



## Adherence to dietary and physical activity guidelines among shift workers: associations with individual and work-related factors

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1 **TITLE PAGE**

2 **TITLE**

3 Adherence to dietary and physical activity guidelines among shift workers: associations with  
4 individual and work-related factors.

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34 **ABSTRACT**

35 **Objectives:** Shift work is associated with adverse effects on the health and lifestyle behaviours of  
36 employees. This study aimed to examine factors associated with adherence among shift workers to  
37 selected indicators of dietary and physical activity guidelines.

38 **Methods:** A cross-sectional study was conducted on 1300 shift workers. Data were collected using a  
39 15-minute telephone-administered questionnaire. Logistic regression methods were used for data  
40 analysis.

41 **Results:** Male shift workers [ $p < 0.001$ , OR = 0.55, 95% CI (0.40 – 0.74)] and those of lower socio-  
42 economic status [ $p = 0.046$ , OR = 0.75, 95% CI (0.57 – 0.99)] were significantly less likely to consume  
43 five or more daily servings of fruits and vegetables. Shift workers with access to workplace vending  
44 machines were significantly more likely to consume soft drinks at least weekly [ $p = 0.003$ , OR = 1.64,  
45 95% CI [1.18 – 2.27]]. Middle-aged shift workers [ $p = 0.012$ , OR = 0.65, 95% CI (0.46 - 0.91)] and  
46 those reporting insufficient break times at work [ $p = 0.026$ , OR = 0.69, 95% CI (0.49 – 0.96)] were  
47 significantly less likely to be sufficiently active.

48 **Conclusions:** Individual, work schedule and workplace environment-related factors were  
49 independently associated with selected indicators of adherence to dietary and physical activity  
50 guidelines in this cohort of shift workers.

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57 **KEY MESSAGES**

58 **What is already known about this subject?**

- 59 • Shift work is associated with adverse effects on the health and lifestyle behaviours of  
60 employees.
- 61 • This study aimed to examine factors associated with adherence among shift workers to  
62 selected indicators of dietary and physical activity guidelines.

63 **What are the new findings?**

- 64 • Males and those of lower socio-economic status were significantly less likely to consume at  
65 least 5 servings of fruits and vegetables per day.
- 66 • Those working predominantly nights, rotating or other shifts (compared to day shifts) were  
67 significantly less likely to consume wholegrains at least once per day.
- 68 • Shift workers with access to workplace vending machines were significantly more likely to  
69 consume soft drinks at least once per week.
- 70 • Middle-aged shift workers and those reporting insufficient break times at work were  
71 significantly less likely to adhere to aerobic physical activity guidelines.

72 **How might this impact on policy or clinical practice in the foreseeable future?**

- 73 • The optimisation of dietary intake and physical activity levels among shift workers should be  
74 a priority for occupational and public health medicine.
- 75 • Insights provided by this study may inform the development of occupational medicine policy  
76 and interventions for shift workers tailored according to individual and work-related factors.

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79 **Introduction**

80 Shift work is defined by the Council of the European Union<sup>1</sup> as *'any method of organising work in*  
81 *shifts whereby workers succeed each other at the same work stations according to a certain pattern'*.

82 Traditionally, only a limited proportion of the workforce was engaged in shift work - however, many  
83 employment sectors have now adopted shift work schedules<sup>2</sup>. In 2010, 17% of the workforce in the  
84 European Union was employed in shift work<sup>3</sup>, a proportion which had increased to 21% by 2015<sup>4</sup>. In  
85 Ireland, approximately 15% of the working population are employed in shift and/or night work<sup>2</sup>.

86 Shift work has been associated with adverse effects on the physical and mental health of those  
87 engaged in it - in particular, increased risks of being overweight or obese, the metabolic syndrome  
88 and other non-communicable diseases (NCDs) including type 2 diabetes mellitus, cardiovascular  
89 disease, gastrointestinal and mental health disorders<sup>5,6</sup>. In 2019, the International Agency for  
90 Research on Cancer categorised 'night shift work' as a Group 2A carcinogen<sup>7</sup>. The disruptive and  
91 irregular nature of shift work schedules may also adversely affect the worker's ability and motivation  
92 to maintain health-promoting lifestyle behaviours<sup>8</sup>. Many such behaviours, including an unhealthy  
93 diet, physical inactivity, smoking, excess alcohol consumption, being overweight, and having  
94 insufficient sleep are considered to be risk factors for NCDs and have been more frequently reported  
95 among shift workers<sup>5,9</sup>. Shift work has been shown to adversely affect the quality and quantity of  
96 dietary intake as well as meal frequency, with greater meal skipping and unconventional meal timing  
97 reported among shift workers compared to non-shift workers<sup>10</sup>. Shift workers may also have  
98 difficulty engaging in regular exercise due to factors such as time constraints, sleep disruption,  
99 fatigue, lack of availability of leisure facilities and opportunities to exercise outside of working hours,  
100 and internal factors such as individual motivation to exercise<sup>11</sup>.

101 The limited published data on the experience of Irish shift workers have demonstrated that shift  
102 work may negatively affect their health behaviours and psycho-social well-being<sup>12</sup>. Factors relating  
103 to the work environment have been identified which may act as barriers or facilitators in their effect

104 on the ability of Irish shift workers to maintain healthy lifestyle behaviours both at work and at  
105 home. Further evidence-based insights of this nature are required to inform the development of  
106 public and occupational health measures to optimise the health and health behaviours of shift  
107 workers. The aim of this study was to examine individual and work-related factors associated with  
108 adherence among shift workers to selected indicators of national dietary and physical activity  
109 guidelines.

## 110 **Methods**

### 111 **Study Design and Participants**

112 This cross-sectional study was conducted on a population of 1300 shift workers from the Republic of  
113 Ireland (RoI) (n = 850) and Northern Ireland (NI) (n = 450), which was demographically,  
114 geographically and occupationally representative of the estimated 270,000 shift workers on the  
115 island of Ireland. The study population was derived from a previous larger study commissioned by  
116 *safefood* entitled 'Managing Food on Shift Work', comprised of quantitative and qualitative  
117 components<sup>13</sup>. The data for the original *safefood* study were collected by the market research  
118 company Millward Brown Ulster (MBU) using a 15-minute telephone-administered questionnaire,  
119 developed by the research team for the *safefood* study. The content of this study questionnaire was  
120 informed by the qualitative component of the *safefood* study, the published shift work literature and  
121 national dietary intake data. A random digit dial sample of telephone numbers in the RoI and NI was  
122 generated using a mathematical formula by MBU, then pulsed to ensure they were 'live' numbers.  
123 Random real numbers were then selected from the database via specialised telephone software.  
124 Eligibility criteria for this study included being aged 18 years or older and working in a shift work  
125 pattern at the time of contact. During the 15-minute telephone interview, participants were asked a  
126 series of questions (referring to the previous one month period of their lives) to obtain information  
127 on their demographic characteristics, shift work pattern, typical dietary intake, physical activity  
128 levels and workplace environment. The questionnaire used to collect data for the *safefood* study

129 was reviewed prior to the commencement of this study, and variables relevant to the research  
130 question and the questions pertaining to those variables were chosen. The original questionnaire is  
131 available as Appendix 1 (online-only supplementary material) with the questions considered relevant  
132 for the current study indicated (highlighted in yellow).

### 133 **Data Management**

134 Upon receipt of the raw data from the original *safefood* study variables not intended for use were  
135 removed and missing values were coded (these data were not included in the analysis of data for the  
136 current study). Selected variables were re-coded into categorical variables. Age was re-coded into  
137 three categories; 18-34 years, 35-54 years and 55+ years, in order to examine age profiles of shift  
138 workers in relation to outcomes of interest. Body mass index (BMI), calculated based on self-  
139 reported height and weight measures, was re-coded into four categories based on the WHO BMI  
140 classification system<sup>14</sup>; underweight (<18.50 kg/m<sup>2</sup>), normal weight (18.50-24.99 kg/m<sup>2</sup>), overweight  
141 (25.00-29.99 kg/m<sup>2</sup>) and obese (≥30 kg/m<sup>2</sup>). Socio-economic status (SES) was derived in the original  
142 *safefood* study from the occupation of the head of the household, categorised according to the  
143 National Readership Survey (2015) classification system<sup>15</sup> into classes ABC1 and C2DE. ABC1 included  
144 those in the upper middle, middle, and lower middle classes, while C2DE included those in the skilled  
145 working, working and non-working classes. Duration of exposure to shift work measured in years  
146 and the average length of shift measured in hours were re-coded respectively into '*less than 8 years*'  
147 and '*8 years or more*', and '*less than 8 hours*', '*8-11 hours*' and '*12 or more hours*.' The predominant  
148 shift pattern of participants was re-coded into '*days*', '*nights*', '*rotating*', and '*other*' (which included  
149 split, inconsistent and equal day/afternoon/night rotating shifts) – Supplementary Table 1, available  
150 as online-only supplementary material, provides further information on this categorisation.

151 Consumption of fruits, vegetables, wholegrains and soft drinks were selected as dietary outcomes of  
152 interest for this study, representing markers of adherence to Irish dietary guidelines. These were

153 chosen following review of the shift work literature, and of dietary intake data and guidelines for the  
154 Irish adult population. These guidelines advise consumption of a minimum of 5-7 daily servings of  
155 fruits and vegetables (unsweetened fruit juice, smoothies, tinned and dried fruit are also counted)  
156 and 3-5 daily servings of foods from the '*wholemeal cereal and breads, potatoes (cooked any way),*  
157 *pasta and rice*' group of the Irish food pyramid<sup>16</sup>, as these are highly nutrient-dense foods associated  
158 with reductions in risk of several chronic diseases and overall mortality<sup>17,18</sup>. The sub-optimal  
159 compliance of the adult population of the ROI and NI with these specific dietary guidelines is well-  
160 described<sup>19,20,21</sup>, while lower intakes of fruit, vegetables, dietary fibre, and various micronutrients  
161 have been observed among shift workers compared to non-shift day workers<sup>22,23,24</sup>.

162 Consumption of fruits and vegetables was re-coded in a binary manner into those who consumed  
163 five or more daily servings of these foods and those who consumed them less frequently than this.  
164 Consumption of wholegrains (a food category which included '*brown pasta, brown rice, wholegrain*  
165 *bread, wholegrain cereals, and porridge*' in the study questionnaire) was also re-coded in a binary  
166 manner into those who consumed one or more daily servings of these foods and those who  
167 consumed them less frequently than this.

168 The frequency of consumption of soft drinks was re-coded into those who consumed one or more  
169 servings of these beverages per week and those who consumed them less frequently than this, as  
170 Irish adults are advised to avoid daily consumption of soft drinks and to limit overall intake to a  
171 maximum of one or two servings per week<sup>16</sup>.

172 National and international physical activity guidelines advise adults to undertake a minimum 150  
173 minutes of moderate intensity aerobic physical activity per week<sup>25,26</sup>. In this study, physical activity  
174 was recorded in minutes per week per participant based on self-reported frequency of episodes of  
175 moderate to vigorous physical activity performed per week and the average length of each. The total  
176 time engaged in physical activity per week was then calculated and categorised according to  
177 whether the participant was meeting the above guideline or not.



## 178 **Data Analysis**

179 SPSS (IBM Version 24) was used for data management and statistical analysis. A descriptive analysis  
180 of the study population was initially conducted. Pearson's chi square tests were used to compare  
181 categorical variables and examine associations between these. Logistic regression methods were  
182 chosen for the analysis of this study as the selected outcomes were binary in nature i.e. meeting the  
183 relevant guideline or not. Univariable binary logistic regression analyses were then performed for  
184 the four (three dietary and one physical activity) outcomes of interest using the same independent  
185 variables for each outcome. Independent variables pertained to the individual (gender, age category,  
186 SES and BMI), shift work exposure (occupational sector, duration of shift work exposure, average  
187 shift length and predominant shift pattern) and the workplace environment (availability of food  
188 preparation, food storage and leisure facilities, vending machines and adequate break times,  
189 whether participants were satisfied with healthy food options at work and whether they felt their  
190 workplace helped them lead a healthy lifestyle). Health and social work was chosen as the reference  
191 occupational sector for the analysis as it is acknowledged that these shift workers may have  
192 achieved greater levels of health literacy and education compared to those working in other  
193 sectors<sup>27</sup>. Independent variables significantly associated with the four outcomes in the univariable  
194 regression analyses were added to separate multivariable logistic regression models for the four  
195 outcomes. All independent variables were mutually adjusted for in the multivariable models for each  
196 of the four outcomes of interest. Significant results were determined by a p-value of <0.05.

## 197 **Results**

### 198 **Demographic Characteristics**

199 Table 1 provides information on the shift workers' demographic characteristics. There was a similar  
200 proportion of males and females, and of those in both categories of socio-economic status. Middle-  
201 aged (35-54 years old) shift workers comprised the largest proportion of participants.

<b>Table 1: Demographic and health-related characteristics of shift workers (n = 1300)</b>		
<b>Variables</b>	<b>n</b>	<b>%</b>
<b>Country of Residence</b>		
Republic of Ireland	850	65.4
Northern Ireland	450	34.6
<b>Gender</b>		
Male	672	51.7
Female	628	48.3
<b>Age Category<sup>1</sup></b>		
18-34 years	490	38.2
35-54 years	606	47.2
55-65 years	187	14.6
<b>Marital Status</b>		
Single never married	528	40.6
Married and living with spouse	637	49.0
Civil partnership	27	2.1
Married and separated from spouse	47	3.6
Divorced	45	3.5
Widowed	16	1.2
<b>Socio-economic status<sup>a, 2</sup></b>		
ABC1	599	48.2
C2DE	644	51.8
<b>Calculated BMI<sup>b, 3</sup></b>		
Underweight	30	2.7
Normal weight	504	45.4
Overweight	397	35.8
Obese	179	16.1
<small>BMI = Body Mass Index  <sup>a</sup>Based on the occupation of the head of household. ABC1 denotes upper middle class, middle class and lower middle class. C2DE denotes skilled working class, working class and non-workers<sup>15</sup>  <sup>b</sup>Calculated based on self-reported height and weight and categorised according to the World Health Organisation BMI classification<sup>14</sup>  <sup>c</sup>Valid denominator = 1283  <sup>2</sup>Some participants declined to respond (n = 57)  <sup>3</sup>Valid denominator = 1110</small>		

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203 **Shift work schedule and work environment characteristics**

204 Table 2 provides information on the characteristics of the shift workers' work schedule and work  
 205 environment. The most common average shift length reported was 8-11 hours. In terms of the  
 206 predominant pattern of shifts worked, those in the 'other' category and those working  
 207 predominantly day shifts comprised the largest groups.

208 Over half of participants had access to food preparation and storage facilities at work. Less than one-  
209 third had access to vending machines. Most participants reported receiving adequate work break  
210 times. The majority did not have access to leisure facilities at work.

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**Table 2: Shift schedule and work environment characteristics of shift workers (n = 1300)**

<b>Variables</b>	<b>n</b>	<b>%</b>
<b>Occupational Sector</b>		
Accommodation and Food Services	218	16.8
Health and Social Work	355	27.3
Retail	229	17.6
Manufacturing	110	8.5
Other <sup>a</sup>	388	29.8
<b>Pattern of SW</b>		
Predominantly days	460	35.4
Predominantly nights	164	12.6
Predominantly rotating	168	12.9
Other	508	39.1
<b>Duration of exposure to SW</b>		
<8 years	622	47.8
≥8 years	678	52.2
<b>Average length of shift</b>		
<8 hours	379	29.2
8-11 hours	622	47.8
≥12 hours	299	23.0
<b>Availability and use of food preparation facilities</b>		
Yes	685	52.7
No	327	25.2
Not available	288	22.1
<b>Availability and use of food storage facilities</b>		
Yes	784	60.3
No	267	20.5
Not available	249	19.2
<b>Availability and use of vending machines</b>		
Yes	355	27.3
No	408	31.4
Not available	537	41.3
<b>Receiving adequate break times<sup>1</sup></b>		
Agree	776	69.7
Disagree	337	30.3
<b>Satisfied with healthy meal/snack availability<sup>2</sup></b>		
Agree	551	59.3
Disagree	378	40.7
<b>Availability of leisure facilities</b>		
Yes	142	10.9
No	1158	89.1
SW = Shift work		
<sup>3</sup> Denotes those employed in sectors of transport/communications, agriculture/animals, construction, call centre/telesales, computer-related activity, distribution and logistics and finance/banking/insurance		
<sup>1</sup> Valid denominator = 1113		
<sup>2</sup> Valid denominator = 929		

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231 **Dietary and physical activity characteristics**

232 Table 3 provides information on the shift workers’ dietary behaviours and physical activity levels.  
 233 Approximately 40% reported consuming five or more daily servings of fruits and vegetables, while  
 234 61% did not consume wholegrains on a daily basis. Over one-third consumed soft drinks at least  
 235 once per week. Thirty-nine per cent adhered to national aerobic physical activity guidelines, while  
 236 59% were engaged in minimal physical effort at work and approximately one-fifth reported mostly  
 237 sedentary occupational behaviour.

<u>Variables</u>	<u>n</u>	<u>%</u>
<b>Fruit and vegetable consumption*</b>		
≥5 servings/day	522	40.2
<5 servings/day	778	59.8
<b>Wholegrain consumption*</b>		
≥1 serving per day	512	39.4
<1 serving per day <sup>a</sup>	788	60.6
<b>Soft drink consumption*</b>		
≥1 serving per week	487	37.5
<1 serving per week <sup>b</sup>	813	62.5
<b>Type of occupational PA</b>		
Mostly sitting	262	20.2
Minimal physical effort	762	58.6
Moderate physical effort	212	16.3
Vigorous physical effort	64	4.9
<b>Time spent in MVPA per week<sup>c, 1</sup></b>		
≥150 minutes	509	39.2
<150 minutes	789	60.8
<small>MVPA = Moderate-vigorous physical activity  <sup>a</sup>Denotes frequency of consumption according to the Food Safety Authority of Ireland dietary guidelines<sup>16</sup>  <sup>b</sup>Denotes consumption multiple times per week, less than weekly or not at all  <sup>c</sup>Denotes consumption less than weekly or not at all  <sup>d</sup>Based on national and international physical activity guidelines<sup>25,26</sup>  <sup>1</sup>Valid denominator = 1298</small>		

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239 **Multivariable regression analysis**

240 The univariable regression analyses which informed the multivariable regression models are  
 241 available as (online-only) Supplementary Tables 2, 3, 4 and 5. Tables 4 and 5 combined present the  
 242 four multivariable regression models with all independent variables listed.

**Table 4: Multivariable analysis of individual and workplace factors independently associated with dietary behaviours and physical activity levels of shift workers (n = 1300)<sup>†</sup>**

Variables	Fruit/Veg Intake ≥ 5 servings/day* (n = 522)		Wholegrain Intake ≥1 serving/day* (n = 512)		Soft Drink Intake ≥1 serving/week* (n = 487)		Physical Activity ≥150 minutes/week** (n = 509)	
	p- Value	OR (95% CI)	p- Value	OR (95% CI)	p- Value	OR (95% CI)	p- Value	OR (95% CI)
<b>Gender</b> (ref: Female) Male	<b>&lt;0.001</b>	<b>0.55 (0.40-0.74)</b>	N/A		ns	1.29 (0.93-1.80)	N/A	
<b>Age Category<sup>1</sup></b> (ref: 18-34 years)								
Middle-aged (35-54 years)	N/A		ns	0.93 (0.70-1.24)	<b>&lt;0.001</b>	<b>0.50 (0.34-0.73)</b>	<b>0.012</b>	<b>0.65 (0.46-0.91)</b>
Older age (55-65 years)	N/A		ns	1.27 (0.87-1.86)	<b>&lt;0.001</b>	<b>0.33 (0.18-0.59)</b>	ns	0.74 (0.46-1.18)
<b>BMI<sup>2,a</sup></b> (ref: Normal)								
Overweight/Obese	ns	0.80 (0.61-1.07)	N/A		N/A		N/A	
<b>SES<sup>3,b</sup></b> (ref: ABC1) C2DE	<b>0.046</b>	<b>0.75 (0.57-0.99)</b>	N/A		N/A		N/A	
<b>Vending Machines</b> (ref: None)								
Available at Work	N/A		N/A		<b>0.003</b>	<b>1.64 (1.18-2.27)</b>	<b>0.025</b>	<b>0.71 (0.52-0.96)</b>
<b>Break Time Adequate<sup>4</sup></b> (ref: Agree)								
Disagree	N/A		N/A		N/A		<b>0.026</b>	<b>0.69 (0.49-0.96)</b>
<b>Satisfied with healthy food availability<sup>5</sup></b> (ref: Agree)								
Disagree	N/A		N/A		ns	1.01 (0.71-1.44)	N/A	
<b>Workplace helps lead a healthy lifestyle<sup>6</sup></b> (ref: Agree)								
Disagree	<b>0.028</b>	<b>0.73 (0.55-0.97)</b>	N/A		<b>0.047</b>	<b>1.43 (1.01-2.04)</b>	ns	0.75 (0.55-1.02)

<sup>†</sup>The full list of co-variables included in the analysis is represented by those in the left-hand columns of Tables 4 and 5.

OR, 95% CI = Odds Ratio, 95% Confidence Interval

N/A = Not applicable (not significantly associated with the outcome of interest in univariable analysis), ns = not significant in the multivariable analysis

\*According to the Food Safety Authority of Ireland dietary guidelines<sup>15</sup>

\*\*Minutes per week based on national and international physical activity guidelines<sup>25,26</sup>

Significant odds ratios (p<0.05) are denoted in bold font (these remained significantly associated with the outcome of interest after multivariable analysis)

<sup>1</sup>Valid denominator = 1283

BMI<sup>2,a</sup> = Body Mass Index, calculated based on self-reported height and weight and categorised according to the World Health Organisation BMI classification<sup>14</sup> ('Underweight' participants were excluded (n = 30))

SES<sup>3,b</sup> = Socio-economic status, based on the occupation of the head of household. ABC1 denotes upper middle class, middle class and lower middle class. C2DE denotes skilled working class, working class and non-workers<sup>15</sup> (Valid denominator = 1243)

<sup>4</sup>Valid denominator = 1113

<sup>5</sup>Valid denominator = 929

<sup>6</sup>Valid denominator = 1035

<b>Table 5: Multivariable analysis of shift work exposure factors independently associated with dietary behaviours and physical activity levels of shift workers (n = 1300) †</b>								
<b>Variables</b>	<b>Fruit/Veg Intake ≥ 5 servings/day*</b> (n = 522)		<b>Wholegrain Intake ≥1 serving/day*</b> (n = 512)		<b>Soft Drink Intake ≥1 serving/week*</b> (n = 487)		<b>Physical Activity ≥150 minutes/week**</b> (n = 509)	
	<b>p-value</b>	<b>OR (95% CI)</b>	<b>p-value</b>	<b>p-value</b>	<b>p-value</b>	<b>OR (95% CI)</b>	<b>p-value</b>	<b>OR (95% CI)</b>
<b>Occupational Sector</b> (ref: Health & Social Work)								
Accommodation & Food	ns	1.06 (0.67-1.66)	ns	0.85 (0.58-1.23)	ns	ns	ns	0.70 (0.39-1.26)
Retail	ns	0.80 (0.52-1.24)	<b>0.022</b>	<b>0.65 (0.44-0.94)</b>	ns	0.81 (0.48-1.35)	ns	1.52 (0.85-2.71)
Manufacturing	ns	1.05 (0.60-1.82)	ns	0.91 (0.58-1.42)	<b>0.019</b>	<b>2.03 (1.12-3.68)</b>	ns	1.34 (0.66-2.75)
Other	ns	0.90 (0.61-1.33)	ns	1.17 (0.86-1.58)	ns	1.11 (0.71-1.75)	ns	1.33 (0.79-2.24)
<b>Duration of SW Exposure</b> (ref: <8 years)								
≥8 years	N/A		<b>0.02</b>	<b>1.38 (1.05-1.82)</b>	ns	0.89 (0.62-1.30)	ns	1.15 (0.74-1.80)
<b>Average Shift Length</b> (ref: <8 hours)								
8-11 hours	N/A		ns	0.99 (0.75-1.32)	ns	0.73 (0.50-1.06)	ns	0.99 (0.63-1.55)
≥12 hours	N/A		ns	1.26 (0.89-1.79)	<b>0.032</b>	<b>0.59 (0.37-0.96)</b>	ns	1.12 (0.64-1.96)
<b>Predominant SW Pattern</b> (ref: Days)								
Nights	N/A		<b>0.011</b>	<b>0.61 (0.41-0.89)</b>	N/A		N/A	
Rotating	N/A		<b>0.026</b>	<b>0.65 (0.45-0.95)</b>	N/A		N/A	
Other	N/A		<b>0.002</b>	<b>0.65 (0.50-0.86)</b>	N/A		N/A	

†The full list of co-variables included in the analysis is represented by those in the left-hand columns of Tables 4 and 5.  
SW = Shift work  
OR, 95% CI = Odds Ratio, 95% Confidence Interval  
N/A = Not applicable (not significantly associated with the outcome of interest in univariable analysis), ns = not significant following multivariable analysis  
\*According to the Food Safety Authority of Ireland dietary guidelines<sup>16</sup>  
\*\*Minutes per week based on national and international physical activity guidelines<sup>25,26</sup>  
Significant odds ratios (p<0.05) are denoted in bold font (these remained significantly associated with the outcome of interest after multivariable analysis)

243 **Fruit and vegetable intake**

244 Male shift workers (relative to females) and those in the lower C2DE social class (relative to those in  
245 the upper ABC1 class) were 45% [ $p < 0.001$ , OR = 0.55, 95% CI (0.40 – 0.74)] and 25% [ $p = 0.046$ , OR =  
246 0.75, 95% CI (0.57 – 0.99)] less likely to consume five or more daily portions of fruits and vegetables  
247 respectively.

248 **Wholegrain intake**

249 Those exposed to shift work for 8 years or more (compared to those exposed for less) were 38%  
250 more likely [ $p = 0.02$ , OR = 1.38, 95% CI (1.05 – 1.82)] to consume wholegrains at least daily, while  
251 compared to those working mostly day shifts, participants working predominantly nights, rotating or  
252 other shift patterns were each over one-third less likely to do so [ $p = 0.011$ , OR = 0.61, 95% CI [0.41 –  
253 0.89),  $p = 0.026$ , OR = 0.65, 95% CI (0.45 – 0.95) and  $p = 0.002$ , OR = 0.65, 95% CI [0.50 – 0.86)  
254 respectively]. Retail shift workers were 35% less likely [ $p = 0.022$ , OR = 0.65, 95% CI (0.44 – 0.94)] to  
255 consume wholegrains on a daily basis compared to those working in health and social work services.

256 **Soft drinks intake**

257 Middle-aged shift workers (35-54 years old) were half as likely [ $p < 0.001$ , OR = 0.50, 95% CI (0.34 –  
258 0.73)] to consume soft drinks at least weekly relative to the youngest participants (18-34 years old),  
259 while the oldest age group of shift workers were 67% less likely to consume soft drinks at least  
260 weekly relative to the youngest group [ $p < 0.001$ , OR = 0.33, 95% CI (0.18 – 0.59)]. When compared to  
261 those working in health and social work, manufacturing employees were just over twice as likely [ $p =$   
262 0.019, OR = 2.03, 95% CI (1.12 – 3.68)] to consume soft drinks at least once per week. Shift workers  
263 with access to vending machines at work (compared to those without) were 64% [ $p = 0.003$ , OR =  
264 1.64, 95% CI [1.18 – 2.27]] more likely to consume soft drinks at least once per week.

265



266 **Physical Activity**

267 Middle-aged shift workers were 35% [ $p = 0.012$ , OR = 0.65, 95% CI (0.46 - 0.91)] less likely to adhere  
268 to national physical activity guidelines relative to the youngest participants, while those who did not  
269 receive adequate break times at work (relative to those who did) were 31% [ $p = 0.026$ , OR = 0.69,  
270 95% CI (0.49 – 0.96)] less likely to do so.

271

272 **Discussion**

273 This study identified factors pertaining to the individual, shift work exposure and the workplace  
274 environment that were independently associated with adherence among a large cohort of shift  
275 workers employed on the island of Ireland to selected indicators of population dietary and physical  
276 activity guidelines. Overall, adherence among participants to these guidelines was sub-optimal - less  
277 than half were adherent to each of the indicators of interest. With respect to dietary intake, this  
278 supports previous studies which have demonstrated lower intakes of fruits, vegetables and dietary  
279 fibre<sup>22,23,24</sup> as well as carbohydrates<sup>28,29</sup> among shift workers compared to day workers. Consistent  
280 observations of higher intakes of soft drinks, and of poorer dietary quality and quantity, have also  
281 been reported among shift workers compared to non-shift workers<sup>10</sup>. In contrast, previous research  
282 has yielded conflicting results regarding the leisure physical activity of shift workers<sup>5</sup>, making  
283 comparison with our findings challenging. The low level of occupational activity, however, among  
284 participants is consistent with some previous data<sup>30</sup> although others have reported greater levels of  
285 same compared to day workers<sup>31</sup>. Such differences may be explained by variable methodological  
286 approaches to measuring physical activity levels across these studies - nonetheless, there are  
287 significant risks to physical and mental health associated with physical inactivity and sedentary  
288 lifestyles<sup>32</sup>.

289 We found that males and those of lower socio-economic status (SES) were significantly less likely to  
290 consume the recommended daily servings of fruits and vegetables. Social class and gender  
291 differences in intake of these foods have been described previously in the general Irish adult  
292 population<sup>19,33</sup> – however, to the authors knowledge, this is the first time this finding has been  
293 confirmed specifically in a range of shift workers. One study conducted on airline shift workers found  
294 lower fruit and vegetable intake among males without in-flight work compared to day and in-flight  
295 workers<sup>23</sup>.

296 Differences in dietary quality according to age among shift workers have been reported previously<sup>34</sup>.  
297 Age category also emerged as a significant factor in our analysis. Younger shift workers, compared to  
298 those who were middle-aged and older, were more likely to consume soft drinks at least weekly. In  
299 the general Irish population, young adults aged 15-34 years have been shown to have the highest  
300 intakes of sugar-sweetened beverages, many of which are soft drinks<sup>19</sup>. In contrast, middle-aged  
301 shift workers, compared to the youngest group, were less likely to adhere to aerobic physical activity  
302 guidelines. Declining levels of awareness of and adherence to these guidelines with age have been  
303 reported in the Irish adult population which may in part explain this finding<sup>35</sup>.

304 We examined several factors pertaining to shift work exposure - duration of exposure, occupational  
305 sector, average shift length, and predominant shift pattern. We found, relative to those working in  
306 health and social work, retail sector shift workers were less likely to consume wholegrain foods daily,  
307 while manufacturing workers were more likely to consume soft drinks at least weekly – the latter  
308 supports prior research demonstrating greater energy intake and poorer dietary quality in the  
309 manufacturing occupational sub-group<sup>22</sup>. Participants working predominantly non-day shifts were  
310 less likely to consume wholegrain foods daily, which is somewhat consistent with previous findings  
311 of poorer dietary quality among night and rotating shift workers compared to day workers<sup>34,36</sup>.  
312 However, we did not observe any significant differences in consumption of fruits and vegetables or  
313 soft drinks across shift pattern. Cumulative years employed in shift work also emerged as a

314 significant factor in relation to daily wholegrain intake even when adjusted for age category, which  
315 may suggest improvements in health and nutritional knowledge among those with greater  
316 experience working in shift systems.

317 With regard to the work environment of participants, we observed two main findings. Those with  
318 access to vending machines at work, compared to those without, were more likely to consume soft  
319 drinks at least weekly - an important finding given improvements in availability (and price) of  
320 healthier choices in vending machines have been shown to improve sales of healthier products<sup>37,38</sup>.  
321 In addition, those who reported that they did not receive adequate break times at work were less  
322 likely to be sufficiently active compared to those who did, supporting previous Irish research which  
323 identified a perceived lack of time to be a barrier to physical activity among shift workers<sup>39</sup>.

#### 324 **Implications of Findings**

325 The gender, age and social class differences we observed across specific dietary behaviours highlight  
326 that nutritional aspects of health education and interventions for shift workers which seek to  
327 improve their adherence to population dietary guidelines should be developed with these  
328 characteristics in mind. Our findings also highlight the need to target middle-aged shift workers with  
329 workplace interventions which aim to improve their adherence to population physical activity  
330 guidelines.

331 Our findings regarding the shift work schedule and occupation of participants in relation to their  
332 adherence to selected indicators of dietary and physical activity guidelines may help employers to  
333 devise and adapt workplace policy and interventions which aim to improve adherence among  
334 employees to such guidelines. The workplace is a social context within which shift workers may  
335 spend a large amount of time and should support health-promoting lifestyle behaviours<sup>40</sup>. This study  
336 has highlighted that provision for shift workers of healthy vending machines, food preparation and  
337 storage facilities, and adequate break times should be a priority for employers.

338 **Strengths and Limitations**

339 The study population was large in size, and was demographically, geographically and occupationally  
340 representative of the Irish shift work population, about whom little is known from a research  
341 perspective to date. Factors independently associated with adherence among participants to  
342 selected indicators of dietary and physical activity guidelines were identified, the optimisation of  
343 which is of importance from a public and occupational health perspective. Although a non-shift  
344 worker control group was not available to us against which the adherence of participants could be  
345 compared, nationally representative data for the general adult populations of the Republic (ROI) and  
346 North of Ireland (NI) were included where appropriate for comparison and context.

347 The cross-sectional design of this study precludes the potential to draw causal inferences from  
348 findings. Data were collected using a questionnaire, raising the possibility of recall and self-report  
349 bias pertaining to potential misreporting of weight, height, dietary behaviours and physical activity.  
350 Minor differences between the dietary and physical activity guidelines used and the corresponding  
351 questions in the questionnaire may have led to a slight under- or over-estimation of adherence to  
352 the selected indicators of the guidelines among participants. The study questionnaire did not  
353 capture all domains of shift work - further research is needed to examine dietary and physical  
354 activity behaviours across different shift schedules and systems. Occupational physical activity,  
355 although not examined as an outcome in our study, remains an important consideration in relation  
356 to the health of shift workers. The possibility of residual confounding due to factors not included or  
357 measured in our analysis cannot be excluded. Finally, multicollinearity was not examined - as such  
358 the possibility of correlation between independent variables remains, which may have affected the  
359 validity of our findings.

360

361

362 **Conclusions**

363 Individual, work schedule and workplace environment-related factors were independently  
364 associated with selected indicators of adherence to dietary and physical activity guidelines in this  
365 cohort of shift workers. Shift workers face unique challenges to their health at the biological,  
366 psychological and social level. Tailored occupational health measures are required which address  
367 these challenges and provide solutions for them. This study has provided insights which may  
368 contribute to the development of such measures, targeting individual and organisational factors to  
369 protect the health of this vulnerable sub-population of the global workforce.

370 **Ethical Approval**

371 An ethics exemption application was approved by the Taught Masters Research Ethics Committee  
372 (TM-REC) of the UCD School of Public Health, Physiotherapy and Sports Science on the basis of  
373 previously granted ethical approval for the original safefood study by the DIT Research Ethics  
374 Committee in 2014 (Ethical Clearance Reference 14-09) - this application and approval from DIT  
375 were also reviewed and agreed by the Biomedical Sciences Ethics Committee of UU, Coleraine,  
376 Northern Ireland at the time. No new data were collected for this study.

377 **Contributorship Statement**

378 This study was a secondary analysis of data collected for a previous larger study commissioned by  
379 safefood entitled 'Managing Food on Shift Work'. CC was the project lead for the original safefood  
380 study, in collaboration with JK and MBL. FN and KP contributed to data collection, analysis and  
381 interpretation for the original safefood study. CK and CC conceptualised the present study and its  
382 methodology. CK lead the statistical analysis and data interpretation and wrote the manuscript. CC  
383 supervised the present study and contributed to data analysis and interpretation, and the writing  
384 and critical review of the manuscript. VOB and MBL contributed to data interpretation and the  
385 critical review of the manuscript. FN, KP and JK contributed to the critical review of the manuscript.  
386 All authors read the manuscript, contributed comments to its revision and have approved and

387 agreed to the final version. CK submitted the manuscript and is responsible for the overall content as  
388 guarantor.

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392 **Competing Interests**

393 Nil.

394 **Acknowledgement**

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408 **References**

- 409 1 The Council of the European Union. Directive 2000/34/EC of the European Parliament and of  
410 the Council of 22 June 2000 amending Council Directive 93/104/EC 'concerning certain  
411 aspects of the organisation of working time to cover sectors and activities excluded from  
412 that Directive.' *Official Journal* 1993;L195:41-45.
- 413 2 Health and Safety Authority. 'Guidance for Employers and Employees on Night and Shift  
414 Work.' Dublin: Health and Safety Authority. 2012. Available at:  
415 [https://www.hsa.ie/eng/Publications\\_and\\_Forms/Publications/Healthcare\\_Sector/Night\\_an  
416 d\\_Shift\\_Work\\_2012.pdf](https://www.hsa.ie/eng/Publications_and_Forms/Publications/Healthcare_Sector/Night_and_Shift_Work_2012.pdf) [Accessed 14 February 2020]
- 417 3 Eurofound. 'Changes over time – First findings from the fifth European Working Conditions  
418 Survey.' Luxembourg: Publications Office of the European Union. 2010. Available at:  
419 [https://www.eurofound.europa.eu/sites/default/files/ef\\_publication/field\\_ef\\_document/ef  
420 1182en.pdf](https://www.eurofound.europa.eu/sites/default/files/ef_publication/field_ef_document/ef_1182en.pdf) [Accessed 14 February 2020]
- 421 4 Eurofound. 'First findings: Sixth European Working Conditions Survey.' Luxembourg:  
422 Publications Office of the European Union. 2015. Available at:  
423 [https://www.eurofound.europa.eu/sites/default/files/ef\\_publication/field\\_ef\\_document/ef  
424 1634en.pdf](https://www.eurofound.europa.eu/sites/default/files/ef_publication/field_ef_document/ef_1634en.pdf) [Accessed 14 February 2020]
- 425 5 Nea F, Kearney J, Livingstone MB, et al. Dietary and lifestyle habits and the associated  
426 health risks in shift workers. *Nutr Res Rev* 2015;28(2):143-66.
- 427 6 Vogel M, Braungardt T, Meyer W, et al. The effects of shift work on physical and mental  
428 health. *J Neural Transm (Vienna)* 2012;119(10):1121-32.
- 429 7 IARC Monographs Vol 125 group. Carcinogenicity of night shift work. *Lancet Oncol*  
430 2019;20:1058-1059.
- 431 8 Lowden A, Moreno C, Holmbäck U, et al. Eating and shift work - effects on habits,  
432 metabolism and performance. *Scand J Work Environ Health* 2010;36(2):150-62.

- 433 9 Zhao I and Turner C. The impact of shift work on people's daily health habits and adverse  
434 health outcomes. *Australian J of Adv Nursing* 2008;25(3):8-22.
- 435 10 Souza RV, Sarmiento RA, de Almeida JC, et al. The effect of shift work on eating habits: a  
436 systematic review. *Scand J Work Environ Health* 2019;45(1):7-21.
- 437 11 Atkinson G, Fullick S, Grindey C, et al. Exercise, energy balance and the shift worker,. *Sports*  
438 *Med* 2008;38(8):671-85.
- 439 12 Nea F, Pourshahidi LK, Kearney JM, et al. A qualitative exploration of the shift work  
440 experience: the perceived effect on eating habits, lifestyle behaviours and psychosocial  
441 wellbeing. *J of Public Health* 2018;40(4):e482-92.
- 442 13 safefood. Managing food on shift work: An exploration of the eating patterns, related  
443 lifestyle behaviours and experiences of shift workers on the island of Ireland. Co. Cork,  
444 Ireland: safefood. 2016. Available at:  
445 [http://www.safefood.eu/SafeFood/media/SafeFoodLibrary/Documents/Publications/Resear](http://www.safefood.eu/SafeFood/media/SafeFoodLibrary/Documents/Publications/Research%20Reports/Managing-food-on-shift-work_Island-of-Ireland-October-2016.pdf)  
446 [ch%20Reports/Managing-food-on-shift-work\\_Island-of-Ireland-October-2016.pdf](http://www.safefood.eu/SafeFood/media/SafeFoodLibrary/Documents/Publications/Research%20Reports/Managing-food-on-shift-work_Island-of-Ireland-October-2016.pdf) [Accessed  
447 14 February 2020]
- 448 14 World Health Organisation. Body mass index: BMI [World Health Organisation website].  
449 2019. Available at: [http://www.euro.who.int/en/health-topics/disease-](http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi)  
450 [prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi](http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi) [Accessed 14 February 2020]
- 451 15 National Readership Survey. Social grade [National Readership Survey website]. 2015.  
452 Available at: <http://www.nrs.co.uk/nrs-print/lifestyle-and-classification-data/social-grade/>  
453 [Accessed 14 February 2020]
- 454 16 Food Safety Authority of Ireland. Healthy eating, food safety and food legislation: A guide  
455 supporting the Healthy Ireland Food Pyramid. Dublin, Ireland: FSAI. 2016.
- 456 17 Wang X, Ouyang Y, Liu J, et al. Fruit and vegetable consumption and mortality from all  
457 causes, cardiovascular disease, and cancer: systematic review and dose-response meta-  
458 analysis of prospective cohort studies. *Bmj* 2014;349:g4490.



- 459 18 Reynolds A, Mann J, Cummings J, et al. Carbohydrate quality and human health: a series of  
460 systematic reviews and meta-analyses. *Lancet* 2019;393(10170):434-45.
- 461 19 Department of Health. Healthy Ireland 2018: A summary of findings. Dublin, Ireland:  
462 Government Publications. 2018.  
463 [https://www.hse.ie/eng/about/who/healthwellbeing/healthy-ireland/publications/healthy-](https://www.hse.ie/eng/about/who/healthwellbeing/healthy-ireland/publications/healthy-ireland-survey-2018.pdf)  
464 [ireland-survey-2018.pdf](https://www.hse.ie/eng/about/who/healthwellbeing/healthy-ireland/publications/healthy-ireland-survey-2018.pdf) [Accessed 14 February 2020]
- 465 20 Corrigan D and Scarlett M. Health Survey (NI): First Results 2017/18. Belfast, Northern  
466 Ireland: Department of Health. 2018. Available at: [https://www.health-](https://www.health-ni.gov.uk/sites/default/files/publications/health/hsni-first-results-17-18.pdf)  
467 [ni.gov.uk/sites/default/files/publications/health/hsni-first-results-17-18.pdf](https://www.health-ni.gov.uk/sites/default/files/publications/health/hsni-first-results-17-18.pdf) [Accessed 14  
468 February 2020]
- 469 21 Irish Universities Nutrition Alliance. National Adult Nutrition Survey: Summary Report. Cork,  
470 Ireland: Irish Universities Nutrition Alliance. 2011. Available at: [https://irp-](https://irp-cdn.multiscreensite.com/46a7ad27/files/uploaded/The%20National%20Adult%20Nutrition%20Survey%20Summary%20Report%20March%202011.pdf)  
471 [cdn.multiscreensite.com/46a7ad27/files/uploaded/The%20National%20Adult%20Nutrition](https://irp-cdn.multiscreensite.com/46a7ad27/files/uploaded/The%20National%20Adult%20Nutrition%20Survey%20Summary%20Report%20March%202011.pdf)  
472 [%20Survey%20Summary%20Report%20March%202011.pdf](https://irp-cdn.multiscreensite.com/46a7ad27/files/uploaded/The%20National%20Adult%20Nutrition%20Survey%20Summary%20Report%20March%202011.pdf) [Accessed 14 February 2020]
- 473 22 Nakamura M, Miura A, Nagahata T, et al. Dietary intake and dinner timing among shift  
474 workers in Japan. *J Occup Health* 2018;60(6):467-74.
- 475 23 Hemio K, Puttonen S, Viitasalo K, et al. Food and nutrient intake among workers with  
476 different shift systems. *Occup Environ Med* 2015;72(7):513-20.
- 477 24 Balieiro LC, Rossato LT, Waterhouse J et al. Nutritional status and eating habits of bus drivers  
478 during the day and night. *Chronobiol Int* 2014;31(10):1123-9.
- 479 25 Department of Health. Get Ireland Active: National physical activity action plan for Ireland.  
480 Ireland: Department of Health. 2016 Available at:  
481 <https://www.getirelandactive.ie/Professionals/National-PA-Plan.pdf> [Accessed 14 February  
482 2020]
- 483 26 World Health Organisation. Global recommendations on physical activity for health. Geneva,  
484 Switzerland: WHO. 2010. Available at:

485 [https://apps.who.int/iris/bitstream/handle/10665/44399/9789241599979\\_eng.pdf;jsessionid=283A70241353F8D9193F6FA2EA6B8B53?sequence=1](https://apps.who.int/iris/bitstream/handle/10665/44399/9789241599979_eng.pdf;jsessionid=283A70241353F8D9193F6FA2EA6B8B53?sequence=1) [Accessed 14 February 2020]

486

487 27 Profis M and Simon-Tuval T. The influence of healthcare workers' occupation on Health Promoting Lifestyle Profile. *Ind Health* 2016;54:439-447. Heath G, Dorrian J and Coates A.

488

489 Associations between shift type, sleep, mood, and diet in a group of shift working

490 nurses. *Scand J Work Environ Health* 2019;45(4):402-12.

491 28 Heath G, Coates A, Sargent C, et al. Sleep duration and chronic fatigue are differently

492 associated with the dietary profile of shift workers. *Nutrients* 2016;8(12):E771.

493 29 Hulsegge G, Gupta M, Holtermann A et al. Shift workers have similar leisure-time physical

494 activity levels as day workers but are more sedentary at work. *Scand J Work Environ Health*

495 2017;43(2):127-35.

496 30 Hulsegge G, Gupta M, Holtermann A et al. Shift workers have similar leisure-time physical

497 activity levels as day workers but are more sedentary at work. *Scand J Work Environ Health*

498 2017;43(2):127-35.

499 31 Loef B, van der Beek AJ, Holtermann A et al. Objectively measured physical activity of

500 hospital shift workers. *Scand J Work Environ Health* 2018;44(3):265-73.

501 32 Guthold R, Stevens GA, Riley LM, et al. Worldwide trends in insufficient physical activity from

502 2001 to 2016: a pooled analysis of 358 population-based surveys with 1.9 million

503 participants. *Lancet Glob Health* 2018;6(10):e1077-e1086.

504 33 National Nutrition Surveillance Centre. Dietary Habits of the Irish Population: results from

505 SLÁN. Dublin: University College Dublin. 2003. Available at:

506 <http://www.ucd.ie/issda/static/documentation/slan/diethab.pdf> [Accessed 14 February

507 2020]

508 34 Morikawa Y, Miura K, Sasaki S, et al. Evaluation of the effects of shift work on nutrient

509 intake: A cross-sectional study. *J Occup Health* 2008;50(3):270-8.

510 35 Department of Health. Healthy Ireland: Survey Report 2019. Dublin: Government  
511 Publications. 2019. <https://assets.gov.ie/41141/e5d6fea3a59a4720b081893e11fe299e.pdf>.  
512 [Accessed 18 July 2020]

513 36 Bonnell EK, Huggins CE, Huggins CT et al. Influences on dietary choices during day versus  
514 night shift in shift workers: a mixed methods study. *Nutrients* 2017;9(3):E193

515 37 Gupta C, Coates A, Dorrian J and Banks S. The factors influencing the eating behaviours of  
516 shift workers: what, when, where and why. *Ind Health* 2019;57:419-53.

517 38 Grech A and Allman-Farinelli M. A systematic literature review of nutrition interventions in  
518 vending machines that encourage consumers to make healthier choices. *Obes Rev*  
519 2015;16(12):1030-41.

520 39 Nea F, Pourshahidi LK, Kearney J et al. A qualitative exploration of the shift work experience:  
521 the perceived barriers and facilitators to a healthier lifestyle and the role of the workplace  
522 environment. *J Occup Environ Med* 2017;59(12):1153-60.

523 40 Lassen AD, Fagt S, Lennernäs M et al. The impact of worksite interventions promoting  
524 healthier food and/or physical activity habits among employees working 'around the clock'  
525 hours: a systematic review. *Food Nutr Res* 2018;62:1115.

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**Supplementary Table 1. Predominant shift work pattern of study participants (re-coded and original categories).**

<b>Predominant Shift Work Pattern (Re-coded)</b>	<b>Predominant Shift Work Pattern (Original)</b>
Days	<ul style="list-style-type: none"> <li>• Days (the majority of the shift falls between 06.00-14.00)</li> <li>• Afternoons (the majority of the shift falls between 14.00-22.00)</li> </ul>
Nights	<ul style="list-style-type: none"> <li>• Nights (the majority of the shift falls between 22.00-06.00)</li> </ul>
Rotating	<ul style="list-style-type: none"> <li>• Rotating but predominantly working days</li> <li>• Rotating but predominantly working afternoons</li> <li>• Rotating but predominantly working nights</li> </ul>
Other	<ul style="list-style-type: none"> <li>• Equal day/afternoon/night rotation (roughly equal split between the above described day/afternoon/night shifts, but does not need to include all 3 types, and can be rotation between just 2 types)</li> <li>• Split shifts (defined as two shifts worked in a 24-hour period, with a short break in between)</li> <li>• Inconsistent shifts</li> <li>• Other (i.e. a shift type which does not fit into the above patterns)</li> </ul>

**Supplementary Table 2: Univariable analysis of individual, shift work exposure and workplace environment factors and number of daily servings of fruits and vegetables<sup>a</sup> of participants (n = 1300)**

<u>Variables</u>	<u>≥5/day</u>	<u>&lt;5/day</u>	<u>p-value*</u>	<u>OR</u>	<u>95% CI</u>
	<u>(n = 522)</u>	<u>(n = 778)</u>			
	<u>n (%)</u>	<u>n (%)</u>			
<b>Gender</b> (ref: Female) Male	227 (43.5)	445 (57.2)	<b>&lt;0.001</b>	<b>0.58</b>	<b>(0.46 - 0.72)</b>
<b>Age Category</b> <sup>1</sup> (ref: 18-34 years)					
Middle-aged (35-54 years)	249 (48.6)	357 (46.3)	ns	1.15	(0.90 - 1.47)
Older age (55-65 years)	78 (15.2)	109 (14.1)	ns	1.18	(0.84 - 1.66)
<b>BMI</b> <sup>2</sup> (ref: Normal)					
Overweight/Obese	215 (49.0)	361 (56.3)	<b>0.018</b>	<b>0.74</b>	<b>(0.58 - 0.95)</b>
<b>Socio-economic status</b> <sup>3</sup> (ref: ABC1)					
C2DE	237 (46.9)	407 (55.1)	<b>0.004</b>	<b>0.72</b>	<b>(0.57 - 0.90)</b>
<b>Occupational Sector</b>					
(ref: Health & Social Work)					
Accommodation & Food	87 (16.7)	131 (16.8)	ns	0.77	(0.54 - 1.08)
Retail	89 (17.0)	140 (18.0)	ns	0.73	(0.52 - 1.03)
Manufacturing	44 (8.4)	66 (8.5)	ns	0.77	(0.50 - 1.19)
Other	137 (26.2)	251 (32.3)	<b>0.002</b>	<b>0.63</b>	<b>(0.47 - 0.84)</b>
<b>Duration of SW Exposure</b> (ref: 8 years)					
≥8 years	269 (51.5)	409 (52.6)	ns	0.96	(0.77 - 1.20)
<b>Average Shift Length</b> (ref: <8 hours)					
8-11 hours	243 (46.6)	379 (48.7)	ns	0.95	(0.73 - 1.23)
≥12 hours	126 (24.1)	173 (22.2)	ns	1.08	(0.79 - 1.46)
<b>Predominant SW Pattern</b> (ref: Days)					
Nights	56 (10.7)	108 (13.9)	ns	0.69	(0.48 - 1.00)
Rotating	76 (14.6)	92 (11.8)	ns	1.10	(0.77 - 1.57)
Other	193 (37.0)	315 (40.5)	ns	0.82	(0.63 - 1.06)
<b>Food Preparation Facilities</b> (ref: Yes)					
Not Available at Work	230 (44.1)	385 (49.5)	ns	0.80	(0.64 - 1.01)
<b>Food Storage Facilities</b> (ref: Yes)					
Not Available at Work	199 (38.1)	317 (40.7)	ns	0.90	(0.71 - 1.13)
<b>Vending Machines</b> (ref: None)					
Available at Work	379 (72.6)	566 (72.8)	ns	0.99	(0.77 - 1.27)
<b>Break Times Adequate</b> <sup>4</sup> (ref: Agree)					
Disagree	145 (32.3)	192 (28.9)	ns	1.17	(0.91 - 1.52)
<b>Satisfied with healthy food availability</b> <sup>5</sup> (ref: Agree)					
Disagree	154 (38.4)	224 (42.4)	ns	0.85	(0.65 - 1.10)
<b>Workplace helps lead a healthy lifestyle</b> <sup>6</sup> (ref: Agree)					
Disagree	186 (43.3)	310 (51.2)	<b>0.011</b>	<b>0.73</b>	<b>(0.57 - 0.93)</b>
<b>Leisure facilities</b> (ref: Yes)					
Not Available at Work	459 (87.9)	699 (89.8)	ns	0.82	(0.58 - 1.17)

BMI = Body Mass Index

\*P values <0.05 were deemed significant (denoted in bold font)

<sup>a</sup>According to the Food Safety Authority of Ireland dietary guidelines<sup>16</sup>

<sup>2</sup>Valid denominator = 1283

<sup>3</sup>Those categorised as 'Underweight' were excluded (n = 30)

OR, 95% CI = Odds Ratio, 95% Confidence Interval

<sup>5</sup>Some participants declined to respond (n = 57)

<sup>6</sup>Valid denominator = 1113

<sup>7</sup>Valid denominator = 929

<sup>8</sup>Valid denominator = 1035

**Supplementary Table 3: Univariable analysis of individual, shift work exposure and workplace environment factors and frequency of wholegrain consumption<sup>a</sup> of participants (n = 1300)**

<u>Variables</u>	<u>≥1 serv/day</u>	<u>&lt;1 serv/day</u>	<u>p-value*</u>	<u>OR</u>	<u>95% CI</u>
	<u>(n = 512)</u>	<u>(n = 788)</u>			
	<u>n (%)</u>	<u>n (%)</u>			
<b>Gender</b> (ref: Female) Male	269 (52.5)	403 (51.1)	ns	1.06	(0.85 - 1.32)
<b>Age Category<sup>1</sup></b> (ref: 18-34 years)					
Middle-aged (35-54 years)	239 (47.2)	367 (47.2)	ns	1.15	(0.90 - 1.47)
Older age (55-65 years)	90 (17.8)	97 (12.5)	<b>0.004</b>	<b>1.64</b>	<b>(1.17 - 2.31)</b>
<b>BMI<sup>2</sup></b> (ref: Normal)					
Overweight/Obese	237 (54.0)	339 (52.9)	ns	1.05	(0.82 - 1.33)
<b>Socio-economic status<sup>3</sup></b> (ref: ABC1)					
C2DE	257 (51.8)	387 (51.8)	ns	1.00	(0.80 - 1.33)
<b>Occupational Sector</b>					
(ref: Health & Social Work)					
Accommodation & Food	77 (15.0)	141 (17.9)	ns	0.78	(0.55 - 1.11)
Retail	69 (13.5)	160 (20.3)	<b>0.007</b>	<b>0.62</b>	<b>(0.43 - 0.88)</b>
Manufacturing	43 (8.4)	167 (8.5)	ns	0.92	(0.59 - 1.42)
Other	177 (34.6)	211 (26.8)	ns	1.20	(0.90 - 1.61)
<b>Duration of SW Exposure</b> (ref: <8 yrs)					
≥8 years	299 (58.4)	379 (48.1)	<b>&lt;0.001</b>	<b>1.52</b>	<b>(1.21 - 1.90)</b>
<b>Average Shift Length</b> (ref: <8 hours)					
8-11 hours	241 (47.1)	381 (48.4)	ns	1.09	(0.84 - 1.43)
≥12 hours	132 (25.8)	167 (21.2)	<b>0.049</b>	<b>1.37</b>	<b>(1.00 - 1.86)</b>
<b>Predominant SW Pattern</b> (ref: Days)					
Nights	54 (10.5)	110 (14.0)	<b>0.007</b>	<b>0.60</b>	<b>(0.41 - 0.87)</b>
Rotating	61 (11.9)	107 (13.6)	ns	0.70	(0.48 - 1.00)
Other	190 (37.1)	318 (40.4)	<b>0.017</b>	<b>0.73</b>	<b>(0.57 - 0.94)</b>
<b>Food Preparation Facilities</b> (ref: Yes)					
Not Available at Work	248 (48.4)	367 (46.6)	ns	1.08	(0.86 - 1.35)
<b>Food Storage Facilities</b> (ref: Yes)					
Not Available at Work	210 (41.0)	306 (38.8)	ns	1.10	(0.87 - 1.37)
<b>Vending Machines</b> (ref: None)					
Available at Work	133 (26.0)	222 (28.2)	ns	1.12	(0.87 - 1.44)
<b>Break Times Adequate<sup>4</sup></b> (ref: Agree)					
Disagree	138 (31.9)	199 (29.2)	ns	1.14	(0.88 - 1.48)
<b>Satisfied with healthy food availability<sup>5</sup></b> (ref: Agree)					
Disagree	140 (37.9)	238 (42.5)	ns	0.83	(0.63 - 1.08)
<b>Workplace helps lead a healthy lifestyle<sup>6</sup></b> (ref: Agree)					
Disagree	196 (46.6)	300 (48.9)	ns	0.91	(0.71 - 1.17)
<b>Leisure Facilities</b> (ref: Yes)					
Not Available at Work	462 (90.2)	696 (88.3)	ns	1.22	(0.85 - 1.76)

BMI = Body Mass Index

Serv = Serving, yrs = years

\*P values <0.05 were deemed significant (denoted in bold font)

<sup>a</sup>According to the Food Safety Authority of Ireland dietary guidelines<sup>16</sup>

<sup>1</sup>Valid denominator = 1283

<sup>2</sup>Those categorised as 'Underweight' were excluded (n = 30)

OR, 95% CI = Odds Ratio, 95% Confidence Interval

<sup>3</sup>Some participants declined to respond (n = 57))

<sup>4</sup>Valid denominator = 1113

<sup>5</sup>Valid denominator = 929

<sup>6</sup>Valid denominator = 1035

**Supplementary Table 4: Univariable analysis of individual, shift work exposure and workplace environment factors and frequency of soft drink consumption<sup>a</sup> of participants (n = 1300)**

<u>Variables</u>	<u>≥1/week</u>	<u>&lt;1/week</u>	<u>p-value*</u>	<u>OR</u>	<u>95% CI</u>
	<u>(n = 487)</u>	<u>(n = 813)</u>			
	<u>n (%)</u>	<u>n (%)</u>			
<b>Gender</b> (ref: Female) Male	273 (56.1)	399 (49.1)	<b>0.015</b>	<b>1.32</b>	<b>(1.06 - 1.66)</b>
<b>Age Category</b> <sup>1</sup> (ref: 18-34 years)					
Middle-aged (35-54 years)	203 (42.4)	403 (50.1)	<b>&lt;0.001</b>	<b>0.50</b>	<b>(0.39 - 0.64)</b>
Older age (55-65 years)	31 (6.5)	156 (19.4)	<b>&lt;0.001</b>	<b>0.20</b>	<b>(0.13 - 0.30)</b>
<b>BMI</b> <sup>2</sup> (ref: Normal)					
Overweight/Obese	221 (55.8)	355 (51.9)	ns	1.17	(0.91 - 1.50)
<b>Socio-economic status</b> <sup>3</sup> (ref: ABC1)					
C2DE	245 (53.6)	398 (50.8)	ns	1.12	(0.89 - 1.41)
<b>Occupational Sector</b>					
(ref: Health & Social Work)					
Accommodation & Food	100 (20.5)	118 (14.5)	<b>0.001</b>	<b>1.79</b>	<b>(1.27 - 2.54)</b>
Retail	75 (15.4)	154 (18.9)	ns	1.03	(0.72 - 1.47)
Manufacturing	52 (10.7)	58 (7.1)	<b>0.004</b>	<b>1.90</b>	<b>(1.23 - 2.93)</b>
Other	146 (30.0)	242 (29.8)	ns	1.28	(0.94 - 1.73)
<b>Duration of SW Exposure</b> (ref: <8 years)					
≥8 years	205 (42.1)	473 (58.2)	<b>&lt;0.001</b>	<b>0.52</b>	<b>(0.42 - 0.66)</b>
<b>Average Shift Length</b> (ref: <8 hours)					
8-11 hours	241 (49.5)	381 (46.9)	ns	0.90	(0.67 - 1.17)
≥12 hours	90 (18.5)	209 (25.7)	<b>0.003</b>	<b>0.62</b>	<b>(0.45 - 0.85)</b>
<b>Predominant SW Pattern</b> (ref: Days)					
Nights	73 (15.0)	91 (11.2)	ns	1.42	(0.99 - 2.04)
Rotating	63 (12.9)	105 (12.9)	ns	1.06	(0.74 - 1.53)
Other	185 (38.0)	323 (39.7)	ns	1.01	(0.78 - 1.32)
<b>Food Preparation Facilities</b> (ref: Yes)					
Not Available at Work	233 (47.8)	382 (47.0)	ns	1.04	(0.83 - 1.30)
<b>Food Storage Facilities</b> (ref: Yes)					
Not Available at Work	186 (38.2)	330 (40.6)	ns	0.90	(0.72 - 1.14)
<b>Vending Machines</b> (ref: None)					
Available at Work	169 (34.7)	186 (22.9)	<b>&lt;0.001</b>	<b>1.79</b>	<b>(1.40 - 2.30)</b>
<b>Break Times Adequate</b> <sup>4</sup> (ref: Agree)					
Disagree	133 (31.6)	204 (29.5)	ns	1.11	(0.85 - 1.44)
<b>Satisfied with healthy food availability</b> <sup>5</sup> (ref: Agree)					
Disagree	160 (44.9)	218 (38.0)	<b>0.038</b>	<b>1.33</b>	<b>(1.02 - 1.74)</b>
<b>Workplace helps lead a healthy lifestyle</b> <sup>6</sup> (ref: Agree)					
Disagree	208 (54.0)	288 (44.3)	<b>0.003</b>	<b>1.48</b>	<b>(1.15 - 1.90)</b>
<b>Leisure Facilities</b> (ref: Yes)					
Not Available at Work	430 (88.3)	728 (89.5)	ns	0.88	(0.62 - 1.26)

BMI = Body Mass Index

\*P values <0.05 were deemed significant (denoted in bold font)

<sup>a</sup>According to the Food Safety Authority of Ireland dietary guidelines<sup>16</sup>

<sup>2</sup>Valid denominator = 1283

<sup>3</sup>Those categorised as 'Underweight' were excluded (n = 30)

OR, 95% CI = Odds Ratio, 95% Confidence Interval

<sup>5</sup>Some participants declined to respond (n = 57)

<sup>4</sup>Valid denominator = 1113

<sup>6</sup>Valid denominator = 929

<sup>7</sup>Valid denominator = 1035

**Supplementary Table 5: Univariable analysis of individual, shift work exposure and workplace environment factors and weekly physical activity levels<sup>a</sup> of participants (n = 1298)**

<u>Variables</u>	<u>≥150min/wk</u>	<u>&lt;150min/wk</u>	<u>p-value*</u>	<u>OR</u>	<u>95% CI</u>
	<u>(n = 509)</u>	<u>(n = 789)</u>			
	<u>n (%)</u>	<u>n (%)</u>			
<b>Gender</b> (ref: Female) Male	242 (47.5)	385 (48.8)	ns	1.05	(0.84 - 1.31)
<b>Age Category<sup>1</sup></b> (ref: 18-34 years)					
Middle-aged (35-54 years)	207 (41.2)	398 (51.2)	<b>&lt;0.001</b>	<b>0.62</b>	<b>(0.49 - 0.79)</b>
Older age (55-65 years)	73 (14.5)	114 (14.7)	ns	0.76	(0.54 - 1.08)
<b>BMI<sup>2</sup></b> (ref: Normal)					
Overweight/Obese	223 (50.1)	353 (55.6)	ns	0.80	(0.63 - 1.02)
<b>Socio-economic status<sup>3</sup></b> (ref: ABC1)					
C2DE	246 (49.5)	397 (53.4)	ns	0.86	(0.68 - 1.08)
<b>Occupational Sector</b> (ref: Health & Social Work)					
Accommodation & Food	100 (19.6)	118 (15.0)	<b>0.008</b>	<b>1.59</b>	<b>(1.13 - 2.25)</b>
Retail	90 (17.7)	138 (17.5)	ns	1.23	(0.87 - 1.73)
Manufacturing	37 (7.3)	73 (9.3)	ns	0.95	(0.61 - 1.50)
Other	159 (31.2)	229 (29.0)	ns	1.30	(0.97 - 1.76)
<b>Duration of SW Exposure</b> (ref: <8 yrs)					
≥8 years	246 (48.3)	431 (54.6)	<b>0.027</b>	<b>0.78</b>	<b>(0.62 - 0.97)</b>
<b>Average Shift Length</b> (ref: <8 hours)					
8-11 hours	253 (49.7)	369 (46.8)	ns	0.90	(0.70 - 1.17)
≥12 hours	93 (18.3)	205 (26.0)	<b>0.002</b>	<b>0.60</b>	<b>(0.44 - 0.82)</b>
<b>Predominant SW Pattern</b> (ref: Days)					
Nights	63 (12.4)	101 (12.8)	ns	0.89	(0.62 - 1.28)
Rotating	60 (11.8)	108 (13.7)	ns	0.79	(0.55 - 1.14)
Other	197 (38.7)	311 (39.4)	ns	0.90	(0.70 - 1.17)
<b>Food Preparation Facilities</b> (ref: Yes)					
Not Available at Work	235 (46.2)	379 (48.0)	ns	0.93	(0.74 - 1.16)
<b>Food Storage Facilities</b> (ref: Yes)					
Not Available at Work	195 (38.3)	319 (40.4)	ns	0.92	(0.73 - 1.15)
<b>Vending Machines</b> (ref: None)					
Available at Work	119 (23.4)	235 (29.8)	<b>0.012</b>	<b>0.72</b>	<b>(0.56 - 0.93)</b>
<b>Break Time Adequate<sup>4</sup></b> (ref: Agree)					
Disagree	113 (25.3)	223 (33.5)	<b>0.004</b>	<b>0.67</b>	<b>(0.52 - 0.88)</b>
<b>Satisfied with healthy food availability<sup>5</sup></b> (ref: Agree)					
Disagree	133 (37.9)	245 (42.5)	ns	0.83	(0.63 - 1.09)
<b>Workplace helps lead a healthy lifestyle<sup>6</sup></b> (ref: Agree)					
Disagree	179 (42.4)	317 (51.8)	<b>0.003</b>	<b>0.67</b>	<b>(0.53 - 0.88)</b>
<b>Leisure facilities</b> (ref: Yes)					
Not Available at Work	445 (87.4)	711 (90.1)	ns	0.76	(0.54 - 1.08)

BMI = Body Mass Index

Min/wk = Minutes per week, yrs = years

\*P values <0.05 were deemed significant (denoted in bold font)

<sup>a</sup>According to national and international physical activity guidelines<sup>25,26</sup>

<sup>2</sup>Valid denominator = 1281

<sup>6</sup>Those categorised as 'Underweight' were excluded (n = 30) (Valid denominator = 759)

OR, 95% CI = Odds Ratio, 95% Confidence Interval

<sup>3</sup>n = 57 participants declined to respond (Valid denominator = 864)

<sup>4</sup>Valid denominator = 1111

<sup>5</sup>Valid denominator = 928

<sup>6</sup>Valid denominator = 1034