and chips | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Fish fried in breadcrumbs | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Oven baked/grilled fish (in breadcrumbs or batter) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Please check that you put a cross (X) on every line**

| | AVERAGE USE LAST YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MEAT, FISH AND POULTRY (Medium serving – the size of a deck of cards) | Never or less than once per month | 1-3 per month | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| Fish fingers/fish cakes | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other white fish, fresh or frozen (e.g. cod, haddock, plaice, sole, halibut, coli) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Oily fish, fresh or canned (e.g. mackerel, kippers, tuna, salmon, sardines, herring) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Shellfish (e.g. crab, prawns, mussels) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | AVERAGE USE LAST YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| BREAD AND SAVOURY BISCUITS (One slice or one biscuit) | Never or less than once per month | 1-3 per month | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| White bread and rolls (including ciabatta and pannini bread) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Brown bread and rolls | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Wholemeal bread and rolls | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Cream crackers, cheese biscuits | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Crisp bread, e.g. Ryvita | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Pancakes, muffins, oatcakes | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

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| | AVERAGE USE LAST YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CEREALS (One medium sized bowl) | Never or less than once per month | 1-3 per month | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| Porridge, Readybrek | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| All Bran, Weetabix, Shredded Wheat | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Branflakes, Bran Buds | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Cornflakes, Rice Krispies | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Muesli (e.g. Country Store, Alpen, sugar coated | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Sugar Coated Cereals (e.g. Frosties, Crunchy Nut Cornflakes, Crunchy Sugar Coated Muesli) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | AVERAGE USE LAST YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| POTATOES, RICE AND PASTA (Medium serving – about a cupful) | Never or less than once per month | 1-3 per month | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| Boiled, instant or jacket potatoes | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Mashed potatoes | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Chips | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Roast potatoes | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Potato salad | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| White rice | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Brown rice | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| White/yellow or green pastas (e.g. spaghetti, macaroni, noodles) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Wholemeal pasta | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

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| | AVERAGE USE LAST YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| POTATOES, RICE AND PASTA (Medium serving – about a cupful) | Never or less than once per month | 1-3 per month | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| Lasagne (meat based) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Lasagne (vegetarian) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Moussaka | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Pizza | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Macaroni Cheese | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | AVERAGE USE LAST YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| DAIRY PRODUCTS AND FATS | Never or less than once per month | 1-3 per month | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| Cream (Tablespoon) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Full-fat yoghurt or Greek-style yoghurt (125g carton) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Low-fat yoghurt, fromage frais (125g carton) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Dairy desserts (125g carton) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Cheddar cheese (medium serving) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Brie, Edam type cheese (medium serving) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Low-fat cheddar cheese (medium serving) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Cottage cheese, cream cheese, low-fat soft cheese (medium serving) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Eggs as boiled, fried, scrambled, poached (one) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Quiche (medium serving) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Light salad cream or light mayonnaise (tablespoon) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Salad cream, mayonnaise (Tablespoon) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Please check that you put a cross (X) on every line**

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| DAIRY PRODUCTS AND FATS | AVERAGE USE LAST YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Never or less than once per month | 1-3 per month | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| French dressing (tablespoon) | | | | | | | | | |
| Other salad dressing (Tablespoon) | | | | | | | | | |

| THE FOLLOWING ON BREAD OR VEGETABLES | Never or less than once per month | 1-3 per mth | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
|---|---|---|---|---|---|---|---|---|---|
| Butter (teaspoon) | | | | | | | | | |
| Lite Butter e.g. Dawn Lite, Connacht Gold (teaspoon) | | | | | | | | | |
| Sunflower margarine e.g. Flora (teaspoon) | | | | | | | | | |
| Low-fat margarine (e.g. Low-low) | | | | | | | | | |
| Cholesterol Lowering Spreads e.g. Flora Pro Active, Dairy Gold Heart (teaspoon) | | | | | | | | | |
| Cream & Vegetable Oil spread e.g. Golden Pasture, Kerrymaid, Dairy Gold – teaspoon | | | | | | | | | |
| Olive oil spread e.g. Golden Olive (teaspoon) | | | | | | | | | |

| FRUIT (1 Fruit or medium serving) | AVERAGE USE LAST YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Never or less than once per month | 1-3 per month | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| Apples | | | | | | | | | |
| Pears | | | | | | | | | |
| Oranges, Satsumas, Mandarins | | | | | | | | | |
| Grapefruit | | | | | | | | | |
| Bananas | | | | | | | | | |

**Please check that you put a cross (X) on every line**

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| | AVERAGE USE LAST YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| FRUIT<br>(1 Fruit or medium serving) | Never or less than once per month | 1-3 per month | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| Grapes | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Melon | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Peaches, Plums, Apricot | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Strawberries, Raspberries, Kiwi fruit | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Tinned fruit | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Dried fruit e.g. raisins | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Frozen fruit | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | AVERAGE USE LAST YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VEGETABLES<br>Fresh, frozen or tinned<br>(Medium serving – 2 tablespoons) | Never or less than once per month | 1-3 per month | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| Carrots | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Spinach | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Broccoli, Spring Greens, Kale | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Brussel Sprouts | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Cabbage | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Peas | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Green Beans, Broad Beans, Runner Beans | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Marrow, Courgettes | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Cauliflower | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Parsnips, Turnips | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Leeks | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Please check that you put a cross (X) on every line**

| | AVERAGE USE LAST YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| VEGETABLES<br>Fresh, frozen or tinned (Medium Serving – 2 tablespoons) | Never or less than once per month | 1-3 per month | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| Onions | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Garlic | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Mushrooms | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Sweet Peppers | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Beansprouts | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Green salad, Lettuce | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Cucumber, Celery | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Watercress | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Tomatoes | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Sweetcorn | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Beetroot | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Coleslaw | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Avocado | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Baked Beans | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Dried lentils, beans, peas | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Tofu, Soya Meat, TVP, Vegeburger | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | AVERAGE USE LAST YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SWEETS AND SNACKS (Medium serving) | Never or less than once per month | 1-3 per month | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| Chocolate coated sweet biscuits e.g. digestive (one) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Plain sweet biscuits e.g. Marietta, digestives, rich tea (one) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Cakes e.g. fruit, sponge | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Scones, flapjacks | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Buns, pastries e.g. croissants, doughnuts | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Please check that you put a cross (X) on every line**

| | AVERAGE USE LAST YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SWEETS AND SNACKS (Medium serving) | Never or less than once per month | 1-3 per month | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| Fruit pies, tarts, crumbles | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Sponge puddings | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Milk puddings e.g. rice, custard, trifle | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Ice cream, choc ices, Frozen desserts | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Chocolates, singles or squares | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Sweets, toffees, mints | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Sugar added to tea coffee, cereal (teaspoon) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Sugar substitute e.g. canderel added to tea coffee, cereal (teaspoon) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Crisps or other packet snacks | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Peanuts or other nuts | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | AVERAGE USE LAST YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SOUPS, SAUCES AND SPREADS | Never or less than once per mth | 1-3 per mth | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| Vegetable soups: Homemade/Fresh (1 bowl) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Vegetable soups: Tinned/packet (1 bowl) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Meat or cream soups: Homemade/Fresh (1 Bowl) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Meat or cream soups: Tinned/packet (1 bowl) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

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| SOUPS, SAUCES AND SPREADS | AVERAGE USE LAST YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Never or less than once per mth | 1-3 per mth | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| Sauces e.g. white sauce, cheese sauce, gravy (Tablespoon) | | | | | | | | | |
| Tomato based sauces e.g. pasta sauces | | | | | | | | | |
| Curry-type sauces | | | | | | | | | |
| Pickles, chutney (Tablespoon) | | | | | | | | | |
| Marmite, Bovril (Tablespoon) | | | | | | | | | |
| Jam, marmalade, honey, syrup (teaspoon) | | | | | | | | | |
| Peanut butter (teaspoon) | | | | | | | | | |

| DRINKS | AVERAGE USE LAST YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Never or less than once per month | 1-3 per month | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| Tea (cup) | | | | | | | | | |
| Coffee instant (cup) | | | | | | | | | |
| Coffee, decaffeinated (cup) | | | | | | | | | |
| Coffee whitener e.g. coffee-mate (teaspoon) | | | | | | | | | |
| Cocoa, Hot Chocolate (cup) | | | | | | | | | |
| Horlicks, Ovaltine (cup) | | | | | | | | | |
| Wine (glass) | | | | | | | | | |
| Beer, Larger or Cider (half pint) | | | | | | | | | |
| Alcopops e.g. Bacardi Breezer (bottle) | | | | | | | | | |
| Port, Sherry, Vermouth, Liqueurs (glass) | | | | | | | | | |

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| | AVERAGE USE LAST YEAR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| DRINKS | Never or less than once per month | 1-3 per month | Once a week | 2-4 per week | 5-6 per week | Once a day | 2-3 per day | 4-5 per day | 6+ per day |
| Spirits e.g. Gin, Whiskey (single measure) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Low calorie or diet soft drink, fizzy (glass) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Fizzy soft drinks e.g. Coca Cola (glass) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Pure fruit drinks e.g. orange juice (small glass) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Fruit squash (small glass) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Please check that you put a cross (X) on every line**

**That is the end of the questionnaire!**

***Your contribution to this research is greatly appreciated.***

## Appendix 3. Research output, dissemination, training and contributions

Research from this thesis has been published in peer-reviewed academic journals (Table 21) and has been presented at national and international conferences (Table 22). The candidate has also contributed to other publications while completing this thesis (Table 23) and completed many courses and training (Table 24). Finally, the candidate has made significant contributions to the Department of Epidemiology and Public Health, UCC while completing her PhD. These contributions are outlined in Table 25.

**Table 21. Peer-reviewed publications from this thesis**

| | Year | References for peer-reviewed journals |
|---|---|---|
| **1** | 2011 | **Geaney F,** Harrington J, Fitzgerald AP, Perry IJ: The impact of a workplace catering initiative on dietary intakes of salt and other nutrients: a pilot study. *Public Health Nutr* 2011, **14**(8):1345–1349. |
| **2** | 2013 | **Geaney F,** Kelly C, Greiner B, Harrington JM, Perry IJ, Beirne P: The effectiveness of workplace dietary modification interventions: a systematic review. *Prev Med 2013*, **57**:438–447. |
| **3** | 2013 | **Geaney F,** Scotto Di Marrazzo J, Kelly C, Fitzgerald AP, Harrington JM, Kirby A, McKenzie K, Greiner B and Perry IJ: The food choice at work study: effectiveness of complex workplace dietary interventions on dietary behaviours and diet-related disease risk - study protocol for a cluster controlled trial. *Trials 2013,* **14**:370-384. |
| **4** | 2015 | **Geaney F,** Fitzgerald S, Harrington JM, Kelly C, Greiner BA, Perry IJ. Nutrition knowledge, diet quality and hypertension in a working population. *Prev Med Rep 2015,* **2**:105-113 |
| **5** | 2015 | **Geaney F**, Kelly C, Harrington JM, Scotto Di Marrazzo J, Fitzgerald AP, Greiner BA, Perry IJ: The effect of complex workplace dietary interventions on employees dietary behaviours, nutrition knowledge and health status: a cluster controlled trial. *To be submitted to the Lancet in April 2015.* |

**Table 22. Conference presentations during the PhD**

| Month/Year | Conference | Title | Presentation |
|---|---|---|---|
| **June 2010** | HRB centre for health and diet research (CHDR) internal conference, UCD, Dublin. | The impact of a workplace catering initiative on dietary intakes of salt and other nutrients: a pilot study. | Oral |
| **September 2010** | Society for Social Medicine, Belfast. | The impact of a workplace catering initiative on dietary intakes of salt and other nutrients: a pilot study. | Poster |
| **May 2013** | International society for behavioural nutrition and physical activity (ISBNPA), Ghent University, Belgium. | 1. The effectiveness of workplace dietary modification interventions: a systematic review.<br>2. The food choice at work study: effectiveness of complex workplace dietary interventions on dietary behaviours and diet-related disease risk - study protocol for a cluster controlled trial. | 2 Posters |
| **October 2013** | HRB centre for health and diet research (CHDR) National Conference, UCC, Cork. | Workplace dietary interventions: a systematic review and work in progress (systematic review and FCW study protocol). | Oral |
| **May 2014** | International society for behavioural nutrition and physical activity (ISBNPA), Grand Hyatt Hotel, San Diego, USA. | Nutrition knowledge, diet quality and hypertension in a working population. | Oral |
| **April 2015** | Food services and best practice standards in healthcare conference 2015, Dublin. | Best practice catering guidelines for healthcare settings: Lessons from the Food Choice at Work Study. | Oral |
| **September 2015** | Society for Social Medicine, UCD, Dublin. | The effect of complex workplace dietary interventions on employees' dietary behaviours, nutrition knowledge and health status: a cluster controlled trial. | Oral |

**Table 23. On-going related Food Choice at Work study publications**

The candidate has also assisted in the development of the study design, data collection and analysis for these studies and is also responsible for co-writing these publications.

| Publication number | Year | References for on-going publications | Publication status |
|---|---|---|---|
| 1 | **2015** | Kelly C, **Geaney F**, Fitzgerald AP, Browne GM, Perry IJ. Validation of diet and urinary derived estimates of sodium against 24-hour urine excretion in a worksite sample. | In press with the Journal of Nutrition, Metabolism and Cardiovascular Disease |
| 2 | **2015** | Tracey ML, **Geaney F**, Fitzgerald S, Greiner B. Socioeconomic inequalities of cardiovascular risk factors among manufacturing employees in Ireland. | Submitted to Preventive Medicine. |
| 3 | **2015** | Fitzgerald S, **Geaney F**, Kelly C, McHugh S, Perry IJ. Barriers to and facilitators of implementing a complex workplace dietary intervention: process evaluation results of a cluster controlled trial. | Abstract accepted for oral presentation at the Global Implementation Conference (May 2015, Dublin). Submitted to Implementation Science. |
| 4 | **2015** | Fitzgerald S, Kirby A, Murphy A, **Geaney F**, Perry IJ. Absenteeism in the Workplace: Results from the Food Choice at Work Study (FCW). | Abstract accepted for oral presentation at the International Health Economics Association Conference (July 2015, Milan). Paper will be drafted and prepared for submission June 2015. |
| 5 | **2015-2016** | Fitzgerald S, Kirby A, Murphy A, **Geaney F**, Perry IJ. Cost-effectiveness of a complex workplace dietary intervention. | At data analysis stage (will be submitted in late 2015 – early 2016). |

**Publication 1:** Validation of diet and urinary excretion derived estimates of sodium excretion against 24-hour urine excretion in a worksite sample.

*Kelly C*[1], *Geaney F*[1], *Fitzgerald AP*[1], *Browne GM*[1] and *Perry IJ*[1]

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**Abstract**

*Background and Aims:* To validate diet and urinary excretion derived estimates of sodium intake against those derived from 24-hour urine collections in an Irish manufacturing workplace sample.

*Methods and Results:* We have compared daily sodium (Na) excretion from PABA validated 24-hour urine collections with estimated daily sodium excretion derived from the following methods: a standard Food Frequency Questionnaire (FFQ), a modified 24-hour dietary recall method, arithmetic extrapolations from morning and evening spot urine samples, predicted sodium excretion from morning and evening spot urine samples using Tanaka's, Kawasaki's and the INTERSALT formula. All were assessed using mean differences (SD), Bland-Altman plots, correlation coefficients and ROC Area under the Curve (AUC) for a cut off of ≥ 100mmol of Na/day. The Food Choice at Work study recruited 802 participants aged 18-64 years, 50 of whom formed the validation sample. The mean measured 24-hour urinary sodium (gold standard) was 138mmol/day (8.1g salt). At the group level, mean differences were small for both dietary methods and for the arithmetic extrapolations from morning urine samples. The Tanaka, Kawasaki and INTERSALT methods provided biased estimates of 24-hour urinary sodium. $R^2$ values for all methods ranged from 0.1 to 0.48 and AUC findings from 0.57 to 0.76.

*Conclusion:* Neither dietary nor spot urine sample methods provide adequate validity in the estimation of 24-hour urinary sodium at the individual level. However, group mean errors from dietary methods are small and random and compare favourably with those from spot urine samples in this population.

**Keywords:** Dietary sodium, urinary sodium, 24-hour dietary recall, 24-hour urine collection, spot urine.

## Introduction

Hypertension is a leading cause of 'death, stroke, myocardial infarction, congestive heart failure and chronic renal impairment' and affects 1 billion people worldwide [1]. Observational and experimental research has provided substantial evidence that excess dietary salt intake is a casual factor for hypertension [2]. Irish and UK authorities have set an upper limit for recommended salt intake of 6g per day while the World Health Organisation (WHO) recommend an upper limit of 5g per day [3]. Globally, new evidence suggests that the average level of sodium consumption is 3.95g per day of sodium (approx. 10g salt) which is almost double the WHO recommendation [4]. There is a compelling need to develop valid and reliable measures of sodium intake that are feasible for use in the study of associations between sodium intake and health outcomes and in on-going surveillance population studies of sodium intake.

Current measurements of dietary and urinary sodium are fraught with methodological difficulties [5]. Dietary methods tend to underestimate sodium consumption due to under-reporting of discretionary sources of salt (added at the table, or during cooking) [6]. The 24-hour urine collection method which is considered the 'gold standard' is burdensome and potentially limited by under-collection [7]. Several methods have also been used to predict 24-hour urinary sodium from spot urine samples, including arithmetic extrapolation [8] the INTERSALT formula [9] and the application of predictive formulae based on spot sodium to creatinine ratios as a means of controlling for urinary concentration, including those of Tanaka [10] and Kawasaki [11]. While the latter spot urine methods may be adequate for population level monitoring where the focus is on estimation of mean sodium intake at the group level, their use in analytical epidemiological research , as in recent studies suggesting potential harms from low intakes of dietary sodium [11,12], remains controversial.

The primary aim of this study was to validate a modified 24-hour dietary recall method for sodium intakes which used specific verbal prompts for discretionary salt consumption and portion size against the gold standard para-aminobenzoic acid (PABA) validated 24-hour urine collections. We also validated a number of other methods for estimation of 24-hour sodium excretion: a standard FFQ, arithmetic extrapolations from morning and evening spot urine samples, predicted sodium excretion from morning and evening spot urine samples using Tanaka’s formula, Kawasaki’s formula and the INTERSALT formula.

## Methods

### Study design

Cross sectional baseline data were obtained from a large clustered controlled trial, the Food Choice at Work (FCW) study which is described elsewhere [14]. Four multinational manufacturing workplaces participated in this trial.

### Study subjects

Participants were aged 18-64 years. Any full time, permanent employee who consumed one daily meal in the workplace canteen was eligible for the study. The FCW study population comprised of 802 participants and from this 50 participants provided a complete 24-hour urine collection for the validation study.

### Data collection

All participants were asked to complete a health, lifestyle and food questionnaire, a physical assessment, a FFQ, a 24-hour dietary recall, spot urine samples and/or a single 24-hour urine collection. Participants who did not were excluded from the analysis. Questionnaires were self-completed by participants electronically or in hard-copy format. Physical assessments and 24-hour dietary recalls were conducted by trained research assistants. All data was collected during employees working hours.

### Health, lifestyle and food questionnaire

Socio-demographic indicators included gender, age, ethnicity, education, marital status and work life (job position and usual working hours).

### Physical assessment

All participants underwent a comprehensive physical assessment where body mass index (BMI), midway-waist circumference and resting blood pressure were measured by trained research assistants as per the detailed guidelines outlined in the Standard Operating Procedures (SOP) manual [15].

**Dietary information**

**FFQ**

The FFQ was an adapted version of the European Prospective Investigation of Cancer (EPIC) FFQ [16]. It was validated for use in the Irish population [17-19]. The average frequency of consumption of each food item over the previous year was recorded by participants. The FFQ was designed to assess extensively the whole diet and included 150 food items arranged into the main food groups.

The food frequency data was analysed using a specifically designed computer program called FFQ Software, Version 2.0, developed by Juzer Lotya of the National Nutrition Surveillance Centre, School of Public Health and Population Science, University College, Dublin. The program converted the dietary information provided to food quantities and subsequently to food nutrient values, based on data from the Food Standards Agency [20] and McCance and Widdowson's Food Composition Tables [21].

**24-hour dietary recall**

The 24-hour dietary recall method was a modified version of the validated UK 24-hour dietary recall method [22]. Two dietary recalls were collected within one week to examine on and off duty work dietary patterns. The 3-step method outlined specifically what the participant had to eat and drink in the previous 24-hour period.

1. Quick list: participants were asked to report everything that they had to eat or drink the day before their appointment (midnight to midnight).
2. The nutritionist or research assistant collected detailed information on items named in the quick list (consumption time, place of consumption, brand and recipe), foods likely to be eaten in combination (milk in coffee) and the quantity consumed and any leftovers or second helpings.
3. Recall review: participants had an opportunity to provide additional information or to refer to foods forgotten in the quick list.

Additional modifications to this method included specific prompts for discretionary salt consumption (at the table and while cooking); information on accurate estimations of portion size, eating times, food brands and labels. All recalls were conducted by trained research assistants' and lasted approximately 20 minutes. Each food, drink and portion size was coded according to the 24-hour coding instructions based on the validated UK method. Food and nutrient analysis was calculated using NetWISP4© (Weighed Intake Software Program; Tinuviel Software, Warrington, UK) [23, 24]. The 24-hour dietary recall corresponded to the same time period as the 24-hour urine collection.

**Urinary Derived Estimates**

**Spot urine samples**

Each participant provided one sample the evening before and morning of their on-duty or off-duty dietary recall. The urine samples were taken approximately 12 hours apart e.g. 8pm-8am either on the evening and morning before the 24-hour urine collection commenced or on the opposite appointment to the 24-hour urine collection.Urinary electrolyte levels were measured using standard reagents and methods by the biochemistry laboratory of the Mercy University Hospital Cork. To estimate total sodium excretion in the spot urines, the sodium content was converted to mmol per day. To estimate mmol of sodium, we used gender specific PABA validated 24-hour mean urinary volume estimations derived from a larger but similar work based population [25].

The INTERSALT formula, Tanaka's and Kawasaki's equations were used to estimate 24-hour urinary sodium. The following equations were used:

INTERSALT formula [9]:

Men: 23 x {25.46 + [0.46 x spot Na (mmol/L)] – [2.75 x spot Cr (mmol/L)] - [0.13 x spot K (mmol/L)] + [4.10 x BMI (kg/m2)] + [0.26 x age (y)]}

Women: 23 x {5.07 + [0.34 x spot Na (mmol/L)] - [2.16 x spot Cr (mmol/L)] - [0.09 x spot K (mmol/L)] + [2.39 x BMI (kg/m2)] + [2.35 x age (y)] – [0.03 x age$^2$ (y)]

Tanaka's equation [10]:

$21.98 \times XNa^{0.392}$ where XNa = SUNa/SUCr x PRCr

SUNA = Na concentration(mEq/L) in the spot urine

SUCr = creatinine concentration(mg/dl) in the spot urine

Predicted creatinine (PRCr) assumes that 24-hour urinary creatinine excretion can be estimated approximately on the basis of age, weight and height at the population level. The predicted creatinine formula as stated by Tanaka was as follows (10):

-2.04 x age + 14.89 x weight (kg) +16.14 x height (cm) -2244.45.

Kawasaki's equation for sodium [11]:

$16.3 \times \sqrt{[\text{Spot Na/Spot Cr}]} \times$ predicted 24-h urinary Cr, where predicted Cr (mg/day) for women is: $-4.72 \times$ age (years) $+ 8.58 \times$ weight (kg) $+ 5.09 \times$ height (cm) $-74.5$; and for men is: $-12.63 \times$ age (years) $+15.12 \times$ weight (kg) $+ 7.39 \times$ height (cm) $-79.9$.

**Single 24-hour urine collection**

A standard verbal and written explanation of the 24-hour urine collection process was provided to all participants prior to participation. Eighty nine participants completed a single 24-hour urine collection. However, 6 did not complete the FFQ and/or HLFQ and 6 did not wish to take the PABA tablets. Three 80mg doses of PABA (a biologically inert substance rapidly excreted in urine) were administered to all participants in tablet form the day of urine collection to validate the completeness of the sample. Each participant was provided with 2 three litre storage containers and one 500ml storage container in a strong opaque carrier bag. Participants were asked to outline whether or not they had accidentally missed a urine collection.

Once 24-hour urine collections were returned, the collections were weighed and urinary electrolyte levels were measured in the biochemistry laboratory of the Mercy University Hospital Cork. Urine samples were stored at -20 C once aliquoted. PABA analysis was conducted at the Medical Research Council Human Nutrition Research Laboratory in Cambridge, United Kingdom. The samples were transferred frozen. A colorimetric microplate method was used to assay the PABA samples. Results were reported as a percentage of the PABA dose excreted.

A complete urine sample was assumed when between 70% and 103% of the PABA ingested dose appeared in the urine. Those containing <70% are interpreted as 'incomplete' and >103% are interpreted as 'over'. In this study, 50 participants had >70-102% PABA excretion and detectable sodium in the sample.

**Statistical Analysis**

Data was recorded manually and entered electronically into SPSS prior to statistical analysis. Data manipulation and statistical analyses were conducted using SPSS Version 21 and $p<0.05$ was considered significant. Unweighted mean (SD), median and 95% CI values were reported for each method. Certain outliers with very high sodium and potassium intakes did remain in the data and analysis of variance (ANOVA) was then used to compare mean nutrient intakes. Outliers were excluded based on z scores for kilocalories, <-3.3 and >3.3.

Bland-Altman plots were generated to validate the agreement between the measured 24-hour urinary sodium (gold standard) and each of the reported methods. The difference between the gold standard and each alternative method was calculated and plotted against the mean of the two measurements. Overall, 95% limits of agreement were calculated as the mean difference ± 1.96 SD, where SD is the standard deviation of the differences in paired measurements. Agreement between methods was also examined by Pearson's correlation coefficients and by receiver operating characteristic (ROC) area under the curve with a cut -off point of >=100mmol/l for sodium. These levels were chosen as it is the upper tolerable limit for sodium intake in Ireland and the UK.

**Ethics**

Ethical approval was granted by the Clinical Research Ethics Committee of the Cork Teaching Hospitals in the Republic of Ireland May 2012 and amended in March 2013. All participants provided written informed consent.

**Results**

The characteristics of the FCW and validation sample population are summarised in Table 1. Majority of participants were aged 18-39 years (60%), male (60%) and had a tertiary education (50.7%). Overweight and obesity levels were higher among males (54.3% and 22.3%) in comparison to females (36.9% and 19.6%). More men (22%) than women (7.3%) were classified as hypertensive. Overall, there were no significant differences between the 2 groups with the exception of those in the validation sample group having a higher level of education (p=0.013) and a lower level of diastolic hypertension (p=0.003).

Estimations of dietary and urinary sodium for the FCW and validation sample population are presented in Table 2. In the FCW population, mean estimated sodium intake was higher in males than in females for all methods. The mean measured 24-hour urinary sodium in the validation was 138mmol/day (8.1g), virtually identical to that estimated from the 24-hour dietary recall (134 mmol/day), the arithmetic extrapolations from morning spot urine samples (136mmol/day) and the INTERSALT formula from evening spot samples (132 mmol/day). Group mean estimates from morning spot samples were closer than evening samples to the 24-hour estimates of urinary sodium. However for some methods, notably the Kawasaki method both morning and evening samples overestimated sodium excretion relative to the measured 24-hour urinary sodium.

Bland-Altman analysis is shown in Figure 1. The degree of bias (i.e. mean difference between measured and estimated mean sodium) at the group level was small for both dietary methods and for some but not all of the urine derived methods ranging from 3.8 to -47mmol sodium. The Kawasaki evening spot prediction had the largest degree of bias (-47mmol sodium). The Tanaka prediction and INTERSALT prediction tended to underestimate 24-hour values at low excretion levels and over estimate at higher levels.

Table 3 presents the findings on the performance of dietary and spot urine derived measures of 24-hour sodium excretion versus measured 24-hour urinary sodium as assessed by mean difference on Bland-Altman analysis, correlation coefficients and ROC Area under the Curve value. The performance of all methods was relatively poor with $R^2$ values ranging from 0.07 to 0.48 and AUC values ranging from 0.56 to 0.76.

## Discussion

The findings suggest that at the individual level neither dietary methods nor spot urine samples provide adequate accuracy in the assessment of 24-hour urinary sodium relative to the gold standard of measured 24-hour urinary sodium. However group mean errors from both dietary methods (FFQ and modified 24-hour dietary recall, a novel method that can be completed in under 20 minutes) were small and random and compare favourably with those from spot urine samples in this population.

The findings are consistent with an emerging consensus that spot urinary sodium is a poor predictor of 24-hour excretion in individuals but may provide adequate mean estimates for population level monitoring [7, 26]. Particularly, there was no evidence that the use of the Tanaka [10] and Kawasaki [11] predictive formulae increases the accuracy of estimates of 24-hour urinary sodium relative to simple arithmetic extrapolation or the dietary methods. Data on the Tanaka formula which underestimated 24-hour values at low excretion levels and overestimated values at higher levels are consistent with the findings from Ji and colleagues who carried out a validation study of spot versus 24-hour urine samples in multi-ethnic populations in Britain and Italy [8]. It is also noteworthy that in the latter study, the validity of spot urine estimates varied between men and women and in different ethnic groups. The extent to which the Kawasaki predictive formula overestimates measured 24-hour urinary sodium raises concern about the appropriateness of using this formula in analytical epidemiological research [12,13].

Several different formulae have been suggested to estimate spot urinary sodium over 24-hours. In this study the INTERSALT formula provided the least bias information regarding mean sodium intake when compared to the Tanaka and Kawasaki formula. This finding is consistent with the findings from Cogswell and colleagues who carried out a validation study of predictive equations for 24-hour urinary sodium excretion in adults aged 18-64 years [9].

The findings from this study suggest that specific dietary intake methods can usefully estimate mean sodium intakes at the population level. This is consistent with reports from the USDA Automated Multiple Pass Method Validation study which uses a 24-hour dietary recall method [27]. The latter study reported that sodium intake was underestimated by less than 9% in comparison to the sodium biomarker and the authors suggest that dietary intake methods are an acceptable measure at the population/group level for estimating sodium intakes. Failure to capture discretionary salt or salt added during cooking or at the table is the major factor in the underestimation of daily sodium intake [23]. However, one of the unique features of the 24-hour dietary recall method used in this study is the use of prompts for discretionary salt and the careful questioning by trained research assistants regarding actual portion size consumed, eating times and food labels.

Strengths of the study include that all workplaces had similar characteristics as they were all manufacturing workplaces with similar shift patterns and work schedules. Employees that participated in the validation study had comparable demographics and health status characteristics when compared to the overall FCW study population. This is one of the few studies to compare both diet and spot urine estimates of 24-hour sodium in the same population.

Limitations associated with this study include the small sample size of the validation population (n=50). It may also be objected that the generalisability of the findings is limited by the fact that the participants are a non-representative group of healthy employees in a workplace setting where dietary exposures are relatively stable. This may have contributed to the relative accuracy of the dietary recall methods versus the spot urine sample estimates in this setting. However as there is no accepted alternative to 24-hour urine collection suitable for use in all settings, the findings highlight the need, in specific settings such as the workplace, to compare and calibrate methods of estimating 24-hour sodium excretion against 24-hour collections. The findings also suggest that in some settings, dietary methods, in addition to providing valuable information on the sources of dietary sodium, may also provide estimates of 24-hour intake of adequate accuracy at the group level.

**Conclusion**

Although the 24-hour urine collection is burdensome for use in large scale studies it remains the gold standard for work addressing the impact of sodium intake on health outcomes. The present study demonstrated that neither dietary nor urinary methods based on morning or evening spot samples provide adequate validity in the estimation of dietary sodium intake at the individual level. However the dietary methods and some of the urinary methods may be applied at the population level for estimations of mean dietary sodium intake.

**Contributions of authors**

CK was responsible primarily for the final content of the paper. CK, FG, GB, IJP worked on the study design and co-wrote the final manuscript. CK, FG, TF, GB, were responsible for data analysis and interpretation of results.. All authors approved the final version of the paper for publication.

**Declarations of interest**

The authors declare that there are no conflicts of interest.

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**Table 1: Baseline characteristics of the Validation sample population (n=50) and the overall FCW sample population (n=802)**

| | Total (n=50) N (%) | Men (n=32) N (%) | Women (n=18) N (%) | p-value | Total (n=802) N (%) | Men (n=556) N (%) | Women(n=246) N (%) | p-value* |
|---|---|---|---|---|---|---|---|---|
| **Age** | | | | | | | | |
| 18-39 years | 32(64) | 23(72) | 9(50) | 0.122 | 478(60) | 335(60) | 143(58) | 0.572 |
| 40-64years | 18(36) | 9(28) | 9(50) | | 324(40) | 221(40) | 103(42) | |
| Mean | 37.7 | 37.9 | 37.3 | | 38.7 | 38.8 | 38.4 | |
| **Education** | | | | | | | | |
| Leaving Cert or less | 4(8) | 3(9) | 1(6) | 0.200 | 181(23) | 100(18) | 81(33) | 0.000* |
| Certificate/diploma | 16(32) | 8(25) | 8(44) | | 214(27) | 143(26) | 71(29) | |
| Primary/Degree | 17(34) | 14(44) | 3(17) | | 241(30) | 192(35) | 49(20) | |
| Post Graduate | 13(26) | 7(22) | 6(33) | | 166(21) | 121(22) | 45(18) | |
| **Job Position/Manager** | | | | | | | | |
| Manager | 5(10) | 4(13) | 1(6) | 0.018 | 86(11) | 73(13) | 13(5) | 0.001* |
| Supervisor | 4(8) | 0 | 4(22) | | 84(11) | 63(11) | 21(9) | |
| Not a manager/not a supervisor | 41(82) | 28(88) | 13(72) | | 632(79) | 420(76) | 212(86) | |
| **BMI Status** | | | | | | | | |
| Normal weight | 15(30) | 7(22) | 8(44) | 0.239 | 236(29) | 130(23) | 106(43) | 0.000* |
| Overweight | 29(58) | 21(66) | 8(44) | | 393(49) | 302(54) | 91(37) | |
| Obese | 6(12) | 4(13) | 2(11) | | 172(22) | 124(22) | 48(20) | |
| Mean | 26.4 | 26.9 | 25.5 | | 27.2 | 27.6 | 26.3 | |
| **Hypertensive** | | | | | | | | |
| Yes | 6(12) | 5(16) | 1(6) | 0.293 | 110(14) | 96(17) | 14(6) | 0.000* |
| No | 44(88) | 27(84) | 17(94) | | 692(86) | 460(83) | 232(94) | |
| **Creatinine:** Mean (SD) median | 15(5)15 | 18(3)17 | 12(5)10 | | | | | |
| **Blood Pressure** | | | | | | | | |
| Systolic: Mean (SD) median | 120(16)119 | 124(14)121 | 112(17)109 | | 121(15)120 | 125(13)123 | 112(15)110 | |
| Diastolic: Mean (SD) median | 73(9)72 | 74(8)74 | 70(9)68 | | 75(10)75 | 76(9)76 | 72(10)71 | |

*significant gender differences P<0.05

**Table2: Validation and FCW sample population- sodium intake (mmol/day) based on dietary and urinary methods – mean (sd)**

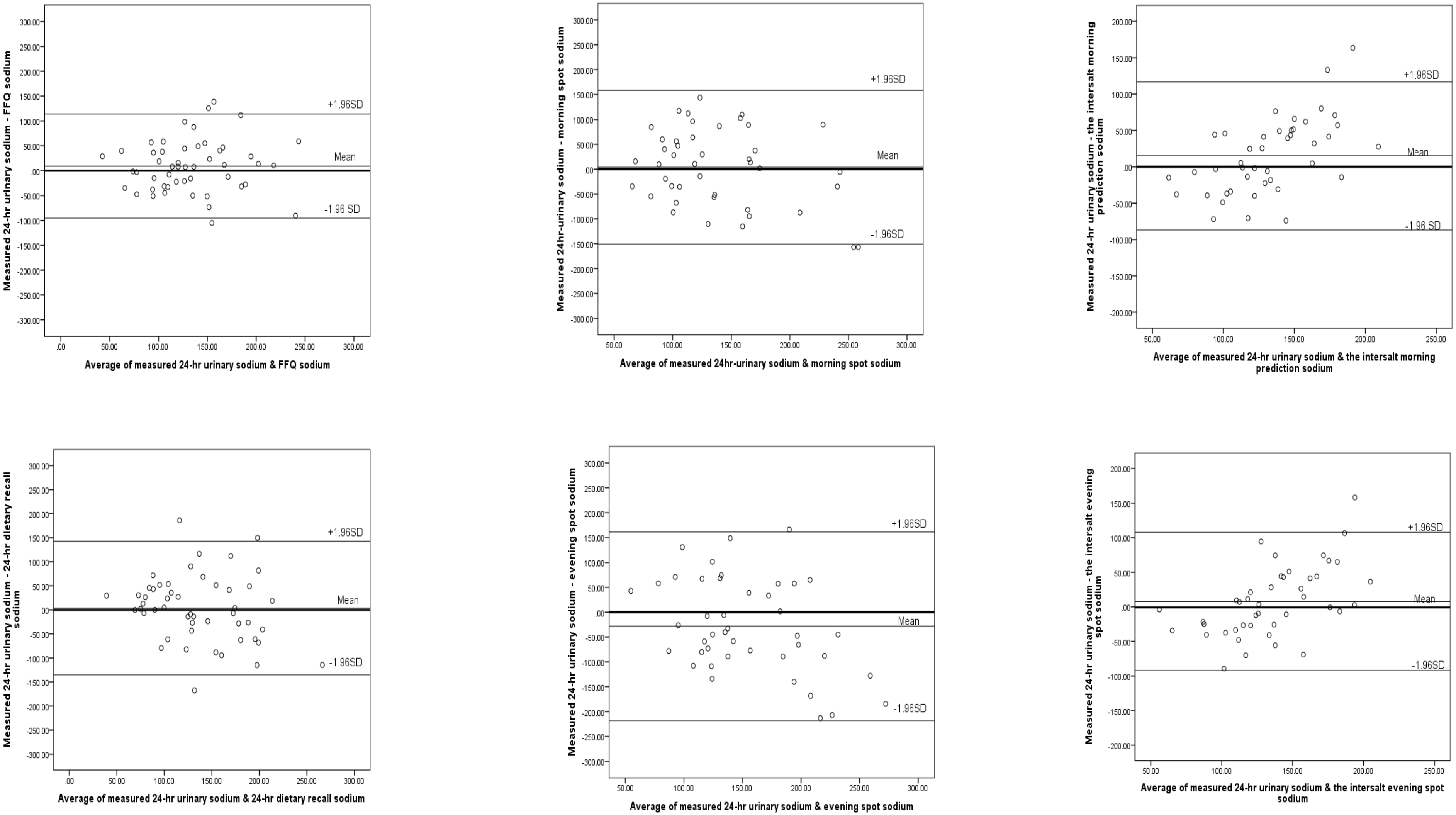
| | Validation Study Population | | | FCW Study Population | | |
|---|---|---|---|---|---|---|
| **Method** | Total (n=50) *** | Men (n=32) | Women (n=18) | Total (n=793) *** | Men (n=550) | Women (n=243) |
| **24 hr urine PABA validated** | **138(53)** | **147(46)** | **121(61)** | -------- | --------- | -------- |
| FFQ* | 129(50) | 126(56) | 133(39) | 132(53) | 135(53) | 128(53) |
| 24 hr dietary recall* | 134(65) | 147(67) | 111(55) | 132(76) | 141(82) | 112(56) |
| Arithmetic extrapolations morning spot ** | 136(72) | 145(83) | 124(61) | 167(82) | 180(84) | 141(73) |
| Arithmetic extrapolations evening spot ** | 168(820 | 191(890 | 137(60) | 186(108) | 201(109) | 150(93) |
| Tanaka's prediction morning spot 24hr estimate | 129(27) | 134(26) | 122(27) | 135(31) | 136(29) | 133(34) |
| Tanaka's prediction evening spot 24hr estimate | 147(32) | 148(33) | 122(27) | 157(32) | 159(32) | 154(33) |
| Kawasaki's prediction morning spot 24hr estimate | 157(45) | 174(42) | 134(38) | 198(64) | 218(59) | 152(48) |
| Kawasaki's prediction evening spot 24hr estimate | 187(53) | 199(57) | 169(42) | 239(72) | 264(67) | 184(49) |
| Intersalt prediction morning spot 24hr estimate | 125(28) | 141(23) | 103(19) | 135(33) | 146(31) | 111(23) |
| Intersalt prediction evening spot 24hr estimate | 132(30) | 148(26) | 110(19) | 145(35) | 158(33) | 118(24) |

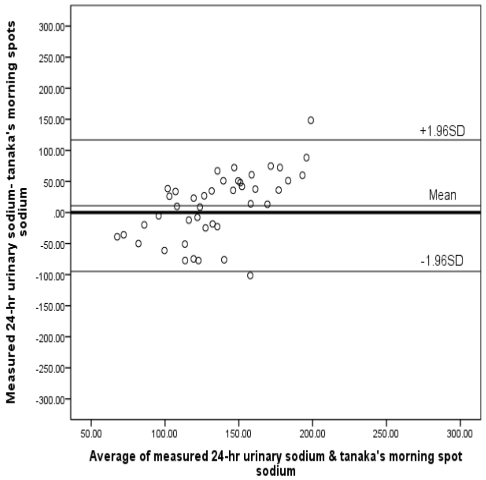
*All dietary assessments have been normalised from mg Na to mmol of sodium/day
**Based on single specimen averaged for 24 hr collection g/day
***Slight variation to total numbers for different methods

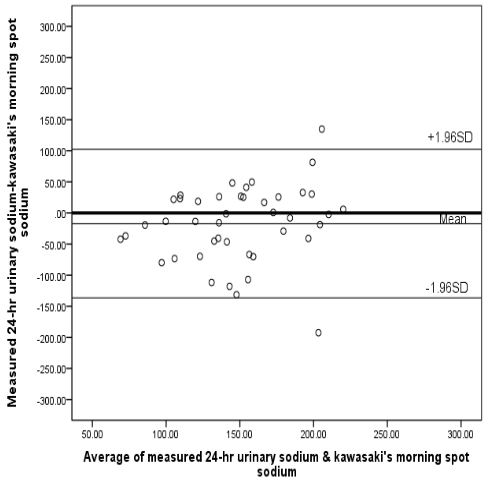
**Table 3: Performance of dietary and spot urine derived measures of 24-hour sodium excretion versus measured 24-hour urinary sodium as assessed by mean difference on Bland-Altman analysis, correlation coefficients and ROC Area under the Curve values based on the validation study population (n=50).**

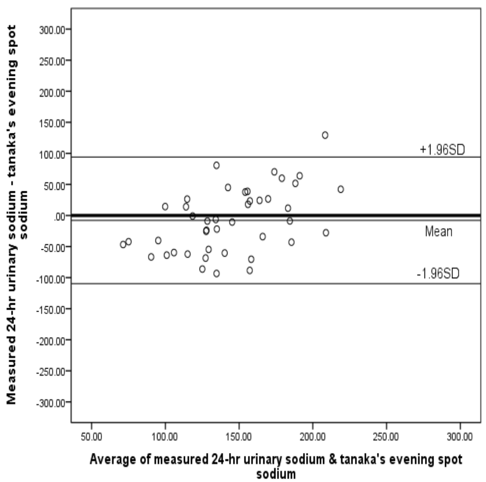
| Method | Mean Difference (SD) | 95% CI on mean difference | 95% Limits of Agreement | $R^2$ | p-value | AUC | 95%CI |
|---|---|---|---|---|---|---|---|
| **FFQ** | 9.1(52.4) | -5.7, 24 | -95.7,113.9 | 0.48 | 0.000 | 0.76 | 0.6,0.9 |
| **24- hour dietary recall** | 3.8(69.4) | -15,23 | -135,142.6 | 0.32 | 0.023 | 0.71 | 0.5,0.8 |
| **Arithmetic extrapolations morning spot** | 3.8(77.4) | -20,27 | -151,158.6 | 0.28 | 0.075 | 0.57 | 0.4,0.7 |
| **Arithmetic extrapolations evening spot** | -28.3(94.7) | -57,10 | -217.7,161.1 | 0.07 | 0.066 | 0.56 | 0.4,0.7 |
| **Tanaka's prediction morning spot 24hr estimate** | 10.9(54) | -5,27 | -94.9,116.7, | 0.24 | 0.114 | 0.60 | 0.4,0.8 |
| **Tanaka's prediction evening spot 24hr estimate** | -7.8(52) | -23,8 | -109.7,94.1 | 0.35 | 0.022 | 0.64 | 0.4,0.8 |
| **Kawaski's prediction morning spot 24hr estimate** | -17.1(61) | -36,1.1, | -136.3,102.5 | 0.24 | 0.122 | 0.63 | 0.4,0.8 |
| **Kawaski's prediction evening spot 24hr estimate** | -47.0(61) | -65,-28 | -166.6,72.6 | 0.34 | 0.025 | 0.68 | 0.5,0.9 |
| **Intersalt prediction morning spot 24hr estimate** | 15.1(52) | -0.8, 31 | -74, 163.6 | 0.32 | 0.033 | 0.70 | 0.5,0.8 |
| **Intersalt prediction evening spot 24hr estimate** | 7.8(51) | -7.9,24 | -89, 158 | 0.36 | 0.019 | 0.71 | 0.5,0.9 |

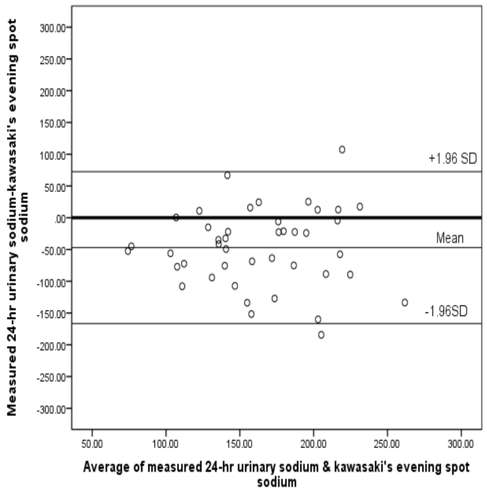
**Figure 1: Bland-Altman analysis for dietary and urinary sodium based on the validation study population (n=50)**




Measured 24-hr urinary sodium- tanaka's morning spots sodium
Average of measured 24-hr urinary sodium & tanaka's morning spot sodium
+1.96SD
Mean
-1.96SD


Measured 24-hr urinary sodium-kawasaki's morning spot sodium
Average of measured 24-hr urinary sodium & kawasaki's morning spot sodium
+1.96SD
Mean
-1.96SD


Measured 24-hr urinary sodium - tanaka's evening spot sodium
Average of measured 24-hr urinary sodium & tanaka's evening spot sodium
+1.96SD
Mean
-1.96SD


Measured 24-hr urinary sodium-kawasaki's evening spot sodium
Average of measured 24-hr urinary sodium & kawasaki's evening spot sodium
+1.96 SD
Mean
-1.96SD

**Publication 2:** Socioeconomic inequalities of cardiovascular risk factors among manufacturing employees in the Republic of Ireland: a cross-sectional study.

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**Key words:** cross-sectional study; social gradient of health; education; job position; occupation; cardiovascular risk factors

**Abstract**

**Objectives:** To explore socioeconomic differences in four CVD risk factors (overweight/obesity, smoking, hypertension, height) among manufacturing employees in the Republic of Ireland (ROI).

**Methods:** Cross-sectional analysis of 850 manufacturing employees aged 18-64 years. Education and job position served as socioeconomic indicators. Group-specific differences in prevalence were assessed with the Chi-squared test. Multivariate regression models explored if education and job position were independent predictors of the CVD risk factors. Cochran-Armitage test for trend was used to assess the presence of a social gradient.

**Results**: A social gradient was found across education levels for smoking and height. Employees with the highest education were less likely to smoke compared to the least educated employees (OR 0.2, [95% CI 0.1-0.4]; p<0.001). Lower education attainment was associated with a reduction in mean height. Non-linear differences were found in both education level and job position for obesity/overweight. Managers were more than twice as likely to be overweight or obese relative to those employees in the lowest job position (OR 2.4 [95% CI 1.3-4.6]; p=0.008).

**Conclusion:** Socioeconomic inequalities in height, smoking and overweight/obesity were highlighted within a sub-section of the working population in ROI.

## Introduction

Socioeconomic inequalities in health are a major population health concern. It places a substantial financial burden on European economies. Similar to other chronic illnesses, cardiovascular disease (CVD) follows a social gradient in both population-based and occupational based studies. (Marmot et al. 1978; Mulcalhy et al. 1984; Kaplan and Keil 1993; Mackenbach et al. 2000; Barry et al. 2001; Balanda and Wilde 2001; Rosengren et al. 2009). This graded pattern is evident at each rank of the socioeconomic hierarchy; not just at the point of severe deprivation (Adler et al. 1994; Marmot, 2005).The burden of CVD has steadily declined in Europe over the past number of years (Mackenbach and Bakker 2003). However, in Western Europe the prevalence of CVD has decreased more rapidly in groups with a higher socioeconomic status and inequalities along the social gradient have increased (Mackenbach and Bakker 2003).

Established risk factors for CVD, such as hypertension, smoking, height and obesity have also been shown to follow the social gradient (Kapal and Kiel 1993; Marmot et al. 1978; Marmot et al. 1991; Mulcahy et al. 2001; Morgan et al. 2008). Combinations of these risk factors have explained 12%-54% of the socioeconomic inequalities in CVD (Marmot et al, 1978; Marmot et al. 1991; Macintyre et al. 1997; Laaksonen et al. 2008; van Oort et al. 2005). It has been suggested that individuals who are classified at the lower end of the socioeconomic hierarchy are more resistant to changing risk behaviours than their more advantaged counterparts (Winkleby et al. 1994). From an international perspective, the social gradient in health and risk factors for CVD has been mainly demonstrated in general population studies and less in occupational studies, with the exception of Whitehall (Marmot, et al. 1978; Marmot et al. 1991) which was limited to civil servants. Occupational samples differ from the general population as they usually do not include poor people, may be healthier and have a higher education level.

Therefore, the aim of this study was to investigate socioeconomic inequalities in overweight/obesity, smoking, hypertension and height using employees from four large multi-national manufacturing companies in the Republic of Ireland (ROI). We hypothesize that: (1) education attainment and job position will be independent predictors for CVD risk factors and (2) a social gradient will be observed; with those from the lowest socioeconomic groups being more likely to be overweight/obese, smokers, hypertensive and shorter in height relative to their socially higher counterparts.

## Methods

*Study population*

Baseline data (Feb-July 2013) was acquired from the Food Choice at Work (FCW) study. The study is a cluster controlled trial (trial registration ISRCTN35108237) involving four multinational manufacturing workplaces in Cork, ROI. This study measures the effectiveness and cost-effectiveness of complex workplace dietary interventions that include environmental dietary modifications alone or in combination with nutrition education. The sample size was powered at 80% to detect a decrease in BMI by $1kg/m^2$ and a 2g average fall in dietary salt intake between the control and intervention groups following delivery of the interventions. Eligibility criteria for participants included all permanent, full-time employees who purchased and consumed at least one main meal at work on a daily basis. A randomly selected sample of 850 employees (aged 18-64 years) were recruited via random number allocation software and invited to participate by email or telephone. A detailed account of the study's protocol is described elsewhere (Geaney et al. 2013). Participants that did not complete a socio-demographic and lifestyle questionnaire and a physical assessment were excluded from the analysis.

*Data collection*

All physical assessments (height, weight and blood pressure) were conducted by trained research assistants in a standardised manner as per the study protocol (Geaney et al. 2013). Questionnaires were self-completed in electronic or hard copy format. All data collection took place during the participants working hours (break times excluded).

*Socioeconomic status (SES) Indicators*

Highest level of completed education and job position served as the indicators for SES. Education was transformed into a four level variable; completed high school or less, certificate/ diploma, basic university degree and higher university degree. Job position was classified as: manager, supervisor and general staff.

*CVD risk factors*

The four CVD risk factors explored were defined as the dependant variables. Current smoking status was determined by the question *"Do you now smoke"*, (Yes or No). Participants body weight (Kg) was taken on a calibrated weighing scale (Tanita WB100MA) and height (cm) was measured using a portable Seca Leicester height/length measure. Body mass index (BMI) ($kg/m^2$) was defined as: underweight/healthy (<$24.99kg/m^2$); overweight ($25.00$-$29.99kg/m^2$) and obese (>$30.00kg/m^2$) in accordance with international classifications (World Health Organisation, 2013). Subsequently, to indicate the presence of overweight or obesity a BMI of $\geq 25$ $Kg/m^2$ was coded as 'yes' and $\leq 24.99$ $kg/m^2$ as 'no'. Blood pressure (BP) was measured three times on the right arm after at least 10 minutes of rest in a seated position using a calibrated digital blood pressure monitor (Omron M7). The average of the last two BP readings was used for analysis. Hypertension was defined as a systolic reading of ≥140 mmHg and/or a diastolic reading of ≥90 mmHg (American Heart Association, 2012). Participants who had a self-reported previous diagnosis of high blood pressure were also classified as hypertensive.

*Other variables*

Other variables of interest (accommodation, marital status and existing medical conditions) were self-reported via a Health, Lifestyle and Food Questionnaire (HLFQ). These were considered as potential confounding factors because of their possible association with CVD risk factors and each of the socioeconomic indicators (Marmot et al. 1991; Nishi et al. 2004; Gupta et al. 2012; Martikainena et al. 2013).

*Statistical analysis*

All analysis was carried out using STATA version 12 (StataCorp, College Station, TX, US). In accordance with standard research methodology, the level of statistical significance was 0.05. A demographic profile of the study sample was generated to give an overview of baseline characteristics. The prevalence of each categorical CVD risk factor was generated according to each SES indicator. Job position was not stratified by gender due to the small sample size in the higher categories. Differences in proportions were tested by a Chi-squared test and a one-way ANOVA test was conducted to compare height in each of the SES groups (education level and job position, respectively). Three multivariate logistic regression models were utilised to establish if education attainment and job position were independent predictors for each dichotomised CVD risk factor (smoking, overweight/obesity, and hypertension). Height (cm) was analysed using multivariate linear regression. All analysis was adjusted for age, gender, house ownership, marital status and medical condition. Regardless of significance in univariate analysis, all potential confounders were considered in accordance with other research in this area (Marmot et al. 1991; Nishi et al. 2004; Gupta et al. 2012; Martikainena et al. 2013). The lowest socioeconomic group served as the reference category in each model. Education and job position were potentially correlated so the variance inflation factor (VIF) was examined to assess the presence of collinearity; a VIF of >10 indicated collinearity. The odds ratio (OR) or beta coefficient (β), respective 95% confidence interval and associated p values were reported. The Cochran-Armitage test for trend was utilised to identify a social gradient.

*Ethical approval*

Ethical approval for the FCW study was granted by the Clinical Research Ethics Committee of the Cork Teaching Hospitals in the Republic of Ireland in March 2013. All participants provided written informed consent before data collection commenced.

**Results**

In total, 883 individuals were recruited for the Food Choice at Work Study, 19 participants were excluded as they did not attend a physical assessment and a further 14 were excluded because the HLFQ was unanswered. Therefore, the sample comprised of 850 adults; 586 males (68 %) and 264 females (31 %) (workplace A: 111 (72% response rate), workplace B: 226 (71% response rate), workplace C: 400 (61% response rate), workplace D: 113 (91% response rate)). The distribution of baseline characteristic for the total population and by gender is illustrated in Table 1.

The distribution of each CVD risk factor, according to education attainment and job position is shown in Table 2. For education attainment the most consistent trends were found for smoking and height, for both men and women. Men who had attained the highest level of education were 5cm taller relative to those in the lowest educational group (174 cm vs. 179 cm; $p < 0.001$). In men, 26% in the lowest education group smoked compared to 11% in the highest ($p<0.001$). Among women, 37 % of the least educated women were current smokers relative to 8% who had a higher university degree ($p=0.003$). A higher percentage of male employees from the lowest education category were hypertensive relative to those with a higher university degree (32% vs. 16%; $p=0.03$).

There were no linear trends for obesity/overweight and hypertension. Among women, the prevalence of overweight/obesity was significantly higher in those at the lowest end of the education scale compared the highest levels (69% vs. 61% vs. 38 %vs. 58%; $p=0.004$). Similarly to smoking, the proportion of hypertensive men decreased as levels of education increased. Male employees who had the least education had a higher prevalence of hypertension compared to those with the highest.

In relation to the pattern of CVD risk factors by job position, no significant linear trend could be identified, however a significantly higher percentage of managers were overweight or obese compared to employees in the two lower job positions. The prevalence of this risk factor was 15% higher (70% vs. 85%; $p=0.003$) in managers relative to employees who were not supervisors or managers.

Results from multivariate regression analysis are shown in Table 2. Multicollinearity was not found between variables (VIF <10). In the fully adjusted logistic regression model, education was an independent predictor of overweight/obesity, smoking, hypertension and height. A non-linear trend was observed for overweight/obesity and hypertension (trend $p> 0.05$). Employees with a basic university degree were 40% less likely to be overweight or obese when compared to employees with the lowest level of education attainment (OR 0.6 [95% CI 0.4-0.8]; $p= 0.01$). An inverse linear relationship between smoking and education was observed; as education level increased the odds of smoking decreased (trend $p=0.02$). Employees with a higher university degree were 80% less likely to smoke compared to the least educated employees (OR 0.2 [95% CI 0.1-0.4]; $p<0.001$). The odds of hypertension were reduced in those who had a certificate/diploma compared to those who had an education of high school or less (OR 0.6 [95% CI 0.3-0.9]; p=0.03). There was a clear significant difference in mean height between education groups and the difference linearly increased as education attainment increased (trend p=0.01). Job position was an independent predictor of overweight/obesity. After taking all variables into account, managers were nearly 2.5 times more likely to be overweight/obese relative to those employees in the lowest job position (OR 2.4 [95% CI 1.3-4.6]; p=0.008).

**Discussion**

We found mixed evidence for our hypothesis of a gradient in CVD risk factors by education and job position. Consistent with previous research, employees who had completed high school or less were more likely to be overweight/obese, hypertensive and shorter in height than those employees in the higher education strata. This indicates that the least educated had a higher CVD risk profile; a finding which has been previously highlighted in the general Irish population (Mulcahy et al. 1984). In accordance with previous research, (Winkleby et al. 1992b; Winkleby et al. 1992b Bobak et al. 1999; Nishi et al. 2004; Yu et al. 2005; Mackenbach et al. 2008; Layte and Whelan 2008; Gupta et al. 2012), a social gradient was observed for smoking. In this study, employees with a higher university degree were 80% less likely to smoke relative to those employees who had completed high school (OR 0.2 [95% CI 0.1-0.4]; p=0.000). These figures suggest that, similarly to other northern European countries, the Republic of Ireland is in the final stage of a smoking epidemic; the overall prevalence of smoking has decreased but it is more common in lower socio-economic groups (Lopez et al. 1994; Alves et al. 2013). Contrary to our expectation, job position was not an independent predictor of smoking.

A social gradient was also observed among education groups in mean height. Results from the multivariate linear regression model were in line with existing literature; individuals with the least education are shorter in height relative to those with the highest education (Bobak et al. 1999; Meyer and Selmer 1999; Magnusson et al. 2006) potentially due to adverse environmental exposure during intrauterine life (Barker, 1997) or during childhood that affected growth. Results for overweight/obesity did not follow the expected linear gradient. Nevertheless, those with a basic university degree were less likely to have an unhealthy BMI relative to those who had completed high school or less (OR 0.6 [95% CI 0.4-0.8], p= 0.01). Managers were 2.5 times as likely to be overweight/obese than those employees from the lowest end of the occupational hierarchy (OR 2.4 [95% CI 1.3-4.6]; p=0.008). This finding contradicts the evidence from other higher income countries (Marmot et al. 1991) and previous Irish population based data (Morgan et al. 2008) but is similar to the overweight/obesity epidemic in lower income countries where it is associated with affluence and higher SES groups (Gupta et al. 2012; Martikainena et al. 2013).

*Strengths and limitations*

Although, caution must be observed when interpreting the findings of a cross-sectional study in a causal way, the findings of this study complement and are in accordance with the current literature pertaining to socio-economic inequalities in health; specifically when education was used as a marker of SES. It is the first piece of novel research to investigate the distribution of CVD risk factors in a specific group of employed adults in the ROI. Objective measurements of BMI, hypertension and height are strength of this research; the ascertainment of these measurements did not rely on self-reported data. It has been suggested that individuals with an unhealthy BMI have a tendency to under-report their weight and height is usually overestimated by most people (Ziebland et al. 1996). It can be assumed that these measurements were not under or overestimated.

Some limitations need to be considered when interpreting the findings. Firstly, participants were recruited from four multi-national manufacturing companies in southern Ireland which would not be representative for the general population or the general working population. The ‘healthy worker effect’ is reflected in the better health status of employed people relative to the general population; therefore the generalisability of these findings to the general population is limited. Also, comparing the findings to other international studies has to be approached with caution as education is a universal indicator for SES but it is measured differently across the world. Additionally, although employees were randomly selected to participate in the FCW study, those who agreed to participate may be systematically different to those who declined, introducing response bias to the data. However, demographic data on non-participants including gender and age showed that participants were similar to the general workforce (non-participants: 77.5% male (n=314) and 70.4% aged 30-44 years (n=285). Finally, our measurement of blood pressure was limited by the fact that we did not have information on the current use of hypertensive medication. However this limitation was somewhat mitigated by the inclusion of participants with prior hypertension diagnosis as hypertensive.

**Conclusion**

The findings from this study highlighted a number of issues that are relevant to the field of population health. Individual choices and physical factors (such as height) seem to be influenced by the wider social determinants of health (Link & Phelan 1995; Morgan 2006). Also, it was demonstrated that inequalities in some risk factors for CVD occur at each rank of the socio-economic hierarchy, not just at the point of severe deprivation (Adler et al. 1994, Marmot 2005). Disparities in overweight or obesity and smoking have been highlighted in Irish population based studies (Morgan et al, 2008) but to our knowledge, this is the first study to highlight similar inequalities within a working population in the ROI. While it is not always feasible to compare population based studies to occupational studies (due to the 'healthy worker effect'), the evidence from this study can contribute to the existing evidence base that relates to the presence of social inequalities in working populations. Findings from this study suggested that managers were more likely to be overweight or obese compared to their socially lower counterparts. The mechanisms underlying this finding could be explored further. For example, the type of work that managers do maybe less physically demanding leading to decrease in overall energy expenditure or perhaps managers have higher stress at work which may cause emotional eating. This study provides clear justification for further research to be carried out among the working population in the ROI. It is important to measure if these findings are also replicated in more diverse work settings (i.e. blue collar vs. white collar employees) to accurately inform future public health policy. Finally, the World Health Organisation (2013) stated that the workplace has been established as a priority setting for health promotion as it can support the implementation of health promoting activities to large groups of people. Many individuals are now spending the majority of their waking hours at work (Chu et al. 2000). Therefore, findings from this research may assist in the critical identification of appropriate targets, which in turn can inform the development of effective workplace complex interventions to reduce socioeconomic inequalities in health.

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**Table 1** Baseline characteristics of Food Choice at Work study participants by gender, RoI (2013)

| | Men (n=586) | Women (n=264) | *p* | Total (n=850) |
|---|---|---|---|---|
| **Age (years)**[a] | 39(3.9) | 38.1(8.3) | 0.1 | 38.7 (8) |
| **Ethnicity**[b] | | | | |
| White Irish | 533 (90) | 233 (88) | | 763 (90) |
| Other | 55 (9) | 30 (11) | 0.5 | 85 (10) |
| **Married**[b] | | | | |
| Yes | 377(64.4) | 122(46.2) | | 499(59) |
| No | 208(35.6) | 142(46.2) | 0.000 | 350 (41.2) |
| **Housing**[b] | | | | |
| Rented/other | 158(27.1) | 79(30) | | 237 (28) |
| Owned | 425(72.9) | 184(70) | 0.4 | 609 (71.9) |
| **Education**[b] | | | | |
| High school/ less | 109 (19) | 87 (33) | | 196 (23) |
| Certificate/diploma | 151 (26) | 74 (28) | | 225 (27) |
| Basic degree | 203 (35) | 55 (21) | | 258 (20) |
| Higher degree | 123 (21) | 48 (18) | 0.000 | 171 (20) |
| **Job Position**[b] | | | | |
| General staff | 432(75.1) | 225 (85.8) | | 657(78) |
| Supervisor | 66(11.4) | 22 (8.4) | | 89 (10.5) |
| Manager | 77 (13.3) | 15 (5.7) | 0.000 | 92(11) |
| **Current smoker**[b] | | | | |
| Yes | 79 (13.3) | 64 (24.3) | | 143(16.9) |
| No | 504(86.5) | 199 (75.6) | 0.000 | 703(82) |
| **Height (cm)**[a] | 177(6.8) | 163(6.3) | 0.000 | 172(9.2) |
| **Weight (Kg)**[a] | 87(12.1) | 70 (14.5) | 0.000 | 81(15.1) |
| **BMI (kg/m$^2$)**[a] | 27 (3.7) | 26.2(5) | 0.000 | 27(4.2) |
| **BMI status**[b] | | | | |
| Normal | 134 (23) | 116 (44) | | 250 (29.4) |
| Overweight | 318(54.4) | 97 (36.7) | | 415 (48.8) |
| Obese | 133(22.7) | 51 (19.3) | 0.000 | 184 (21.6) |
| **Systolic (mmHg)**[a] | 125 (13) | 111(13.6) | 0.000 | 121(14.7) |
| **Diastolic (mmHg)**[a] | 76 (9.1) | 71.5(9.6) | 0.000 | 74(9.5) |
| **Hypertension**[b] | | | | |
| Yes | 135(23) | 32(13) | | 167(19.6) |
| No | 451(77) | 232(87) | 0.000 | 683(80.3) |
| **Medical Condition**[b] | | | | |
| Yes | 186(31.7) | 58(21.9) | | 244(28.1) |
| No | 400(68.2) | 206(78) | 0.27 | 606(71.3) |

Data are [a] mean (SD) or [b] n (%)

**Table 2** Prevalence of CVD risk factors among Food Choice at Work Study Participants by each SES indicator, RoI (2013)

| | CVD Risk Factors | | | |
|---|---|---|---|---|
| | Height | Overweight | Smoking | Hypertension |
| SES indicator | cm[c] | n (%) | n (%) | n (%) |
| **EDUCATION** | | | | |
| **Males (n= 586)** | | | | |
| High school/less | 174 (7.6)[d] | 84 (77) | 28 (26)[d] | 35 (32)[d] |
| Certificate/diploma | 176 (6)[d] | 127 (84) | 19 (13)[d] | 31 (21)[d] |
| Basic degree | 178 (6.8)[d] | 147 (72) | 26 (13)[d] | 44 (22)[d] |
| Higher degree | 179 (7.2)[d] | 90 (73) | 14 (11)[d] | 20 (16)[d] |
| **Females (n= 264)** | | | | |
| High school/less | 162 (150-165)[d] | 60 (69)[d] | 32 (37)[d] | 15 (17) |
| Certificate/diploma | 164 (155-175)[d] | 45 (61)[d] | 19 (26)[d] | 9 (13) |
| Basic degree | 164 (160-172)[d] | 21 (38)[d] | 12 (22)[d] | 4 (7) |
| Higher degree | 163 (160-171)[d] | 28 (58)[d] | 4 (8)[d] | 5 (11) |
| **JOB POSITION** | | | | |
| **Total (n= 850)** | | | | |
| Lowest | 173 (150-195)[d] | 641(70)[d] | 126(19) | 122(19) |
| Supervisor | 176 (150-190)[d] | 75 (64)[d] | 18 (20) | 19 (22) |
| Manager | 175 (155-180)[d] | 83 (85)[d] | 10 (10) | 22 (23) |

[c] Male=mean and standard deviation; female and job position=median with associated lower and upper quartile values;

[d] $p$ value difference <0.05

**Table 3** Results from multivariate regression analysis exploring independent predictors in CVD risk factors in Food Choice at Work study participants, RoI (2013)

| | Overweight/ obesity | | Smoking | | Hypertension | | Height (cm) | |
|---|---|---|---|---|---|---|---|---|
| | **OR (95% CI)** | ***p*** | **OR (95% CI)** | ***p*** | **OR (95% CI)** | ***p*** | **β (95% CI)** | ***p*** |
| **Age (years)** | 1.02 | 0.1 | 0.9 | 0.6 | 1.05(1.05-1.1) | 0.000 | -0.1(-0.2, 0.05) | 0.000 |
| **Gender** | | | | | | | | |
| Male | 1 | | 1 | | 1 | | 1 | |
| Female | 0.4(0.3-0.5) | 0.000 | 1.9 (1.6-2.8) | 0.6 | 0.4 | 0.000 | -13.3(-14.4,-12.4) | 0.000 |
| **Education level** | | | | | | | | |
| High school/ less | 1 | | 1 | | 1 | | 1 | |
| Diploma/certificate | 1.1(0.7-1.7) | 0.8 | 0.5(0.3-0.8) | 0.007[e] | 0.6(0.3-0.9) | 0.03 | 1.3(0.1-2.6) | 0.04[e] |
| Primary degree | 0.6(0.4-0.8) | 0.01 | 0.4 (0.27-0.7) | 0.003[e] | 0.8(0.4-1.3) | 0.3 | 3.0(1.72-4.3) | 0.000[e] |
| Postgraduate | 0.7(0.4-1.2) | 0.2 | 0.2(0.1-0.4) | 0.000[e] | 0.6(0.3-1.0) | 0.05 | 3.2(1.8-4.5) | 0.000[e] |
| **Job position** | | | | | | | | |
| General staff | 1 | | 1 | | 1 | | | |
| Supervisor | 0.9 (0.5-1.5) | 0.7 | 1.4(0.8-2.5) | 0.9 | 1.4(0.8-2.6) | 0.8 | 0.3(-1.2-1.7) | 0.4 |
| Manager | 2.4 (1.3-4.6) | 0.008 | 0.9 (0.4-2.0) | 0.3 | 0.9(0.5-1.7) | 0.2 | 0.6(-.9-2.1) | 0.7 |
| **Owned House** | | | | | | | | |
| No | 1 | | 1 | | 1 | | 1 | |
| Yes | 1.5 (0.9-2.1) | 0.05 | 0.6 (0.4-0.9) | 0.01 | 0.8(0.3-1.8) | 0.1 | -0.06(-1.2-1.03) | 0.9 |
| **Married** | | | | | | | | |
| No | 1 | | 1 | | 1 | | 1 | |
| Yes | 1.01 (0.7-1.5) | 0.06 | 1.4(0.9-2.2) | 0.09 | 0.7(0.9-2.1) | 0.06 | 0.009(-1.0-1.03) | 0.9 |
| **Medical condition** | | | | | | | | |
| No | 1 | | | | 1 | | 1 | |
| Yes | 1.7 (1.1-2.5) | 0.01 | 0.8 (0.5-1.2) | 0.2 | 0.7(0.4-1.1) | 0.1 | -1.4(-2.4,-0.3) | 0.009 |

[e] Trend $p < 0.05$

**Publication 3: Barriers to and facilitators of implementing complex workplace dietary interventions: process evaluation results of a cluster controlled trial**

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**Trial registration:** Current Controlled Trials: ISRCTN35108237.

**Key words:** process evaluation; implementation; facilitators; barriers; workplace dietary intervention

**Abstract**

**Background**

Ambiguity exists regarding the effectiveness of workplace dietary interventions. Rigorous process evaluation is vital to understand this uncertainty. This study was conducted as part of the Food Choice at Work trial which assessed the comparative effectiveness of a workplace environmental dietary modification intervention and an educational intervention both alone and in combination versus a control workplace on employees' dietary intakes, nutrition knowledge and health status in four large manufacturing workplaces. The aim of this study was to examine barriers to and facilitators of implementing complex interventions, from the perspectives of key workplace stakeholders and researchers involved in implementation.

**Methods**

A detailed process evaluation monitored and evaluated intervention implementation. Interviews were conducted at baseline (27 interviews) and at 7-9 month follow-up (27 interviews) with a purposive sample of workplace stakeholders (managers and participating employees). Topic guides were used to explore factors which facilitated or impeded implementation. Researchers involved in recruitment and data collection participated in focus groups at baseline and at 7-9 month follow-up to explore their perceptions of intervention implementation. Data were imported into NVivo software and were analysed using a thematic framework approach.

**Results**

Four major themes emerged; perceived benefits of participation, negotiation and flexibility of the implementation team, viability and intensity of interventions and workplace structures and cultures. The latter three themes either positively or negatively affected implementation, depending on context. The implementation team included managers involved in coordinating and delivering the interventions and the researchers who collected data and delivered intervention elements.  Stakeholders' perceptions of the benefits of participating, which facilitated implementation, included managers' desire to improve company image and employees seeking health improvements. Other facilitators included stakeholder buy-in, organisational support and cohesiveness between stakeholders with regards to level support provided to the intervention. Anticipation of employee resistance towards menu changes, workplace restructuring and the target-driven culture of workplaces impeded intervention implementation.

**Conclusions**

Contextual factors such as workplace structures and cultures need to be considered in the implementation of future workplace dietary interventions. Negotiation and flexibility of key workplace stakeholders play an integral role in overcoming the barriers of workplace cultures, structures and resistance to change.

## Background

The increasing prevalence of diet-related diseases is a major global public health problem. The growing burden on population health and unsustainable cost escalation is crippling our healthcare systems [1-4]. The causal factors of diet-related diseases are inherently complex and require complex solutions [5]. Behavioural interventions aim to improve dietary behaviours and reduce the associated burden of diet-related diseases at a population-level [6, 7]. The Medical Research Council (MRC) advocate the importance of combining the evaluation of outcomes and process when evaluating complex interventions [7]. Process evaluations monitor and evaluate the fidelity of interventions and provide an in-depth understanding of factors that lead to the success or failure of complex interventions [7-9].

The workplace has been identified as an important health promotion setting as individuals spend long periods of time in their work environments [2, 10]. The workplace provides access to a stable population in a controlled setting, making it conducive to the implementation of complex interventions [11]. However, uncertainty exists regarding the effectiveness of workplace dietary interventions. Previous interventions have demonstrated limited efficacy with small effect sizes [12-14]. These interventions failed to include detailed process evaluations but recommended that future workplace interventions should integrate rigorous qualitative and quantitative evaluation methods to explore reasons for ambiguous findings [12-16].

Very few comprehensive process evaluations of workplace dietary interventions have been conducted. Furthermore, few studies explore the opinions of those directly involved in workplace dietary interventions either as a decision maker or a participant. The evidence base consists mainly of process evaluations that evaluate low-intensity workplace health promotion interventions or workplace stress interventions. The available evidence on process evaluation of these low-intensity workplace interventions has focused on the effectiveness of interventions rather than on why interventions succeed or fail [17]. The evidence indicates that contextual factors, particularly structural and organisational changes can greatly influence the implementation of workplace interventions [18-21]. A study exploring obstacles to implementing workplace stress interventions found that the complexities of the modern working environment including on-going structural changes and competing work projects impeded implementation. The active involvement of managers in implementation, negotiation skills, consideration of workplace culture and assessing readiness for change were found to facilitate implementation [19]. Contextual factors were also identified as influential in the implementation of a health promotion intervention in four Danish industrial canteens [21]. Structural changes which resulted in downsizing, high employee turnover and job insecurity impeded successful implementation.

There are a number of theories and frameworks which describe the implementation of interventions within organisations. [22]. Lewin's model of organisational change is one such theory and involves, unfreezing of current attitudes to change, implementing the new intervention and refreezing new attitudes and behaviour by supporting and reinforcing change [23, 24]. This theory suggests that assessing organisational readiness for change and minimising the restraining factors of tacit organisational cultures are central for successful implementation [22-24]. The principals of this theory are reinforced in implementation frameworks which outline the enablers and barriers to successful implementation within organisations [25]. Stakeholder buy-in, organisational support, supportive organisational culture, monitoring and evaluation are defined as enablers of implementation. The external environment, resistance to change and vested interests are outlined as barriers to implementation within organisations [25].

To improve the implementation of complex, high-intensity workplace dietary interventions and achieve sustainable organisational change, it is imperative that factors which facilitate and impede the implementation process are identified by exploring the opinions of those directly involved [8]. The aim of this study was to define and explore the facilitators of and barriers to the implementation of complex, high-intensity workplace dietary interventions from the perspectives of key workplace stakeholders, participating employees and research assistants delivering the intervention.

## Methods

### *Context*

The current study was carried out as part of the Food Choice at Work (FCW) study, a cluster controlled trial conducted in four large manufacturing workplaces in Cork, Ireland. Details of the FCW study have been published elsewhere [27]. The FCW study assessed the comparative effectiveness of a workplace environmental dietary modification intervention and an educational intervention both alone and in combination versus a control workplace on employees dietary behaviours, nutrition knowledge and health status. Table 1 outlines the allocation of the interventions. Changes in employees' dietary intakes and health status (BMI, waist circumference and blood pressure) outcomes were measured at baseline, follow-up at 3-4 months and 7-9 months. In the control workplace participants were informed that they were involved in a university-led study to observe employees dietary behaviours. Implementation was monitored and evaluated using a detailed process evaluation throughout the intervention period, analysing perspectives of management stakeholders, participating employees and research assistants.

Steckler and Linnan's conceptual framework guided the process evaluation and was based on the components of context, reach, dose delivered, dose received, fidelity and recruitment [8]

***Participants***

We used purposive sampling to recruit management stakeholders who were involved in the intervention either through initial consultation, decision-making or on-going collaboration with the researchers who collected data. Employees who participated in the intervention were selected using random number generation software. We conducted 27 face-to-face semi-structured interviews at baseline (13 managers and 14 employees) and 27 interviews (12 managers and 15 employees) post intervention implementation. Where feasible we interviewed the same people at follow-up stage, however this was dependent on participants availability. Research assistants who conducted the interviews were involved in recruitment and data collection but were not known to the participants they interviewed. Table 2 outlines the characteristics of managers and employees who took part. We used purposive sampling to recruit research assistants for the focus groups. All research assistants involved in the FCW study were invited to participate at baseline and at follow-up stage. Nine out of eleven research assistants took part at baseline and four out of six research assistants took part at follow-up. The reason for non-participation in the focus groups was the part-time availability of research assistants and there were fewer researchers employed at follow-up stage.

For the interviews, individuals were contacted by email and follow-up telephone call when necessary. The focus group moderator emailed research assistants and invited them to participate. All participants provided written informed consent. Data were digitally recorded and transcribed verbatim. To preserve confidentiality, data were anonymised. Ethical approval was granted by the Clinical Research Ethics Committee of the Cork Teaching Hospitals in Ireland, March 2013.

***Topic guides***

Pilot interviews, overall study objectives, preliminary analysis of baseline data and researchers' experience of intervention implementation further informed the topic guides. The topic guides were used to explore facilitators of and barriers to the implementation of the interventions from the perspective of management, employees and research assistants and to explore the experiences of the research assistants delivering a complex intervention in the workplace.

***Data collection***

We conducted semi-structured face-to-face interviews at baseline between February and April 2013 and at follow-up stage between April and July 2014. Interviews were conducted in the workplaces and lasted between forty and sixty minutes. The baseline focus group was conducted in May 2013 and the follow-up focus group was conducted post intervention implementation in August 2014. These were hosted in University College Cork by an independent moderator and lasted for one hour. An assistant moderator took observational notes. In the interviews and focus groups probes were used to initiate discussion when there was a pause and also to further explore points of interest.

### *Analytical tools*

We used the framework approach for data analysis [8, 28]. This was considered appropriate as the process evaluation had pre-specified objectives while it also permitted the emergence of unexpected themes. Framework analysis is dynamic, allowing for change throughout the analytical process while its systematic nature provides transparency. This was beneficial as multiple researchers were involved in data collection, analysis and interpretation. We completed the following [8]:

*1) Familiarisation:* Three researchers (SF, FG and CK) conducted the interviews. We became familiar with the data by re-reading transcripts, audio tapes, field notes and observational notes. Recurring themes and initial ideas were noted in an analytical memo.

*2) Identification of a thematic framework:* Four researchers (SF, SMH, FG and CK) undertook initial coding of a selection of transcripts (one management stakeholder and one employee participant). These were subject to inter-coder reliability as one of the researchers (SMH) was not involved in data collection. Open coding allowed for an inductive approach. Our preliminary coding framework was developed by discussing the convergence and divergence of codes. We refined this framework for subsequent stages of coding.

*3) Indexing:* We imported data into NVivo software (QSR International Pty Ltd) for coding. The refined coding framework was systematically applied to data and the main thematic categories and sub-categories were formed.

*4) Charting*: The coded data was further abstracted and synthesised. Based on headings included in the thematic framework we arranged themes into illustrative charts.

*5) Mapping and interpretation:* The charts provided a schematic diagram which guided data interpretation which were checked and discussed.

**Results**

***Major themes***

Four major themes emerged; 1) perceived benefits of participation, 2) negotiation and flexibility of the implementation team, 3) viability and intensity of intervention and 4) individual workplace structures and cultures. Depending on context, the latter three themes were found to have both a positive and negative impact on implementation and are discussed as either facilitators or barriers. Findings are presented from the perspective of management stakeholders, employees and research assistants.

***Perceived benefits of participation:***

Both managers and employees highlighted the benefits of participating in the study. Managers had a desire to improve company image and foster employee loyalty while employees had a desire to improve their health. The perception of a long-term benefit rather than the benefit itself facilitated implementation in the short-term as it encouraged engagement and fostered buy-in.

1. Concern with company image: Managers had a vested interest in ensuring successful implementation of the interventions as they had a strong desire to portray a positive company image to both industry and employees. Managers believed that participation in the study would be a means of achieving this objective. Managers wanted to depict an image of a progressive company both nationally and internationally in the manufacturing industry. This desire facilitated implementation as managers were supportive of the

interventions and they facilitated access to employees by releasing them from work activities to attend study appointments. Managers felt involvement in a university-led study would be regarded as prestigious by other companies. They expressed pride in being 'chosen' to participate and believed that it created a sense of elitism in the manufacturing industry. According to some of the researchers who collected data, a concern with company image motivated workplace stakeholders to provide recruitment and implementation support.

2. Managers' personal interest: In some workplaces key workplace stakeholders expressed a personal interest in maintaining a healthy lifestyle. Occupational health stakeholders in the control and combined workplaces had a professional background in nursing and had great interest in supporting initiatives that would enhance health consciousness in the workplace. Similarly in the education workplace, a HR stakeholder had professional training and interest in nutritional sciences. This interest was a driver for workplace participation and ensured that implementation of the interventions received organisational support.

3. Fostering employee loyalty: A desire to improve relations between employers and employees was a motivating factor for participation. Managers identified the study as an opportunity to improve relations with employees. In order to demonstrate their support for the study to employees, they released staff from work activities for appointments and provided resources for the study. They believed that driving health consciousness among employees would foster employee loyalty and boost morale within the workplace which could result in financial benefits for the company by reducing absenteeism and increasing productivity. It was anticipated that this could be achieved by managers promoting participation in elements such as the healthy-eating group presentations.

4. Health concerns among employees: The main reasons for employees participating included age concerns, individual health concerns (weight, cholesterol level, blood pressure, and digestive disorders) and lifestyle concerns. Older participating employees felt pressure to keep up with younger employees in their fast-paced working environments. Employees were seeking health improvements in an effort to curtail any negative effects of ageing and the need to 'slow down' their working pace. Employees appreciated the investment their employers made in the study as it provided them with a unique opportunity to have a nutritional consultation and a free health check-up during their working hours. It reassured employees that their employer concerns went beyond generating profit hence they felt obliged to participate.

***Flexibility and negotiation***

The researchers who collected data and were involved in coordination and delivery of intervention elements were adaptable to dynamic workplace environments which facilitated implementation. This flexibility enabled the researchers to successfully negotiate with workplace managers on degrees of change that were agreeable to all parties and ensured the study received organisational support.

1. Flexibility: The flexibility and adaptability of the researchers manifested itself in a number of ways. To facilitate timely data collection, it was critical for the researchers to adapt to the structure and practices of each worksite. Researchers were required to schedule appointments that complemented rotating shift patterns. Similarly, monthly group nutrition presentations were delivered multiple times each day to complement rotating shifts. Data collection often occurred during busy times on site such as 'end of quarter'. On these occasions, employees frequently rescheduled appointments and researchers had to

facilitate these late changes. At the outset, managers were concerned that the target-driven culture of manufacturing workplaces would not be suitable for implementing a study that requires employee interaction and significant logistical planning. However, researchers' adaptability to changes facilitated implementation.

2. Negotiation: The researchers also perceived negotiation as central to successful implementation. It was necessary for the researchers to negotiate a level of change that was agreeable to mangers, caterers and the researchers themselves. In some instances this resulted in changes to the planned intervention components or the scale of change. Effective communication with managers was necessary to reach a compromise with regards to what intervention elements were implemented and to what degree they were implemented, particularly for the environmental modification intervention. For example, the proposed portion size restrictions were heavily negotiated between the researchers and catering staff with compromises being made by all parties. Willingness to change among catering staff and researcher negotiation skills facilitated compromises being reached.

The researchers described how certain meals appeared to be non-negotiable in the environmental and combined workplaces. The cooked breakfast was part of the workplace culture and researchers found reaching an agreement on modifying this option challenging. A compromise was eventually reached on reducing the portion size of the cooked breakfast and cooking method was changed from frying to baking when possible. In this instance, workplace culture was identified as a barrier to full-scale implementation. Catering stakeholders anticipated employee resistance to change in response to changes being made to the breakfast options. This expectation persisted and impeded the implementation of some of the environmental modification elements.

3. High-level workplace management support: Due to the target-driven culture in the manufacturing industry, supervisors were reluctant to release production staff to attend appointments. A disruption on the production line could lead to knock-on effects for overall site-level efficiencies. However, supervisors were instructed by managers to adapt to the demands of the intervention for the duration of the study period. To ensure that catering staff adhered to the intervention elements, management needed to reinforce the commitment that the workplace had made to the study. This was particularly evident in the environmental and combined workplaces, where environmental modification elements were implemented and more negotiation was needed in these workplaces. Stakeholder cohesiveness with regards to organisational support was central to achieving successful implementation.

***Workplace structures and cultures***

Individual workplace structures and cultures had an impact on implementation. In workplaces where senior management were actively involved in the study, it encouraged employee participation and secured more buy-in from production supervisors and team leaders. In the environmental workplace, the support of HR managers went beyond providing basic logistical support and HR contacts became involved in providing recruitment support. Organisational restructuring and a 'traditional' workplace culture had a negative effect on implementation.

1. Stakeholder buy-in: Employees recognised the importance of receiving 'buy-in' from catering and management stakeholders in order for the intervention to be successfully implemented. This was also highlighted by the researchers who acknowledged their flexibility and willingness to change as a crucial facilitating factor. Enthusiasm of caterers

towards the intervention further facilitated the progress of implementation. Support of the catering company in their workplace stemmed from caterers realising that involvement in the study could be a valuable learning opportunity and serve as a foundation on which to enhance the knowledge of the catering staff. Catering stakeholders anticipated that their involvement would impress the head office of their catering company as staff will have the opportunity to apply the knowledge and skills they gained on how to produce healthy menus after the study period and also in future interventions. This long term potential benefit garnered buy-in from catering stakeholders and facilitated intervention implementation as they were more invested in making the intervention a success in their workplace.

2. Production work: Both managers and employees' perceived shift work to be a barrier to implementation. This was due to the logistical problems of arranging appointments for shift workers outside standard office hours. However it emerged that it was the nature of production work rather than the shift cycles that impeded implementation. Removing people from production lines can have knock on effects on the overall site level efficiencies which was a cause of concern from the workplaces point of view.

3. Organisational restructuring: Conversely, a number of workplace factors were identified as aspects that impeded implementation. Two of the largest workplaces (education and combined) underwent major restructuring during the study. This involved the relocation of a large number of employees from both workplaces, which resulted in them being ineligible to participate in the study as they were no longer exposed to the intervention. As a direct result of the restructuring, a large proportion of the remaining employees changed shift patterns. In order to deal with these effects researchers had to liaise with management on

how to best minimise loss to follow-up and had to adapt elements of the study to these changes. This involved researchers creating an appointment schedule to facilitate changes in shift work patterns to encourage employees to complete all stages of data collection. The time it took to liaise with management regarding restructuring changes had a direct impact on the timeline of the study. Adjusting to the restructuring changes and the delays in recruitment meant that data collection timelines had to re-evaluated, however getting approval from the management stakeholders for these readjustments proved to be very time consuming.

4. Workplace culture: According to the researchers involved in data collection, the workplace culture provided challenges during implementation. This manifested itself particularly in the environmental modification site, with the majority of employees described as having 'traditional' eating habits. The cooked breakfast menu options and side portion of chips were described as part of the tradition of the workplace. The expectation of poor uptake of the interventions made catering stakeholders reticent to agree to all modifications. Catering stakeholders were cautious when agreeing changes which resulted in the cooked breakfast menu option not being fully modified in the workplace. However, as previously mentioned researchers overcame this by reaching compromises on method of cooking, portion size and reducing the number of days that chips were available in the workplaces.

***Viability and intensity of interventions:***

The design of the interventions also impacted how they were implemented. The sustainability of the interventions and the ability of workplaces to tailor the interventions to meet the needs of their workplace facilitated implementation. The anticipated employee resistance to change in response to the environmental modification impeded implementation of the interventions. The intensity of the interventions also affected implementation. The high-intensity intervention (combined intervention) was well received by employees. However, the low-intensity interventions (education and environmental) did not meet employee expectations which impeded implementation.

<u>1. Sustainability of interventions:</u> Intervention design had impact on implementation. At the outset, catering staff were apprehensive about implementing environmental modification elements as they anticipated it would cause a significant increase in workload. However, it transpired that any extra workload initially created dissipated once the intervention was in place and as a result the study was easier to maintain. Environmental modification elements became part of the normal catering routine within workplaces even after the study, with workplaces sustaining elements. Similarly, the environmental modification site maintained the healthy default menu options, increased the number of 'chip free' days per week in the workplace and removed free-flowing sugar and salt from the canteen. The catering staff in the combined intervention decided to keep elements that modified the nutritional quality of food in terms of fat, saturated fat, sugar and salt.

However, there was a perception among the researchers that catering stakeholders in the combined workplace found the initial implementation of the intervention burdensome in terms of extra workload. Researchers suggested that this caused a delay in implementation at the outset which was overcome through negotiation of elements that were more feasible for the catering staff to implement.

2. Tailoring of interventions: The advantage of being able to tailor the intervention to address certain needs was also alluded to by the employees. An employee being able to 'pick and choose' to engage with certain elements was not an intended feature of the study design. This occurred naturally throughout the study as employees reported that different elements of the intervention worked for them, for example, some employees found the health eating chat table more beneficial to them compared to the monthly group nutrition presentations. Employees also appreciated that participation in the study was open to all employees in the workplace, regardless of job position. This inclusive study design which allowed employees to adapt elements to meet their own requirements was perceived as a key facilitating factor for implementation by employees and management stakeholders. The intervention created scope to positively impact all employees in terms of dietary behaviour, regardless of participation in the study with all employees being exposed to the intervention in the canteen.

3. Information at a glance: Employees outlined how the traffic light system enabled them to make informed decisions with regards to healthy or unhealthy menu options. It provided information at a glance in a fast-paced environment which was particularly helpful to production workers as their lunch times were very restrictive. This visibility of the intervention was described as a talking point among employees and they discussed their clinical measurements, progress and feedback with each other. Displays of nutritional information in the canteen and the daily email of healthy options were considered effective. The traffic lights created a social desirability response as employees were reluctant to choose a menu option that was coded as red when they were eating in a group. It also emerged that since the study finished in the workplaces, employees and catering

stakeholders found the absence of intervention very noticeable, mainly the traffic light coding system and the nutritional information that was displayed in the canteen. The design of the intervention in terms of its inclusive and visible nature was perceived to be a key facilitator for successful implementation.

4. Employee resistance to change: The potential for employee 'backlash' in response to choice restriction impeded implementation. Caterers anticipated that the implementation of choice restriction may create a sense of perceived powerlessness amongst employees. They also anticipated employee 'backlash' in reaction to the introduction of chip free days and reduced portion size. Some of these concerns were both anticipated and realised concerns. The combined intervention workplace reported that employees' resistance to change was largely in response to the removal of some of the unhealthy options on the menu. This impeded the implementation of the intervention slightly as caterers were reluctant to introduce a further chip free day that had been suggested during the negotiation with the researchers. However, catering stakeholders were determined to implement the agreed intervention elements to an extent they thought was feasible. The expectation of resistance to change was one of the main reasons cited for negotiating the degrees of change in the workplace. There was a perception among researchers that the 'backlash' was not as great as expected. Researchers suggested that any resistance that occurred was due to a small minority in the workplaces and the catering company were capable of dealing with it.

5. Intervention intensity: Catering stakeholders and employees in the education and environmental workplaces felt that the study lost momentum towards the end of the study period. The interventions implemented in the education and environmental workplaces

were low intensity by design compared to the high intensity intervention that was implemented in the combined workplace. Employees and catering stakeholders in the education and environmental workplaces felt that the interventions would have benefited from more regular stages of data collection and suggested that more emphasis should be placed on physical measurements and weight loss to increase intervention intensity. The low intensity interventions delivered in these workplaces did not meet employee expectations. Employees felt that delays in data collection and long stages of follow-up resulted in a loss of interest and focus in the study.

**Discussion:**

This study aimed to establish what factors facilitated or impeded implementation of complex workplace dietary interventions. Four principal themes emerged; perceived benefits of participation, negotiation and flexibility of the implementation team, viability and intensity of intervention design and workplace structures and cultures. Contextual factors were found to heavily influence implementation. Tacit workplace cultures including 'traditional' menu preferences and anticipated and realised resistance to change prevented full-scale implementation of the environmental intervention. The target-driven culture of manufacturing workplaces impeded implementation as the researchers involved in data collection experienced challenges in arranging appointments with employees. Our results suggest that manufacturing production work rather than restrictive shift cycles impeded implementation of a complex workplace dietary intervention. Organisational restructuring caused delays to the study timeline, attrition and disruptions to schedules. These barriers persisted throughout the study but were eased by the flexibility and negotiation skills of the researchers. The adaptability of the implementation team was a vital facilitator for implementation and helped accommodate the impact of extensive organisational restructuring.

Despite consensus in the literature that workplace dietary process evaluations should be conducted concurrently with evaluations of outcomes, the current evidence base is extremely limited.  However, findings from this study are consistent with process evaluations of other types of organisational interventions. The structural environment can act as a major barrier to implementation if it cannot tolerate the intervention that is being implemented [25]. Previous research indicates that contextual factors have significant influence on the implementation of workplace interventions. Complexities of the modern working environment including structural changes, competing projects, employee turnover and downsizing have all been outlined as potential barriers to implementation [19, 21]. Workplaces are dynamic environments and their contexts cannot be controlled. The flexibility and adaptability of the researchers were important factors that helped the study overcome contextual barriers.

The findings are consistent with research that suggests stakeholder buy-in and supportive organisational cultures facilitate implementation [19, 21]. Managers perceived benefits and personal interest in the study fostered their buy-in and support which facilitated implementation. Stakeholder consultation and buy-in is critical for successful implementation [25]. The implementation team openly consulted with each other throughout recruitment, intervention allocation and intervention implementation. This consultation process was beneficial for the researchers collecting data and coordinating and delivering the intervention as they were able to assess the capacity and suitability of each workplace for particular intervention elements. The process also assisted in workplaces providing organisational support to the study. Supportive organisational structures and systems are a key enabler of successful implementation [25]. This study reported the presence of strong organisational support from one of the workplaces whereby the HR manager assisted in recruiting and scheduling of employees for their appointments which facilitated timely implementation.

Our findings are in line with Lewin's theory of organisational change. The theory suggests that organisational change is achieved by workplaces achieving a balance between minimising restraining factors and promoting facilitating factors [23, 24]. Tacit organisational cultures such as resistance to change and fragmented relationships between workplace stakeholders need to be managed. Resistance to change is a key barrier to achieving sustainable organisational change [25]. In order to overcome this resistance, negotiation on degrees of change occurred during the implementation of the Food Choice at Work intervention. Restrictive factors can be overcome by key workplace stakeholders reinforcing the benefits of participation and by negotiation and compromise to minimise negative internal politics.

Based on the results of this study, it is vital that future intervention teams consider individual workplace cultures and structural changes during the development and implementation of interventions. The effects of structural changes need to be monitored regularly throughout the study. Workplaces need to be able to tailor the intervention to meet their own specific needs. Consultation with key stakeholders should be an integral aspect of complex workplace interventions prior to implementation and can assist in considering the challenges of manufacturing work and in assessing an organisations readiness for change. Stakeholders need to be aware of the demands of the study and researchers need to determine if the workplace structure can tolerate all aspects of the intervention. Understanding the feasibility of implementing the FCW interventions will help researchers and workplace stakeholders anticipate future barriers of implementing multisite workplace dietary interventions.

Consideration also needs to be given to employee expectations. Employees' expectations of an intervention can impact how it is implemented and received. The control, education and environmental workplaces received low intensity interventions and employees in these workplaces felt that the momentum of the study was lost over time. Employees had anticipated an interactive intervention that would be of high intensity with more frequent physical assessments. This perceived loss of momentum impeded implementation as employees' interest in the study declined. Employees should be made fully aware of what the intervention entails at the outset.

This study has several strengths and limitations. To ensure rigour, we adhered to Guba's framework for ensuring trustworthiness in qualitative research [29]. This framework proposes four criteria for assessing trustworthiness; credibility, transferability, dependability and confirmability. Credibility is concerned with assessing the internal validity of the findings, ensuring they are congruent with reality [29]. We attempted to ensure credibility by using well established research methods, using random sampling when appropriate, holding regular debriefing discussions during data collection and triangulating findings from different stakeholders. Transferability refers to the extent to which findings can be generalised or applied to other contexts [29]. These findings may be generalisable nationally and transferable internationally as the workplaces included are multi-national manufacturing companies with similar worldwide structures and operations. Dependability addresses the reliability of the study and whether or not the same results would be achieved if the study were repeated [29]. In this study dependability is concerned with the repeatability of the methods [29, 30]. We provided an in-depth methodological description and reported extensively on processes used and provided a comprehensive description on how changing contexts affected implementation.

The fourth construct of confirmability is concerned with the objectivity of the research [29]. In this study, researcher bias cannot be ruled out as some of the authors were involved in the overall FCW study and were familiar with participants. Efforts were made to remain as objective as possible with researchers conducting interviews in workplaces that they did not visit for data collection. Furthermore, there were a number of members of the multidisciplinary FCW research team involved in the analysis and interpretation of findings. However, the inclusion of respondent validation may have been useful as respondents' interpretation of emerging results can help refine findings and strengthen conclusions.

**Conclusion**

This study demonstrates how process evaluations can be used to explore factors that may influence implementation in controlled intervention studies and highlights the complexities associated with implementing complex workplace dietary interventions. Perceived benefits of participation, stakeholder buy-in and organisational support are intrinsic facilitators of implementing workplace dietary interventions. Flexibility and negotiation play a pivotal role in overcoming the barriers of individual workplace cultures, structures and resistance to change. Interventions also need to be adaptable as the manufacturing companies need to tailor interventions to meet specific structural and cultural requirements of their workplaces. Workplace stakeholders play a central role in achieving organisational change by reinforcing benefits and providing fundamental organisational support. Cohesiveness between different stakeholders within the workplace and between the implementation team (stakeholders involved in co-ordination and delivery of interventions and researchers involved in data collection and delivery of intervention elements) is essential for successful implementation. Intervention implementation within organisations is largely influenced by contextual factors. To achieve organisational change, these factors need to be carefully considered prior to implementation along with an assessment of readiness for change. This study provides an in-depth understanding of the implementation context to further illuminate the findings of the FCW study. Our results may also inform the implementation of future workplace dietary interventions for the development of sustainable diet-related disease prevention and provide an opportunity for scaling of the intervention for use in practice.

**Competing interests**

The authors declare that there are no conflicts of interest.

**Authors' contributions**

All authors worked on the design of this study. SF, FG and CK were responsible for data collection. SF and SMH were primarily responsible for data analysis. SMH acted as the inter-rater during analysis and moderator of the focus groups. All authors provided feedback on interpretation of analysis. SF drafted the paper and all authors provided feedback and approved the final manuscript.

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**Table 1: Intervention allocation**

| Workplace | Intervention implemented | Description of interventions |
|---|---|---|
| Control (Food & beverage industry) | Control site | Monitored employees eating behaviours. |
| Education (Health industry) | Nutrition education intervention | Nutrition education consisted of three elements: 1) monthly group presentations, 2) individual nutrition consultations and 3) detailed nutrition information (shopping cards, posters, leaflets and emails), including the application of a healthy eating traffic light coding system to daily menus and vending machines. This displayed the number of calories and nutritional breakdown of the meal or food item. |
| Environmental (Automotive industry) | Environmental dietary modification intervention | Environmental dietary modification consisted of five elements: 1) restriction of fat, saturated fat, sugar and salt, 2) increase fibre, fruit and vegetables, 3) price discounts on whole fresh fruit, 4) strategic positioning of healthier alternatives and 5) portion size control. |
| Combined (IT industry) | Combined intervention | All the elements of the nutrition education intervention and the environmental dietary modification intervention were implemented. |

**Table 2: Characteristics of interviews with managers and employees**

| | Managers | | Employees | |
|---|---|---|---|---|
| **Workplace** | **Baseline** | **Follow-up at 7-9 months** | **Baseline** | **Follow-up at 7-9 months** |
| **Control** | 2 (Occupational health and administrative managers) | 3 (Occupational health and HR managers) | 4 (2 male and 2 female) | 4 (2 male and 2 female) |
| **Education** | 3 (Occupational health, HR and catering managers) | 3 (Occupational health, HR and catering managers) | 3 (2 female and 1 male) | 4 (3 male and 1 female) |
| **Environmental** | 4 (Managing director, HR and catering managers) | 3 (Managing director, HR and catering managers) | 4 (2 female and 2 male) | 4 (2 male and 2 female) |
| **Combined** | 4 (Occupational health and catering managers) | 3 (Occupational health and catering managers) | 3 (1 female and 2 male) | 3 (1 male and 2 female) |

**Table 3: Theme of 'perceived benefits of participation' and verbatim examples**

| Theme | Verbatim Examples |
|---|---|
| Perceived benefits of participation | 1. <u>Concern with company image:</u> *"We were one of the ones to be chosen, that's a huge cannon feather in our cap you know we're thrilled about that and you know again to promote the fact that it's not everybody that was selected….we were chosen as a company for a particular reason and we're honoured to be included"* (HR manager, Environmental site - follow-up stage).<br><br>2. <u>Managers' personal interest:</u> *"I would have been the person who pushed it to say 'let's go and do this, it's an opportunity, yeah'…having dieticians on site, having access to all this expertise you know, and it is a great pile of health promotion going on in the background"* (Occupational health, Control site – follow up stage).<br><br>3.<u>Fostering employee loyalty:</u> *"If you're trying to convince employees that you're interested and trying to engage with them, show them that you care about their health and well-being so that's a good engagement tool"* (Occupational health, nutrition education site - baseline stage).<br><br>*"If we can keep our employees healthy, they'll be happier, they'll produce better work, they'll hit their efficiencies a lot better and they're more likely to be in here"* (HR, nutrition education site - follow-up stage).<br><br>4. <u>Health concerns among employees</u>: *"We don't have the luxury in this modern day and age of getting to 54, in days of old you'd get to this age and you pull back a little, there's young and progressive people coming up underneath you and they take the pressure and that, that doesn't happen today. They are going to work people until they're 65"* (Employee, nutrition education site - follow-up stage). |

**Table 4: Theme of 'negotiation and flexibility' and verbatim examples**

| Theme | Verbatim Examples |
|---|---|
| Negotiation and flexibility | *1. <u>Flexibility:</u> "You need to adapt and be understanding because schedules do change so you go in with your full schedule and you mightn't get all of them or people last minute can't make it and you're getting annoyed when you're there on site waiting but out on site things are changing constantly so you really have to adapt".* (Researcher 2 - follow-up stage)<br><br>*2. <u>Negotiation</u>: "Changing down to nearly half, we just couldn't, there would be uproar…we did a taste test, we put three plates out one with what we serve now, one with what UCC wanted us to serve and something somewhere in the middle that we felt we could serve and get away with, that's the way we made our choice"* (Occupational health, combined intervention site baseline stage).<br><br>*"The breakfast option alright was something that you couldn't change too much. I suppose from their side they were just afraid that there would be a lot of backlash from the employees and there at the front line then dealing with it"* (Researcher 2 - follow-up stage)<br><br>*3. <u>High-level workplace management support</u>: "I found it very, very hard to get product builders released for their sessions. That was a huge struggle for me, it's the team leaders and they're all about their metrics, they want to have, net efficiencies, be on target"* (Occupational Health - nutrition education site - follow-up stage). |

**Table 5: Theme of 'workplace structures and cultures' and verbatim examples**

| Theme | Verbatim Examples |
|---|---|
| Workplace structures and cultures | 1. <u>Stakeholder buy-in</u>: *"We had really good contacts with HR, they helped with recruitment, they helped schedule some participants…..that was probably the easiest site in terms of scheduling and recruiting…. if someone didn't turn up all I had to do was go downstairs and tell one of the HR people and they would actually go and get the employee"* (Researcher 1 - follow-up stage).<br><br>2. <u>Production work:</u> *"There's a big, discrepancy between the support staff and the people who work on the line, in that the support staff have that freedom to, to go to these things"* (Occupational health, nutrition education site -follow-up stage).<br><br>3.<u>Organisational restructuring:</u> *"Those who are in charge they'd have the overall influence because they're the ones bringing in the stock and stuff, so they have to be behind it 100%. Like if there was opposition from the management that could hinder it"* (Employee, nutrition education site - baseline stage).<br><br>*"Many employees they left the company and were moved to other departments, so it was hard to get them back for the last stage of the study but we got agreement from the managers in order to allow us to complete the last stage"* (Researcher 3 - follow-up stage).<br><br>4.<u>Workplace culture:</u> *"Well it's another concern, its more rural here, people are a bit more conservative about their food, I mean we've been asked over the years for stuff like Panini's, honestly, I'd give them a week and they just don't go"* (Catering Manager, environmental site baseline stage). |

**Table 6: Theme of 'viability and intensity of intervention design' and verbatim examples**

| Theme | Verbatim Examples |
|---|---|
| Viability and intensity of intervention design | 1. <u>Sustainability of interventions:</u> *"It was much easier than I thought it was going to be…I was a little bit scared at the start of all the changes that would have to be made, but actually it was fine, it was fine, it was all quite manageable"* (Catering manager, environmental site - follow-up stage).<br><br>2. <u>Tailoring of interventions:</u> *"Even though the study is over it still continued, there was no dramatic okay that's done go back to the old ways, pretty much there's a lot of things that we kept on board"* (Catering manager, combined intervention site - follow-up stage).<br><br>3. <u>Information at a glance</u>: *"People are in a hurry so it was a perfect situation where you were rushing in and out you could still see at a glance what your options were in terms of healthy choices" (Occupational health, nutrition education site – follow-up stage).*<br><br>4. <u>Employee resistance to change:</u> *"The glazed loin of bacon, we took it off for two weeks and we had something like 300 common cards or something you know it's like, 'where is bacon' because it would always be on a Monday or Tuesday"* (Catering manager, combined intervention site - follow-up stage).<br><br>*"I suppose from their side they were just afraid that there would be a lot of backlash from the employees and there at the front line then dealing with it but to be fair when we spoke again with them there wasn't too much backlash"* (Researcher 2 - follow-up stage).<br><br>5. <u>Intervention intensity:</u> *"It's not very regular, should I say and it's not very intrusive, you know what I mean… it's the idea of, you know, getting weighed in once a week and kind of like the competition type thing"* (Employee, environmental site - follow-up stage). |

**Publication 4: Abstract - Absenteeism in the Workplace: Results from the Food Choice at Work Study (FCW)**

**Background:** This study is being conducted as part of a large cluster controlled trial, The Food Choice at Work Study (FCW). The FCW study will assess the cost-effectiveness of complex dietary interventions in the workplace. Effectiveness will be assessed in four similarly structured multinational manufacturing companies in Cork, Ireland (Geaney, 2013). Inclusion of multinational companies with similar worldwide structures and operations, ensures that the findings will be generalisable nationally and transferrable internationally. Annual absenteeism data for study participants will be monitored prior to intervention implementation (baseline) and post intervention implementation. This will determine what clinical or lifestyle factors effect absenteeism and also if the significance of these factors changes after the dietary intervention implementation. Studies have revealed that increasing levels of body mass index (BMI) are associated with reduced workplace productivity (Proper, 2007). Research has further demonstrated that a gradient exists between obesity and absenteeism duration (Robroek, 2014). Adverse lifestyle factors including smoking, poor dietary habits and low levels of physical activity have been found to be associated with productivity loss in the workplace. A healthy workforce is critical from the perspective of employers and also from a societal perspective (Proper, 2007 and Anderson, 2009). In Ireland, productivity loss due to overweight and obesity was estimated at €865 million in 2009, with absenteeism identified as one of main drivers (Perry, 2012). Given this significant economic burden, there is a need for research to identify the contributing factors of workplace absenteeism.

**Aim:** The aim of this study is to investigate what clinical and lifestyle factors contribute to workplace absenteeism.

**Methods:** Cross-sectional baseline data were obtained from the FCW study. Participants included 850 randomly selected employees (18-64 years) recruited from four manufacturing companies. Annual absenteeism data are collected from each workplace prior to the nutritional interventions being implemented. Logistic regression analyses will be performed to assess the relationship between clinical outcomes (BMI and midway waist circumference), lifestyle factors (smoking and physical activity) and absenteeism. Results will be adjusted for potential confounding variables including age and gender.

**Conclusion:** This study will examine the relationship between clinical and lifestyle factors and absenteeism and will identify the factors significantly associated with increased loss of productivity. Previous findings show that obese employees (identified through measured BMI and midway waist circumference) have higher rates of absenteeism compared to normal weight employees. Similarly, employees with adverse lifestyle behaviours, including smoking, low physical activity levels and poor dietary habits have high levels of absenteeism and show lengthy durations of absenteeism. These findings will contribute to the overall findings of the FCW study, investigating the cost-effectiveness of complex workplace interventions in the manufacturing working population. The findings will critically inform public health policy-makers, national and international catering stakeholders and the food industry on the cost-effectiveness of workplace dietary interventions in the promotion of healthy dietary behaviours in the working population. Strategic investment in such interventions has the potential to improve employee health outcomes and result in a positive return on investment for employers.

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**Conflict disclosure:**
The authors declare that they have no competing interests.

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**Key terms:** Absenteeism; productivity loss; workplace dietary interventions; workplace health promotion.

**Table 24: Courses completed during PhD**

| | Course modules | Date completed | Credits awarded |
|---|---|---|---|
| 1 | PG6001: Scientific training for enhanced postgraduate studies (STEPS), UCC. | Dec 2010 | **5 credits** |
| 2 | PG7016: Systematic reviews for the health sciences, UCC. | May 2011 | **5 credits** |
| 3 | Summer school in statistics – Introductory level, UCC. | June 2011 | **Cert awarded for successful completion** |
| 4 | University of Limerick winter school in social science research methods. | Jan 2012 | **10 credits** |
| 5 | PG6003: Teaching and learning for postgraduate studies. | May 2012 | **5 credits** |
| 6 | An introduction to Cochrane systematic reviews (delivered by Martin Burton, Director of UK Cochrane Centre). | Oct 2012 (2 days) | **Cert of attendance awarded** |
| 7 | Stat2.1x: Introduction to statistics: descriptive statistics (online course with Edx, Berkley). | April 2013 | **Cert awarded for successful completion** |
| 8 | EH6031: Advanced epidemiology (result: 1H). | June 2013 | **10 credits** |
| 9 | ST6011: Advanced biostatistics (result: 1H). | June 2013 | **5 credits** |
| 10 | ST6012: Survival analysis (result: 2H1). | June 2013 | **5 credits** |
| **Total number of credits received** | | | **45 credits** |

**Table 25. Contributions to the Department of Epidemiology and Public Health during the PhD**

| Task | Additional detail |
|---|---|
| 1. Member of fieldwork | Assisted with fieldwork data collection for the 'Mitchelstown Cohort 2010' (2010-2011). |
| 2. Tutor | Tutored 7 Masters in Public Health (MPH) students (2011-2014). |
| 3. Co-supervisor for an MPH student | Student is using FCW data (2015). |
| 4. Demonstrator | Demonstrator for 3rd year BSc public health students (2011-2012). |
| 5. Co-ordination of CHDR workshop | Assisted in the organisation of the Junior researcher HRB Centre for Health and Diet Research (CHDR) workshop 2012. |
| 6. Teaching | Delivered lectures for the following courses:<br>a. Nursing:<br>- 1st year students (NU1034: Public Health lecture).<br>- 3rd year students (Workplace health promotion - lessons from the FCW study).<br>b. 2nd year BSc Public Health (EH2005: Food and Health lecture (2012-2015)).<br>c. MPH: Advanced Epidemiology and Statistics (FCW study protocol (2013,2014)) and health promotion pathway. (Workplace Health Promotion - FCW, a practical example (2013, 2014)).<br>d. Graduate entry of medicine 2nd year students (Gems 2): Public Health challenge of obesity, food and health and obesity in Ireland (2014).<br>e. MSc occupational health students: Non-randomised study designs (2015). |
| 7. Supervisor for work placement students/ interns | I supervised a number of 3rd year BSc work placement students, MPH interns and 1 Phd student. These students assisted with participant recruitment, data collection, data entry and data analysis for the FCW study.<br>These students were working with me for various periods of time:<br>a. 1 CIT student (16 weeks, 2013).<br>b. 4 MPH interns (1 year each, 2013-2015).<br>c. 5 BSc Public health students (12 weeks, 2013).<br>d. 1 PhD student from Queens University, Belfast. Student wished to gain experience about developing a workplace dietary intervention (worked with us for 6 months: 2014) and now involved in an ongoing collaboration with the student and her supervisor Professor Jane Woodside. |
| 8. Lead investigator | Responsible for the development and co-ordination of the FCW study. Organised the research team to conduct the study (agreed contracts, salaries). |
| 9. Funding | Contributed to writing a number of grant applications including:<br>a. Received donations from some of the study workplaces: Boston Scientific (€16,000), ALPS (€2,000) and Kerry Group (€1,000) (2012).<br>b. Awarded €3,000 from Nutrition and Health Foundation (NHF) research bursary (2013). |

| | |
|---|---|
| | c. Awarded 2 research bursaries (€15,000) from the Irish Heart Foundation (IHF) (2013, 2014).<br>d. Contributed to the HRB CHDR renewal funding regarding the FCW study (2014).<br>e. Awarded €10,000 from Enterprise Ireland (2 innovation vouchers) and €5,000 from an SME for the development of the 'Food and Health Programme' (2014).<br>f. Awarded the Department of Health's tender for the 'Evaluation of Calorie Labelling in Ireland' in March 2015 (€25, 000).<br>g. Applied to the HRB Health Research Awards (HRA) 2015 (awaiting results June/July 2015). |
| 10. Established new national and international collaborations | a. Cork's cardiac rehabilitation support groups: Deliver presentations about healthy eating for these groups in Bishopstown, Douglas, Kinsale and Wilton (2012-2015).<br>b. Cork Rebel Wheelers: Voluntarily delivered a healthy eating and potion size presentation for Cork Rebel Wheelers (children with physical disabilities) and their families (2013).<br>c. Project Sláinte: Member of the advisory committee (Attend bi-monthly meetings from 2013-2015). Project Slainte is an internal project that aims to reduce the amount of fat, saturated fat, sugar and salt in all Musgrave Group's own brand products to create healthier products for their customers both nationally and internationally.<br>d. The recipe for health programme: Developed a 12-week healthy eating and well-being programme for a wellness company (Grove Health Spa) in Mallow. Delivered 2 programmes in 2014 with 25 clients.<br>e. McKinsey and Company: This global consulting firm contacted us regarding our findings from the FCW study (2014). Our FCW study protocol has been cited in their discussion paper 'Overcoming obesity: An initial economic assessment'. We have also promised to contact them regarding the overall findings of the FCW study.<br>f. Leading commercialisation of the 'Food Choice at Work Programme'. Based on the findings of the FCW study, I am hoping to develop a social enterprise business structure. I am currently developing a business plan along with the advice of the office of Technology transfer in UCC (2015). The Irish Heart Foundation (IHF) and Brook's catering have interest in the commercialisation plan. |

## Appendix 4. Published papers

## Appendix 5. HRB health research awards application 2015