

The factors influencing the eating behaviour of shiftworkers: what, when, where and why

Charlotte C. GUPTA^{1*}, Alison M. COATES², Jill DORRIAN¹ and Siobhan BANKS¹

¹Sleep and Chronobiology Laboratory, Behaviour Brain Body Research Centre, University of South Australia, Australia

²Alliance for Research in Exercise, Nutrition and Activity, University of South Australia, Australia

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Abstract: Shiftwork leads to altered eating patterns, with workers often eating foods at all times across the 24 h period. Strategies to reduce the burden of shiftwork on the workers should be prioritised and altering these eating patterns is an important area for change. This narrative review examines the current evidence on the individual and environmental factors influencing the eating behaviours of shiftworkers. A systematic search was conducted and yielded 62 articles. These were split into four themes that influence eating patterns; When shiftworkers eat, What type of foods shiftworkers eat, Where the food is sourced from, and Why shiftworkers choose to eat on shift. Irregular working hours was the biggest influence on when workers ate on shift, shift-type was the biggest influence on what workers ate, the majority of food was sourced from canteens and cafeterias, and socialising with colleagues was the biggest reason why workers chose to eat. While more research is needed to explore multiple industries and shift-types, and to investigate the ideal size, type and timing of food on shift, this review has highlighted that future research into shiftworker eating needs to adopt an integrative approach and consider the different individual and social contexts that influence eating patterns.

Key words: Shiftwork, Meal timing, Eating at night, Nightshift, Safety

Introduction

Shiftwork, characterised by working outside of regular daytime hours, is increasingly common in today's society¹. Having workers available 24 h a day is a requirement for many industries including healthcare, transport, mining and aviation. These industries require workers to complete important tasks across a 24 h schedule, including caring for patients and piloting aircrafts². In addition to shiftwork being an advantage for employers³, many work-

ers may work shiftwork due to factors such as the pay, the schedule allowing school or childcare, or because other work was not available for various reasons⁴. However there are a number of negative consequences of shiftwork that can impact the often safety critical tasks that workers are required to do⁵.

The health impacts of shiftwork have been widely researched, including the increased risk of metabolic disorders, insulin resistance, type 2 diabetes, obesity, and gastrointestinal disorders^{6–13}. Shiftwork is also associated with fatigue and performance impairments^{1, 14–16}, particularly at night when circadian and homeostatic processes typically promote sleep¹⁷. This has serious implications for the safety of shiftworkers, especially during the commute home from a nightshift which is at time of increased

*To whom correspondence should be addressed.
E-mail: Charlotte.Gupta@mymail.unisa.edu.au

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accident risk^{18–20}). Additionally, shiftwork is linked to high levels of stress, exhaustion, burnout, job dissatisfaction, absenteeism, presenteeism, and increased social and family conflict^{21–24}). These negative aspects of shiftwork have significant consequences for employers, employees and for the wider society. Research must prioritise strategies and countermeasures, at both the individual and environmental level, to reduce the burden of shiftwork.

Diet is a large contributor to both health²⁵) and performance^{26, 27}). The timing of eating has become an important area of research given that food intake has been shown, largely in studies of rodents, to be an external cue involved in entraining the circadian clock^{28–31}). Circadian clocks regulate metabolic processes, glucose homeostasis, gastrointestinal motility and digestive processes³²). It has been shown that eating food at times that contradict our circadian rhythms can therefore entrain rhythms in peripheral tissues, such as the liver²⁸), and lead to weight gain and obesity³³). This is particularly important to consider in shiftworkers, who are frequently disrupting food intake across the 24 h period^{7, 34}). This altered meal timing includes eating during the night^{10, 35}) which is problematic given that at night, the body is naturally primed for sleep¹) and we are eating at a time where we experience reduced glucose tolerance³⁶), reduced rates of gastric emptying³⁷) and changes in body temperature³⁸). Consequently, understanding and modifying the eating behaviours of shiftwork may play a key role in addressing the health risks associated with shiftwork³⁴).

Much of the discussion of shiftworker eating patterns to date has focussed on the effects of these eating patterns on metabolism and health³⁹). However, two significant reviews have demonstrated the large number of biological, social and cultural factors that influence eating patterns^{34, 40}), and these must be considered when understanding eating behaviour. These factors are at both the individual level, such as eating as a way to socialise with co-workers⁴¹) and at the organisational level, for example bringing in certain foods to eat due to a lack of storage options in the workplace⁴²). The current review aims to extend the scope of previous reviews by investigating the evidence on the range of individual and environmental factors that influence eating patterns at work, and to determine the interactions between these different factors. We will argue that a holistic approach is key, and demonstrating how these factors influence each other is important for identifying areas for further research and change. Further, this review aims to evaluate the evidence on these factors and identify differences among shift-types

and industries. It is important to identify similarities and differences across shift-types and industries given there are differences that may impact eating behaviours, such as work demand¹⁴), food availability⁴³), and social interaction on shift⁴⁴).

Method

Search methods

This is a scoping review with a systematic search (Fig. 1) and a narrative analysis. This approach overcomes the evidence bias that may be present in a narrative review⁴⁵). A literature search for relevant, peer-reviewed articles was conducted on March 7th 2018 using three databases (PubMed, PsycINFO and Scopus). Relevant search terms included “shift work”, “eating”, “meal timing”, “work”, “food”, and “night”. Repeating the search on July 5th 2018 did not return any articles not already identified in the initial search. On September 20th 2018 the search was repeated with the addition of the search terms “work schedule” and “health behaviour” to capture articles that may have considered eating behaviours in a broader measure of health behaviour. This led to the addition of seven articles to the final literature review. As shown in Fig. 1, the searches yielded 1,458 articles. Once duplicates were removed, 1,106 articles remained that were screened for eligibility. Articles were considered for this review if they were available in full text, were written in English, were conducted with human participants, were field studies (not laboratory-based), included shift-workers in the sample (shiftwork defined as work outside of typical daytime hours¹), including rotating shifts, split shifts, and fixed nightshifts, in order to capture eating patterns that may be conflicting with typical biological, social and cultural eating times), and presented information about dietary intake including description of the timing of food intake, food items, macronutrient content, where food is sourced from and reasons for eating (using quantitative or qualitative measures). Articles were included in the review regardless of the year of publication. As shown in Fig. 1, the number of articles that were excluded was 1,044. A total of 62 articles remained and were included in this literature review.

This review has an overview section, followed by results and discussion sections for each theme (What, When, Where and Why). Within each results section, a description of the studies including the measures used and the shift-types and industries included will be provided.

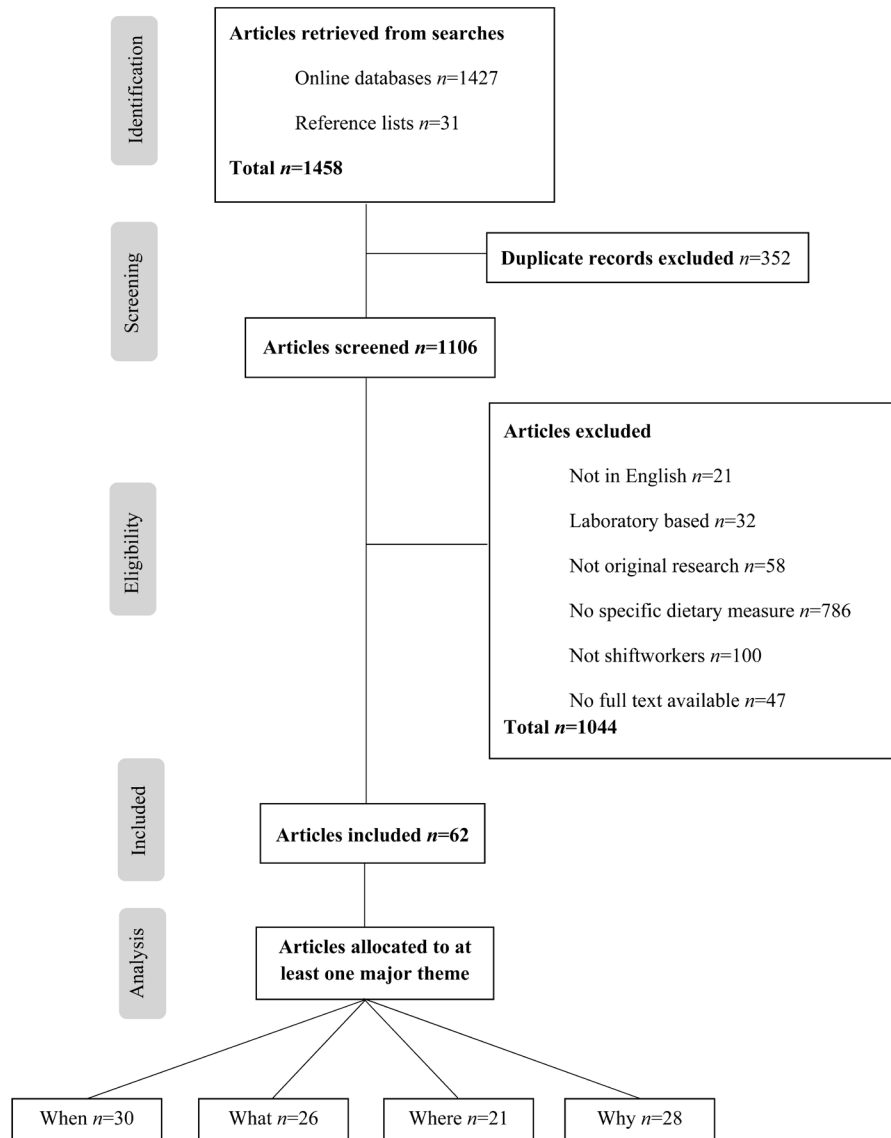


Fig. 1. Flow chart illustrating the systematic search for articles included in this review.

Results: Overview

Among the studies included in this review, there were a variety of industries, methodologies, countries and shift-types studied. Of the 62 articles included in this review, overall the healthcare industry was the most commonly studied ($n=30$). The studies included in this review included quantitative, cross-sectional designs ($n=30$), quantitative longitudinal study designs ($n=10$), qualitative, cross sectional ($n=14$), qualitative longitudinal ($n=3$), mixed-method, cross sectional ($n=4$) and mixed-method longitudinal ($n=1$). Although the studies included samples of rotating ($n=17$) and fixed shiftworkers ($n=20$; fixed day, morning, evening and night), a majority of the studies

included shiftwork samples but did not specify the shift-types worked ($n=24$). The most frequent method used to capture food habits and timing was questionnaires ($n=30$), and studies were most commonly conducted in Western populations ($n=38$). A majority of the samples included male and female shiftworkers ($n=28$), although the numbers were rarely even for both sexes. A range of shift schedules were sampled including rotating (a shift schedule where shift-type rotates according to a set schedule), nightshift, and day workers, however shift-type was not provided in all studies included.

Four major themes emerged from the results and these were: 1) When shiftworkers eat on shift, 2) What shiftworkers eat, 3) Where the food is sourced from, and

4) Why shiftworkers choose to eat on shift. Each of the articles was allocated to at least one of these themes; 30 articles were allocated to the theme of 'When' (Table 1), 26 articles to 'What' (Table 2), 21 articles to 'Where' (Table 3) and 28 articles to 'Why' (Table 4). Figure 2 shows the four themes of the review and each of the factors identified in the literature that influence each theme. The findings of each theme will be summarised and discussed

When Do Shiftworkers Eat?

Results

From the search of the literature, 30 articles were identified that explore when shiftworkers eat (Table 1). The key factors identified from these articles included, irregular working hours^{46–58}, break availability^{39, 42–44, 66}, family life^{39, 65, 67–71} and cultural influences⁷². Articles were published from 1972 to 2018, indicating that when shiftworkers eat has been an area of research for some years. In this theme, a majority of the samples were in the healthcare industry ($n=15$). This may be due to the size of the workforce and patient safety issues, in addition to the convenience of the sample. Two studies included multiple industries^{52, 66} and this approach allowed for comparisons across industries. As can be seen in Table 1, a questionnaire approach was the most common method used to capture when shiftworkers were eating ($n=12$). While a convenient and cost-effective method, the few studies that employed focus group and interview techniques allowed for greater description of the factors influencing these eating patterns. For example, one study used a focus group approach with air force security workers and their spouses, and this identified the large disruption of shiftwork to family eating patterns⁶⁸. There were both quantitative ($n=14$) and qualitative ($n=13$) articles included in this theme, and three mixed-methods studies^{44, 46, 71}. Three studies utilised a longitudinal method through the use of food-diaries^{53, 54} and logbooks⁶². The shift-types sampled included samples of rotating workers ($n=11$), fixed shift workers ($n=8$) and one study including a sample of on-call workers⁷¹. There were ten studies in which specific shift-types were not provided.

More research is needed to unpack differences across industries and shift-types, and longitudinal research on the effect of shiftwork experience on the timing of food consumption would also be beneficial.

Discussion

This section explores the theme of 'When shiftworkers report eating.' Those working during the day often consume a standard three meals per 24 h⁷⁵. However, shiftworkers, who are working irregular hours, have difficulty maintaining these regular eating patterns^{49, 76}. The first step in this review is to investigate what influences the timing of eating for shiftworkers.

Irregular working hours

Shiftworkers that follow a traditional western three meals a day routine may tend to eat a main meal during the night¹⁵. However there may be cultural differences, as only 21% of a sample of rotating nightshift workers in Korea reported three meals a day. Irregular work schedules and a lack of time may also impact when food is consumed on shift^{40, 50}. Rotating shiftworking nurses report more abnormal temporal eating patterns and unbalanced diets, compared to day working nurses⁵⁸. Likewise, mine workers working rotating shifts found it difficult to follow regular patterns of meal consumption⁵⁵. There is also evidence that nightshift workers may skip breakfast if they are on shift during the morning hours, and prioritise sleep when they get home rather than eating a meal⁵⁶ or may consume breakfast but at times outside of regular breakfast timing (outside of 6 am to 8:30 am)⁴⁷. The impact of irregular working hours on food consumption may also be influenced by hunger. There is a decrease in hunger during the night compared to during the day³⁴, as hunger displays an endogenous circadian rhythm and is decreased during the night⁷⁷, when homeostatic processes are promoting sleep¹. This may be a reason why some workers report not eating during a nightshift, compared to during the day³⁴. However, given that many shiftworkers are eating during the nightshift, there must be factors other than appetite that motivate them to eat, and this will be discussed in the discussion section for the theme of 'Why'.

Sex differences may play a part in these differences in meal timing⁷⁸. In a study of residential nursing home and hospital workers, the greatest amount of kilojoules per 24 h were eaten around lunchtime on rest days for male workers⁵⁴. On nightshift days, this was pushed to around 4 pm, as this is when shiftworkers were waking up. In contrast, female workers ate the greatest amount of kilojoules at 7 pm on both work and rest days, so shiftwork did not appear to disrupt meal timing⁵⁴. Moreover, in a study with night and day working employees, male nightshift workers were more likely to skip breakfast and female workers were more likely to skip lunch⁵². Notably, workers in this

Table 1. Summary of research on the first theme of the review, 'When shiftworkers eat during the nightshift', including the authors, participants, food related measure, key findings and the factor within this theme to which this article relates

Author(s), year	Country & Participant information	Study design	Shift-type	Industry	Eating behaviour methodology	Findings
1. 1 Irregular working hours						
Bonnell, Huggins, 2017 ⁴⁶⁾	Australia, 42 males and females	Mixed method, cross-sectional	Rotating	Firefighting	Focus groups and 24h dietary recalls	Shift-type influenced food intake. Participants stated that they would consume healthier foods on the day shift than on the nightshift and would consume more takeaway foods on nightshift.
De Freitas, Canuto, 2015 ⁴⁷⁾	Brazil, 1,206 males and females	Quantitative, cross-sectional	Fixed day and night-shifts	Poultry slaughterhouse	Diet questionnaire	Almost all nightshift workers reported eating breakfast at an inappropriate time.
Esquirol, Bongard, 2009 ⁴⁸⁾	France, 198 males	Quantitative, cross-sectional	Rotating and day	Chemical plant	Diet history questionnaire	Total energy consumption was comparable between different shift types but the energy distribution across the day differed amongst shift types.
Geliebter, Gluck, 2000 ⁴⁹⁾	USA, 85 male and females	Quantitative, cross-sectional	Day shift and evening/nightshift	Healthcare and security	Questionnaire	Late-shift workers reported fewer meals compared to day-shift workers.
Han, Choi-Kwon, 2016 ⁵⁰⁾	Korea, 240 females	Quantitative, cross-sectional	Rotating and fixed	Healthcare	Questionnaire	Nurses who worked rotating schedules with nightshifts had irregular meals more often than rotating schedule workers without nightshifts. Among nurses with a rotating schedule with nightshifts, only 21% had 3 meals per day. The most common reasons for skipping meals were irregular work schedules and lack of time.
Kräuchi, Nussbaum, 1990 ⁵¹⁾	Switzerland, 28 males and females	Quantitative, cross-sectional	Nightshift	Healthcare	Daily food and drink frequency questionnaire	The content of meals did not change on different shifts, but the timing of food intake changed.
Lasfargues, Caccès, 1996 ⁵²⁾	France, 2,400 males and females	Quantitative, cross-sectional	Day shift and nightshift	Middle management, employee (including nursing staff), worker, police/army, other (including service)	Questionnaire	Men were more likely to skip breakfast during the nightshift.
Pasqua and Moreno, 2004 ⁵³⁾	Brazil, 28 males	Quantitative, longitudinal	Fixed morning, fixed afternoon and fixed nightshifts	Transport	3-d dietary record	The season of the year impacts the eating habits of shiftworkers. Food consumption was greater in winter compared to summer.
Reeves, Newling-Ward, 2004 ⁵⁴⁾	UK, 36 males and females	Quantitative, longitudinal	Nightshift and day-shift	Healthcare	6-d food diary	Timing of meals differs on work days to non-work days.
Strzemecka, Bojar, 2014 ⁵⁵⁾	Poland, 700 males and females	Quantitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Mine workers	Questionnaire	46.3% of respondents considered their eating habits as inappropriate, 68.2% cited shiftwork as the reason for their irregular nutrition habits. Shiftwork made it difficult to follow regular consumption of meals for 66% of the sample.

Table 1 continued

Author(s), year	Country & Participant information	Study design	Shift-type	Industry	Eating behaviour methodology	Findings
Sudo and Ohtsuka, 2001 ⁵⁶⁾	Japan, 1,37 males and females	Quantitative, cross-sectional	Rotating and fixed day shift	Computer factory	Questionnaire	Late workers had lower energy and nutrient intake compared to daytime workers. Late workers had lower daily energy from breakfast, the authors suggest that this indicates that breakfast was skipped.
Takagi, 1972 ⁵⁷⁾	Japan, 1,335 males and females	Quantitative, cross-sectional	Rotating	Textile factory, iron works and a chemical factory	Questionnaire	Nightshift workers reported eating 4 meals on nightshift days. In both factories, a meal was eaten during the nightshift.
Yoshizaki, Kawano, 2016 ⁵⁸⁾	Japan, 285 females	Quantitative, cross-sectional	Rotating and fixed day shift	Healthcare	Questionnaire	An increase in improper eating habits and a higher probability of obesity was found for rotating shiftworkers compared to day workers.
1.2 Break availability						
Anstey, Tweedie, 2016 ⁴²⁾	Australia, 15 males and females	Qualitative, cross-sectional	Rotating	Healthcare (paramedics)	Interviews	Breaks were often interrupted for an emergency call out, or not available at all due to a heavy workload. Eating events were seen as opportunistic. Paramedics reported that an increased workload led to a greater incidence of disrupted or missed meal breaks.
Faugier, Lancaster, 2001 ⁴³⁾	England, 126 participants (sex of participants not provided)	Quantitative, cross-sectional	Specific shift type(s) not provided	Healthcare	Questionnaire	Participants cited a lack of breaks as a barrier to healthy eating and were unable to take sufficient breaks due to workload.
Grifkins, Johnston, 2018 ⁷³⁾	21 females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Interviews	Participants reported skipping meals due to increased workload.
Jack, Piacentini, 1998 ⁴⁴⁾	Scotland, 46 males and females	Mixed method, cross-sectional	Variable shift patterns (specific shift type(s) not provided)	Transport	Focus group (n=6) and repertory grid method sessions where individual questionnaires on specific food use were generated and completed	Drivers report choosing to eat when convenient and when there was time available.
Keogh, 2014 ⁵⁹⁾	England, approximately 3500 participants (specific sample size and participant sex not provided)	Quantitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Questionnaire	The walk to the canteen is time-consuming and limits food options. After walking to the canteen to get food there is not a lot of time left in the break to eat it.

Table 1 continued

Author(s), year	Country & Participant information	Study design	Shift-type	Industry	Eating behaviour methodology	Findings
Lemaire, Wallace, 2011 ⁽⁶³⁾	Canada, 20 males and females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Semi-structured interviews	Doctors were concerned about not enough time during the work day to eat, and that workload and work schedule prevents them from taking breaks to eat. There is also not enough time to walk to purchase something to eat.
Monaghan, Dinour, 2018 ⁽⁶⁵⁾	USA, 20 females	Qualitative, cross-sectional	Rotating, fixed day shift, fixed nightshift	Healthcare	Interviews	All participants reported that they were unable to take their full breaks, largely due to prioritizing patient care. 85% of the participants reported taking a break affected their eating habits and 75% attributed taking a break to healthier eating.
Nea, Pourshahidi, 2017 ⁽⁷⁴⁾	Ireland, 109 males and females	Qualitative, cross-sectional	Rotating, fixed day shift, fixed nightshift	Accommodation and food services, health and social care sector, manufacturing/industry sector	Focus groups	A lack of a consistent routine and erratic work schedule were perceived as one of the most difficult aspects of shiftwork, as well as a demanding environment with a lack of breaks and heavy workload.
Nyberg and Lennemäs Wiklund, 2017 ⁽⁶⁰⁾	Denmark and Sweden, 20 males and females	Qualitative, cross-sectional	Short- and long-haul flights	Aviation (flight attendants)	Interviews	Meals at work were characterised by irregularity and involved eating in a hurry and often standing up. Meals were unpredictable with regard to time, place and food available. Eating during short-haul flights was described as stressful and time-pressured.
Phiri, Draper, 2014 ⁽⁶¹⁾	South Africa, 102 participants (participant sex not provided)	Qualitative, cross-sectional	Nightshift, dayshift and non-shiftworkers	Healthcare	Focus group	Nurses reported a lack of time to prepare healthy meals, due to long working hours and being over-tired.
Rogers, Hwang, 2004 ⁽⁶²⁾	USA, 393 males and females	Quantitative, longitudinal	Shiftwork (specific shift type(s) not provided)	Healthcare	Log books	Nurses were able to have a break, free of patient care responsibilities on less than half of the shifts worked. During 10% of the shifts, nurses had no opportunity to break and on 43% of the shifts nurses had time for a break but were not relieved from patient care responsibilities.
Strickland, Eyley, 2015 ⁽⁶⁶⁾	USA, 102 males and females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare and retail	Focus group	Schedules and breaks were reported as having an impact on the healthy eating of workers. Short and interrupted breaks made it difficult to eat healthy.
Torquati, Kolbe-Alexander, 2016 ⁽⁶⁴⁾	Australia, 17 males and females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Focus groups	A lack of breaks were reported as common, particularly during the nightshift, and this led to poor food choices. The work demands made it challenging to find time to take a break and this led to overeating as nurses would eat as much as they could when given the opportunity to take a break.

Table 1 continued

Author(s), year	Country & Participant information	Study design	Shift-type	Industry	Eating behaviour methodology	Findings
1.3 The interaction between shiftwork and family life on meal timing						
Atia, Mustafa, 1985 ⁶⁷	Kuwait, 40 males	Quantitative, cross-sectional	Rotating	Police	Food intake checklist	Fewer meals were eaten with family when working shiftwork compared to days off.
Jay, Paterson, 2018 ⁷¹	Australia, 24 females	Mixed method, cross-sectional	On-call workers (salaried and volunteer)	Emergency services	Interview	Participants reported that they may be called to a job in the middle of family dinner and pre-planning of meals was done to make the disruption of on-call work easier.
Hertz and Charlton, 1989 ⁶⁸	USA, 44 males and their female spouses	Qualitative, cross-sectional	Rotating	Air force security	Interviews	Shiftwork disrupts the regular diurnal pattern of family life and shifts the timing of family meals.
Knifin, Wansink, 2015 ⁶⁹	USA, specific sample size and participant sex not provided	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Firefighting	Semi-structured group interviews	Nightshifts started at 6pm and some firefighters, particularly those married, reported eating dinner at home with their wife and/or family and then again at the firehouse.
Monaghan, Dinour, 2018 ⁶⁵	USA, 20 females	Qualitative, cross-sectional	Rotating, fixed day shift, fixed nightshift	Healthcare	Interviews	Work hours typically conflicted with their families' eating habits on non-work days.
Naweed, Chapman, 2017 ⁷⁰	Australia, 29 males and females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Train drivers	Focus group	Time pressures and misalignment with shiftwork and life schedules prevent the ability to eat meals at times that suited the participants and their family.
Nea, Kearney, 2015 ³⁹	Ireland, 109 males and females	Qualitative, cross-sectional	Rotating, fixed day shift, fixed nightshift	Accommodation and food services, health and social care sector, manufacturing/industry sector	Focus groups	Difficulties with time management were reported, with workers experiencing pressures from the workplace and at home.

The table is organised by factor.

Studies may appear multiple times in the table as the findings address more than one factor.

Table 2. Summary of research on the second theme of the review, 'What shiftworkers eat during the nightshift', including the authors, participants, food related measure, key findings and the factor within this theme to which this article relates

Author(s), year	Country & Participant information	Study design	Shift-type	Industry	Eating behaviour methodology	Findings
2.1. Meal Size						
Bonnell, Huggins, 2017 ⁴⁶⁾	Australia, 42 males and females	Mixed method, cross-sectional	Rotating	Firefighting	Focus groups and 24 h dietary recalls	On nightshifts a greater proportion of snacks were consumed (chocolates, ice-cream, sweet pastries).
De Freitas, Canuto, 2015 ⁴⁷⁾	Brazil, 1,206 males and females	Quantitative, cross-sectional	Fixed day and nightshifts	Poultry slaughterhouse	Diet questionnaire	Nightshift workers report greater incidence of snacking during the afternoon and less breakfast and morning snack consumption.
Gander, Gregory, 1998 ⁹¹⁾	USA, 74 males	Observational, longitudinal	Shiftwork (short-haul flights)	Aviation	Observational monitoring	More snacks were eaten on shift than pre-shift or post-shift. The provision of crew meals did not affect the number of meals or snacks eaten on shift.
Gander, Gregory, 1998 ⁹²⁾	USA, 34 males and females	Observational, longitudinal	Shiftwork (8-d trip patterns)	Aviation	Observational monitoring	More snacks reported on duty days than pre-shift, post-shift or days off.
Grifkins, Johnston, 2018 ⁷³⁾	21 females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Interviews	Nurses reported more snacking behaviour during shiftwork, particularly nightshifts. Most of the participants believed their diets had changed since starting shiftwork, with some reporting less healthy diets since starting shiftwork.
Han, Choi-Kwon, 2016 ⁵⁰⁾	Korea, 240 females	Quantitative, cross-sectional	Rotating and fixed	Healthcare	Questionnaire	Rotating nurses with night shifts snacked the most frequently, whereas rotating nurses without nightshifts snacked mostly in the afternoon.
Haus, Reimberg, 2016 ⁸⁹⁾	France, 7 males	Quantitative, longitudinal	Rotating and non-shiftwork	Oil refinery	56-d food diary	Nibbling behaviour occurred during the nightshift, and included sweet foods and carbohydrate consumption.
Holmes, Power, 1996 ⁹³⁾	USA, 63 males and females	Quantitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Transport	Questionnaire on health and nutrition habits	On weekdays, most drivers ate a dinner meal while on the road, and snacks were also frequently eaten.
Lennerås, Åkerstedt, 1994 ⁸⁴⁾	Sweden, 22 males	Quantitative, longitudinal	Rotating	Industrial factory workers	24 h dietary recall	Across morning, afternoon and night shifts, total 24 h energy intake did not differ. On the nightshift 30–40% of 24 h energy intake was consumed, compared to 40–50% of intake consumed on morning and afternoon shifts.
Novak and Auvil-Novak, 1996 ⁴¹⁾	USA, 45 females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Focus group	Working the nightshift made it harder to eat nutritionally balanced meals and meal splitting was utilised to maintain a balanced diet. Some nurses refrained from eating while on shift.

Table 2 continued

Author(s), year	Country & Participant information	Study design	Shift-type	Industry	Eating behaviour methodology	Findings
Reeves, Newling-Ward, 2004 ⁵⁴	UK, 36 males and females	Quantitative, longitudinal	Nightshift and day-shift	Healthcare	6-d food diary	On work days, male shiftworkers ate the greatest amount of kilojoules at 4 pm, compared to 1 pm on rest-days. Female food intake peaked at 7 pm on both work and rest days and when working the nightshift they were more likely to eat during the night and less during the day.
Sahu and Dey, 2011 ⁹⁴	India, 75 participants (sex of participants not provided)	Quantitative, cross-sectional	Rotating	Healthcare	Questionnaire on shiftwork, digestive problems, food habits, food intake, ratings of eating satisfaction and appetite, and diet surveys	The number of full meals eaten during the nightshift was less than eaten during morning and afternoon shifts, and the number of snacks was greater during the nightshift.
Torquati, Kolbe-Alexander, 2016 ⁶⁴	Australia, 17 males and females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Focus groups	Working the nightshift was considered by nurses to be one of the major barriers for following a healthy diet. Irregular meal patterns resulted from nightshifts.
2.2. Type of food						
Balheiro, Rossato, 2014 ⁹⁵	Brazil, 150 males	Quantitative, cross-sectional	Fixed nightshift and dayshift	Transport (bus drivers)	Food frequency questionnaire	Nightshifts were associated with greater vegetable, fruit, milk and dairy product and dessert intake.
Bonnell, Huggins, 2017 ⁴⁶	Australia, 42 males and females	Mixed method, cross-sectional	Rotating	Firefighting	Focus groups and 24 h dietary recalls	Total energy intake did not differ between day or nightshifts. During a 24h period that included nightshift a higher % of energy was from sugar than during a 24h period with a day shift.
De Assis, Nahas, 2003 ⁸³	Brazil, 66 participants (sex of participants not provided)	Quantitative, longitudinal	Fixed nightshift and dayshift	Garbage collectors	24 h recall and two 24 h records of food intake	A traditional Brazilian meal was provided to workers during the nightshift, this consisted of meat, rice, beans, roots and/or pulses, vegetables and fruit). Meat was the biggest contributor to daily energy intake across different shift types.
Fernandes Jda, Portela, 2013 ⁹⁶	Brazil, 2,279 males and females	Quantitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Health questionnaire	Male nurses reported greater consumption of fried foods and lower consumption of fruit and vegetables compared to the female nurses. For female nurses, longer working hours was associated with greater consumption of fried foods.

Table 2 continued

Author(s), year	Country & Participant information	Study design	Shift-type	Industry	Eating behaviour methodology	Findings
Fisher, Rutishauser, 1986 ⁹⁷⁾	Australia, 25 males	Mixed-method, longitudinal	Rotating	Oil refinery workers	Interviews during one nightshift, one afternoon shift and one day shift, and 24 h food record	On nightshifts, milk/milk products, non-alcoholic beverages and yellow and green vegetables were consumed more frequently than on other shift types.
Han, Choi-Kwon, 2016 ⁹⁸⁾	Korea, 240 females	Quantitative, cross-sectional	Rotating and fixed	Healthcare	Questionnaire	Of the sample, 76% of nurses reported having a healthy dietary intake. 30% of nurses ate high carbohydrates snacks every day.
Haus, Reinberg, 2016 ⁸⁹⁾	France, 7 males	Quantitative, longitudinal	Rotating and non-shiftwork	Oil refinery	56-d food diary	No differences between the groups in caloric intake, protein, lipids and carbohydrates. Lower intake of fat and greater carbohydrate consumption during a nightshift compared to a day shift.
Heath, Coates, 2016 ⁹⁹⁾	Australia, 118 males and females	Quantitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Printing, postal, nursing, oil and gas industries	Food frequency questionnaire	Permanent night workers were the only group to report higher than recommended fat intake. All workers reported lower than recommended levels of carbohydrate, and protein was in the recommended levels (as a percentage of daily intake).
Hemö, Puttonen, 2015 ⁷⁸⁾	Finland, 1,478 males and females	Quantitative, cross-sectional	Shiftwork and non-shiftwork	Aviation	Food intake questionnaire	Male and female in-flight workers used high-fat milk products more than the day workers. For males, estimated energy intake from fat and saturated fat was the highest in the shift work group and lowest in the in-flight group. For females, energy intake from saturated fat was higher among shift workers compared with day workers. In shift-working men who did not work nightshifts, sucrose intake was lower compared with men who worked at least three nights per month.
Holmes, Power, 1996 ⁹³⁾	USA, 63 males and females	Quantitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Transport	Questionnaire on health and nutrition habits	The drivers' favourite meals were steak and burgers, and the preferred snacks were chips and fruit.
Kräuchi, Nussbaum, 1990 ⁵¹⁾	Switzerland, 28 males and females	Quantitative, longitudinal	Fixed nightshift	Healthcare	Daily food and drink frequency questionnaire	Total food intake and overall sweets intake did not change across different shift types. Caffeine rich drinks and milk intake were consumed more during the nightshift.
Lennerås, Hambreus, 1995 ⁸⁵⁾	Sweden, 96 males	Quantitative, longitudinal	Rotating and day shift	Industrial factory workers	24 h dietary recall	Shiftwork did not affect the 24h intake of energy and nutrients but caused a redistribution of food intake. For three-shift workers, the intake of energy, protein, total carbohydrates, sucrose, total fat, calcium and selenium were significantly lower during nightshifts compared to afternoon shifts.

Table 2 continued

Author(s), year	Country & Participant information	Study design	Shift-type	Industry	Eating behaviour methodology	Findings
Morikawa, Miura, 2008 ⁽¹⁰⁾	Japan, 2,254 males	Quantitative, cross-sectional	Rotating	Factory workers	Questionnaire	No difference in macronutrients consumed among different shift types.
Mota, De-Souza, 2013 ⁽⁸⁶⁾	Brazil, 72 males and females	Quantitative, longitudinal	Shiftwork (specific shift type(s) not provided)	Healthcare	Dietary recall	Data evaluated using the adapted healthy eating index. The average overall score of residents was 82.6, indicating the diet needs improvement.
Mota, Waterhouse, 2014 ⁽⁸⁷⁾	Brazil, 72 males and females	Quantitative, longitudinal	Shiftwork (specific shift type(s) not provided)	Healthcare	Dietary recall	A shorter duration of sleep was associated with a greater intake of cereals, meat and cholesterol. Poorer sleep quality was associated with increased hours of additional work per week and a decrease in fruit and bean consumption.
Roskoden, Krüger, 2017 ⁽⁸⁸⁾	Germany, 44 males and females	Quantitative, longitudinal	Rotating and non-shiftwork	Healthcare	Food diary	Total energy intake was similar between the shiftwork and non-shiftworking groups. There was a higher percentage of fat intake among the office staff compared to the shiftworking and non-shiftworking nurses. The percentage of carbohydrate intake was less in the office group compared to shiftworking nurses.
Sahu and Dey, 2011 ⁽⁹⁴⁾	India, 75 participants (sex of participants not provided)	Quantitative, cross-sectional	Rotating	Healthcare	Questionnaire on shiftwork, digestive problems, food habits, food intake, ratings of eating satisfaction and appetite, and diet surveys	When working the nightshift, the mean energy intake of carbohydrate, protein and fat were less than other shift types.
Zapka, Lemon, 2009 ⁽¹⁰¹⁾	USA, 194 males and females	Quantitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Food frequency questionnaire	Participants consumed less servings of fruit and vegetables per day than government guidelines and had a higher average percentage of calories from fat compared to government guidelines. Overweight participants reported fewer fruit and vegetable servings as those who perceived themselves as just right or underweight.

The table is organised by factor.

Studies may appear multiple times in the table as the findings address more than one factor.

Table 3. Summary of research on the third theme of this review, 'Where shiftworkers source food from during the nightshift', including the authors, participants, food related measure, key findings and the factor within this theme to which this article relates

Author(s), year	Country & Participant information	Study design	Shift-type	Industry	Eating behaviour methodology	Findings
3.1 Canteen/Cafeteria						
Faugier, Lancaster, 2001 ⁽⁴³⁾	England, 126 participants (sex of participants not provided)	Quantitative, cross-sectional	Specific shift type(s) not provided	Healthcare	Questionnaire	Nurses were not satisfied with hospital catering facilities.
Lemaire, Wallace, 2011 ⁽⁶³⁾	Canada, 20 males and females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Semi-structured interviews	Doctors reported that the after-hours access to canteen services was limited. Canteens were too far away for some wards and lining up for food took too long.
Monaghan, Dinour, 2018 ⁽⁶⁵⁾	USA, 20 females	Qualitative, cross-sectional	Rotating, fixed day shift, fixed nightshift	Healthcare	Interviews	The cafeterias offered healthy options, however 60% of the sample reported there was not enough time to eat there.
Novak and Auwil-Novak, 1996 ⁽⁴¹⁾	USA, 45 females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Focus group	The closing of the hospital cafeteria limited food choice availability.
Phiri, Draper, 2014 ⁽⁶¹⁾	South Africa, 102 participants (participant sex not provided)	Qualitative, cross-sectional	Nightshift, dayshift and non-shiftworkers	Healthcare	Focus group	Buying fast food was considered the most convenient option. The cafeteria was closed at night, but day shift nurses agreed that the cafeteria had predominantly unhealthy food options, and while there were some healthier options (such as fruits and salads) these were more expensive.
Stewart and Wahlqvist, 1985 ⁽⁰⁴⁾	Australia, 267 males and females	Quantitative, cross-sectional	Fixed day, afternoon and nightshifts	Steel and aluminium plants	Questionnaire	Food was purchased from the canteen by a greater proportion of workers on day shift than on nightshift.
Sudo and Ohtsuka, 2001 ⁽⁵⁶⁾	Japan, 137 males and females	Quantitative, cross-sectional	Rotating and fixed day shift	Computer factory	Questionnaire	A large majority of the workers had dinner at the cafeteria but there was dissatisfaction with the menu.
Waterhouse, Buckley, 2003 ⁽⁷⁵⁾	United Kingdom, 93 males and females	Quantitative, cross-sectional	Fixed nightshift and non-shiftworkers	Healthcare	Food intake questionnaire	During the nightshift the canteen was open but had limited food options.
3.2 Workplace provides meals						
De Assis, Nahas, 2003 ⁽⁸³⁾	Brazil, 66 participants (sex of participants not provided)	Quantitative, longitudinal	Fixed nightshift and dayshift	Garbage collectors	24 h recall and two 24 h records of food intake	A traditional Brazilian meal was provided to workers during the nightshift.
Gander, Gregory, 1998 ⁽⁹²⁾	USA, 34 males and females	Observational, longitudinal	Shiftwork (8-d trip patterns)	Aviation	Observational monitoring	Some airlines provide crew meals in flight.
Nea, Kearney, 2015 ⁽³⁹⁾	Ireland, 109 males and females	Qualitative, cross-sectional	Rotating, fixed day shift, fixed nightshift	Accommodation and food services, health and social care sector, manufacturing/industry sector	Focus groups	In the accommodation and food services sector, meals were provided at the workplace.

Table 3 continued

Author(s), year	Country & Participant information	Study design	Shift-type	Industry	Eating behaviour methodology	Findings
3.3 Vending machines						
Faugier, Lancaster, 2001 ⁽⁴³⁾	England, 126 participants (sex of participants not provided)	Quantitative, cross-sectional	Specific shift type(s) not provided	Healthcare	Questionnaire	The majority of participants used vending machines at work.
Keogh, 2014 ⁽³⁹⁾	England, approximately 3,500 participants (specific sample size and participant sex not provided)	Quantitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Questionnaire	Only 3 in 10 respondents rated the quality of food offered at their workplace as good or excellent. 20% of respondents reported they have a ready meal or vending machine snack at work once or twice a week and 7% had snacks or microwave meals up to 4 times a week. To improve healthy eating habits, nurses called for vending machines to be stocked with healthier options (nuts, fruit, low-sugar drinks).
Lillehoj, Nothwehr, 2015 ⁽¹⁰⁵⁾	USA, 333 males and females	Quantitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Manufacturing	Vending machine intervention to increase healthy food options and a pre-intervention and post-intervention survey	Across the 4 worksites, vending machine snack purchase increased post-intervention. Some worksites increased and some decreased in satisfaction with vending machines post-intervention.
3.4 Food from home						
Stewart and Wahlqvist, 1985 ⁽¹⁰⁴⁾	Australia, 267 males and females	Quantitative, cross-sectional	Fixed day, afternoon and nightshifts	Steel and aluminium plants	Questionnaire	Afternoon and night shift workers used the vending machines.
Waterhouse, Kao, 2006 ⁽¹⁰⁷⁾	United Kingdom, 93 males and females	Quantitative, cross-sectional	Fixed nightshift and non-shiftworkers	Healthcare	Food intake questionnaire	Vending machines were utilised frequently at night.
Anstey, Tweedie, 2016 ⁽⁴²⁾	Australia, 15 males and females	Qualitative, cross-sectional	Rotating	Healthcare (paramedics)	Interviews	An ambulance has a lack of facilities to store and prepare food, leading to paramedics bringing in transportable, pre-packaged, non-perishable foods on shift.
Bonnell, Huggins, 2017 ⁽⁴⁶⁾	Australia, 42 males and females	Mixed method, cross-sectional	Rotating	Firefighting	Focus groups and 24 h dietary recalls	Workers tended to bring food from home to cook communally and eat on shift or purchase takeaway.
Fisher, Rutishauser, 1986 ⁽⁹⁷⁾	Australia, 25 males	Mixed-method, longitudinal	Rotating	Oil refinery workers	Interviews during one nightshift, one afternoon shift and one day shift, and 24 h food record	Facilities to prepare meals were available on shift and a range of food was brought to work to consume. The canteen was only open during day and afternoon shifts.

Table 3 continued

Author(s), year	Country & Participant information	Study design	Shift-type	Industry	Eating behaviour methodology	Findings
Jack, Piacentini, 1998 ⁴⁴⁾	Scotland, 46 males and females	Mixed method, cross-sectional	Variable shift patterns (specific shift type(s) not provided)	Transport	Focus group ($n=6$) and repertory grid method sessions where individual questionnaires on specific food use were generated and completed	Food was brought from home.
Lemaire, Wallace, 2011 ⁶³⁾	Canada, 20 males and females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Semi-structured interviews	There were inadequate storage facilities for items brought from home.
Naweed, Chapman, 2017 ⁷⁰⁾	Australia, 29 males and females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Train drivers	Focus group	Participants felt it important to plan ahead and bring food onto shift, however factors such as roster changes, fatigue and the need to sleep often prevented this.
Nea, Kearney, 2015 ³⁹⁾	Ireland, 109 males and females	Qualitative, cross-sectional	Rotating, fixed day shift, fixed nightshift	Accommodation and food services, health and social care sector, manufacturing/industry sector	Focus groups	There were inadequate facilities for storing foods from home.
Novak and Auvil-Novak, 1996 ⁴¹⁾	USA, 45 females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Focus group	Nurses had readily available or pre-prepared food from home to consume on shift.
Nyberg and Lennemäs Wiklund, 2017 ⁶⁰⁾	Denmark and Sweden, 20 males and females	Qualitative, cross-sectional	Short- and long-haul flights	Aviation (flight attendants)	Interviews	The lack of adequate storage facilities was a barrier to bringing food from home. Bringing in canned food or smaller snacks such as raisins, nuts and fruits were more convenient to store and did not require heating.
Stewart and Wahlqvist, 1985 ¹⁰⁴⁾	Australia, 267 males and females	Quantitative, cross-sectional	Fixed day, afternoon and nightshifts	Steel and aluminium plants	Questionnaire	For all shift types, most food is brought from home.
3.5 Take-away						
Anstey, Tweedie, 2016 ⁴²⁾	Australia, 15 males and females	Qualitative, cross-sectional	Rotating	Healthcare (paramedics)	Interviews	To save time on shifts without set meal breaks, paramedics would choose to purchase take-away foods if their colleague was also purchasing take-away foods.
Jack, Piacentini, 1998 ⁴⁴⁾	Scotland, 46 males and females	Mixed method, cross-sectional	Variable shift patterns (specific shift type(s) not provided)	Transport	Focus group ($n=6$) and repertory grid method sessions where individual questionnaires on specific food use were generated and completed	On shift, food was mainly sourced from motor service areas, truck stops and filling stations.

Table 3 continued

Author(s), year	Country & Participant information	Study design	Shift-type	Industry	Eating behaviour methodology	Findings
Naweed, Chapman, 2017 ⁷⁰	Australia, 29 males and females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Train drivers	Focus group	There were few outlets available at night offering healthy food options. This commonly led to purchasing convenient options from the service stations.
Nea, Pourshahidi, 2017 ⁷⁴	Ireland, 109 males and females	Qualitative, cross-sectional	Rotating, fixed day shift, fixed nightshift	Accommodation and food services, health and social care sector, manufacturing/industry sector	Focus groups	For health and social care workers, there was a lack of canteen facilities at nights/weekends.
3.6 Break area						
Cheung, 2003 ¹⁰⁶	United Kingdom, 128 participants (sex of participants not provided)	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Questionnaire	Participants consumed an average of 5.4 chocolates that were in the ward per day. In the sample, 43% felt guilty about eating so many chocolates and felt the need to reduce their intake.
Monaghan, Dinour, 2018 ⁶⁵	USA, 20 females	Qualitative, cross-sectional	Rotating, fixed day shift, fixed nightshift	Healthcare	Interviews	Of the sample, 75% reported that food donated from patients' families was high in sugar and fat, and often the only option in the break room. The most donated foods included donuts, cookies and cakes.
Torquati, Kolbe-Alexander, 2016 ⁶⁴	Australia, 17 males and females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Focus groups	Nurses reported that the quality of the food eaten was influenced by the food available in the hospital wards, such as chocolates. Nurses would continuously snack on these because they were available and accessible. If healthier options were available at work then they felt they would make better food choices.

The table is organised by factor.

Studies may appear multiple times in the table as the findings address more than one factor.

Table 4. Summary of research on the fourth theme of this review, 'Why shiftworkers choose to eat during the nightshift', including the authors, participants, food related measure, key findings and the factor within this theme to which this article relates

Author(s), year	Country & Participant information	Study design	Shift-type	Industry	Eating behaviour methodology	Findings
4.1 Time available						
Bonnell, Huggins, 2017 ⁽⁴⁶⁾	Australia, 42 males and females	Mixed method, cross-sectional	Rotating	Firefighting	Focus groups and 24 h dietary recalls	Shift schedule was a main influence on dietary intake.
Holmes, Power, 1996 ⁽⁹³⁾	USA, 63 males and females	Quantitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Transport	Questionnaire on health and nutrition habits	Drivers ate their main meals on the road and food choice was influenced by factors such as convenience, cost and time.
Persson and Mårtensson, 2006 ⁽¹⁹⁾	Sweden, 27 males and females	Qualitative, cross-sectional	Fixed nightshift	Healthcare	Interviews analysed with the critical incident technique	Leisure-related factors (eg don't have the time to prepare healthy food) influence the choice to eat on shift.
Waterhouse, Buckley, 2003 ⁽⁷⁵⁾	United Kingdom, 93 males and females	Quantitative, cross-sectional	Fixed nightshift and non-shiftworkers	Healthcare	Food intake questionnaire	On work days the reasons for eating were schedule, with a decrease in citing social and hunger as reasons. The reason determining the type of food eaten was time available significantly more on workdays. When eating during the nightshift, hunger motivated workers less and habit motivated them more.
4.2 Eating with colleagues						
Anstey, Tweedie, 2016 ⁽⁴²⁾	Australia, 15 males and females	Qualitative, cross-sectional	Rotating	Healthcare (paramedics)	Interviews	Psychosocial factors influenced food choice.
Bonnell, Huggins, 2017 ⁽⁴⁶⁾	Australia, 42 males and females	Mixed method, cross-sectional	Rotating	Firefighting	Focus groups and 24 h dietary recalls	The attitudes and decisions of co-workers influenced dietary intake.
Kniffin, Wansink, 2015 ⁽⁶⁹⁾	USA, specific sample size and participant sex not provided	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Firefighting	Semi-structured group interviews	Participants reported a strong tradition of eating and cooking together. A significant correlation was found between work-group performances and eating.
Persson and Mårtensson, 2006 ⁽¹⁹⁾	Sweden, 27 males and females	Qualitative, cross-sectional	Fixed nightshift	Healthcare	Interviews analysed with the critical incident technique	Work related factors (eg influence of colleagues) influence the decision to eat on shift.
Phiri, Draper, 2014 ⁽⁶¹⁾	South Africa, 102 participants (participant sex not provided)	Qualitative, cross-sectional	Fixed nightshift, dayshift and non-shiftworkers	Healthcare	Focus group	Some nurses suggested that the food choices of colleagues influenced their food choice, both positively and negatively.
Strickland, Eyles, 2015 ⁽⁶⁶⁾	USA, 102 males and females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare and retail	Focus group	Nearly all participants reported that their healthy eating would improve with social support and accountability to colleagues.

Table 4 continued

Author(s), year	Country & Participant information	Study design	Shift-type	Industry	Eating behaviour methodology	Findings
Torquati, Kolbe-Alexander, 2016 ⁽⁶⁴⁾	Australia, 17 males and females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Focus groups	Stress eating was commonly reported by nurses and related to emotional eating and craving high-fat, high-sugar foods. Nurses could limit the intake of unhealthy snacks during the nightshift if there was a group commitment to this goal. Snacks were eaten continuously during the nightshift to help nurses stay awake.
Wandel and Roos, 2005 ⁽²⁰⁾	Norway, 46 males	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Carpenter, engineering and transport	Interviews	Eating on shift was considered a social occasion to meet colleagues, get to know each other and have work-related discussions. Drivers also had cafeterias that were frequently visited and would meet up with colleagues there.
4.3 Health						
Anstey, Tweedie, 2016 ⁽⁴²⁾	Australia, 15 males and females	Qualitative, cross-sectional	Rotating	Healthcare (paramedics)	Interviews	Paramedics reported concern that not eating for an extended period on shift could be potentially unsafe and detrimental to their health.
Bonnell, Huggins, 2017 ⁽⁴⁶⁾	Australia, 42 males and females	Mixed method, cross-sectional	Rotating	Firefighting	Focus groups and 24 h dietary recalls	Knowledge of the relationship between food and health impacted dietary intake.
Naweed, Chapman, 2017 ⁽⁷⁰⁾	Australia, 29 males and females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Train drivers	Focus group	Participants reported experiencing negative and judgemental reactions from fellow drivers when they discussed healthier eating habits.
Nyberg and Lennemäs Wiklund, 2017 ⁽⁶⁰⁾	Denmark and Sweden, 20 males and females	Qualitative, cross-sectional	Short- and long-haul flights	Aviation (flight attendants)	Interviews	Flight attendants reported eating less during a flight in order to stay fit.
Phiri, Draper, 2014 ⁽⁶¹⁾	South Africa, 102 participants (participant sex not provided)	Qualitative, cross-sectional	Fixed nightshift, dayshift and non-shiftworkers	Healthcare	Focus group	Nightshift workers reported a balanced diet as a main aspect of staying healthy, including eating breakfast in the morning.
4.4 Alertness						
Baba, Darina Indah Daruis, 2011 ⁽²¹⁾	Malaysia, 117 males	Quantitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Aviation	Questionnaire	Before and during a flight, nutritious food is considered a strategy used to overcome fatigue.
Grikins, Johnston, 2018 ⁽⁷³⁾	21 females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Interviews	Healthy eating was a self-care activity reported by participants to prepare for a shift.
Haus, Reinberg, 2016 ⁽⁸⁹⁾	France	7 males (5 rotating shiftworkers, 2 non-shiftworkers)	Oil refinery		Food diary	Work during the nightshift was considered so boring that snacks such as biscuits, candy bars, seeds, sweets and sandwiches were consumed to stay awake.
Kräuchi, Nussbaum, 1990 ⁽⁵¹⁾	Switzerland, 28 males and females	Quantitative, cross-sectional	Nightshift	Healthcare	Daily food and drink frequency questionnaire	An increase of sweet foods on shift was associated with less self-reported fatigue.

Table 4 continued

Author(s), year	Country & Participant information	Study design	Shift-type	Industry	Eating behaviour methodology	Findings
Nea, Pourshahidi, 2017 ⁷⁴	Ireland, 109 males and females	Qualitative, cross-sectional	Rotating, fixed day shift, fixed nightshift	Accommodation and food services, health and social care sector, manufacturing/industry sector	Focus groups	Tiredness was reported as a barrier to healthy eating, as it lead to a lack of motivation and will-power.
Novak and Auvil-Novak, 1996 ⁴¹	USA, 45 females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Focus group	Nurses reported refraining from eating during the 12 h work period to reduce drowsiness.
Zadeh, Shepley, 2017 ¹²²	USA, 136 males and females	Mixed-methods cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Questionnaire including questions on identifying aids to improve alertness and reduce sleepiness on shift	Dietary strategies were reported as the greatest behavioural tactic used to maintain alertness and reduce sleepiness.
4.5 Gastric upset						
Novak and Auvil-Novak, 1996 ⁴¹	USA, 45 females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Focus group	Many nurses reported putting on weight after eating meals and snacks during nightshifts.
Nyberg and Lennernäs Wiklund, 2017 ⁶⁰	Denmark and Sweden, 20 males and females	Qualitative, cross-sectional	Short- and long-haul flights	Aviation (flight attendants)	Interviews	Some flight attendants described eating during the nightshift as leading to stomach aches.
Persson and Mårtensson, 2006 ¹¹⁹	Sweden, 27 males and females	Qualitative, cross-sectional	Fixed nightshift	Healthcare	Interviews analysed with the critical incident technique	Nurses reported maintaining a healthy diet to aid digestion.
4.6 Stress eating						
Almajwal, 2016 ¹²³	Central Saudi Arabia, 365 females	Quantitative, cross-sectional	Fixed shift and non-shiftworkers	Healthcare	Questionnaire	Nurses with high stress had more eating problems. Those working nightshifts were more likely to experience restrained eating (which, under stress, is associated with eating more than usual and binge eating) .
Han, Choi-Kwon, 2016 ⁵⁰	Korea, 240 females	Quantitative, cross-sectional	Rotating and fixed	Healthcare	Questionnaire	Nurses with greater food intake than normal while under stress were more frequently found among those with rotating shifts compared to fixed shift nurses. Only 11% of nurses reported no overeating.
Jordan, Khubchandani, 2016 ¹²⁴	USA, 120 males and females	Quantitative, cross-sectional	Fixed day and nightshift	Healthcare	Questionnaire	70% of nurses reported a greater consumption of junk food and 63% reported consuming more food than normal as a way of coping with work-place stress.
Monaghan, Dinour, 2018 ⁶⁵	USA, 20 females	Qualitative, cross-sectional	Rotating, fixed day shift, fixed nightshift	Healthcare	Interviews	Unhealthy foods, such as cookies and brownies, were often eaten during stressful shifts.

Table 4 continued

Author(s), year	Country & Participant information	Study design	Shift-type	Industry	Eating behaviour methodology	Findings
Sahu and Dey, 2011 ⁹⁴	India, 75 participants (sex of participants not provided)	Quantitative, cross-sectional	Rotating	Healthcare	Questionnaire on shiftwork, digestive problems, food habits, food intake, ratings of eating satisfaction and appetite, and diet surveys	The appetite and satisfaction of workers was lower after eating during the nightshift than after morning or afternoon shifts.
Silva, Lopes, 2017 ²⁶	Brazil, 34 males	Quantitative, cross-sectional	Fixed nightshift	Security	6-d food diary and a questionnaire evaluating perceptions related to meals	After a nightshift, participants enjoyed eating breakfast, lunch and dinner less than after a night of sleep.
Wong, Wong, 2010 ²⁵	Hong Kong, 378 males and females	Quantitative, cross-sectional	Fixed shifts and non-shiftwork	Healthcare	Questionnaire	The majority of nurses had abnormal eating scores. Shift duties at least 4 times per month were associated with abnormal emotional eating behaviour.
4.7 Shiftwork experience						
Grifkins, Johnston, 2018 ⁷³	21 females	Qualitative, cross-sectional	Shiftwork (specific shift type(s) not provided)	Healthcare	Interviews	The more experienced workers ensured the less experienced nurses took breaks and had time to eat.
Morikawa, Miura, 2008 ¹⁰⁰	Japan, 2,254 males	Quantitative, cross-sectional	Rotating	Factory workers	Questionnaire	20–29 year olds, intakes of meat and vegetables were the lowest in shiftworkers with midnight shifts and among 40–49 year olds, intake of meat, fat and oil were lowest in shiftworkers with midnight shifts.
Mota, De-Souza, 2013 ⁸⁶	Brazil, 72 males and females	Quantitative, longitudinal	Shiftwork (specific shift type(s) not provided)	Healthcare	Dietary recall	80.5% of residents reported negative changes in eating habits after beginning their residency.

The table is organised by factor.

Studies may appear multiple times in the table as the findings address more than one factor.

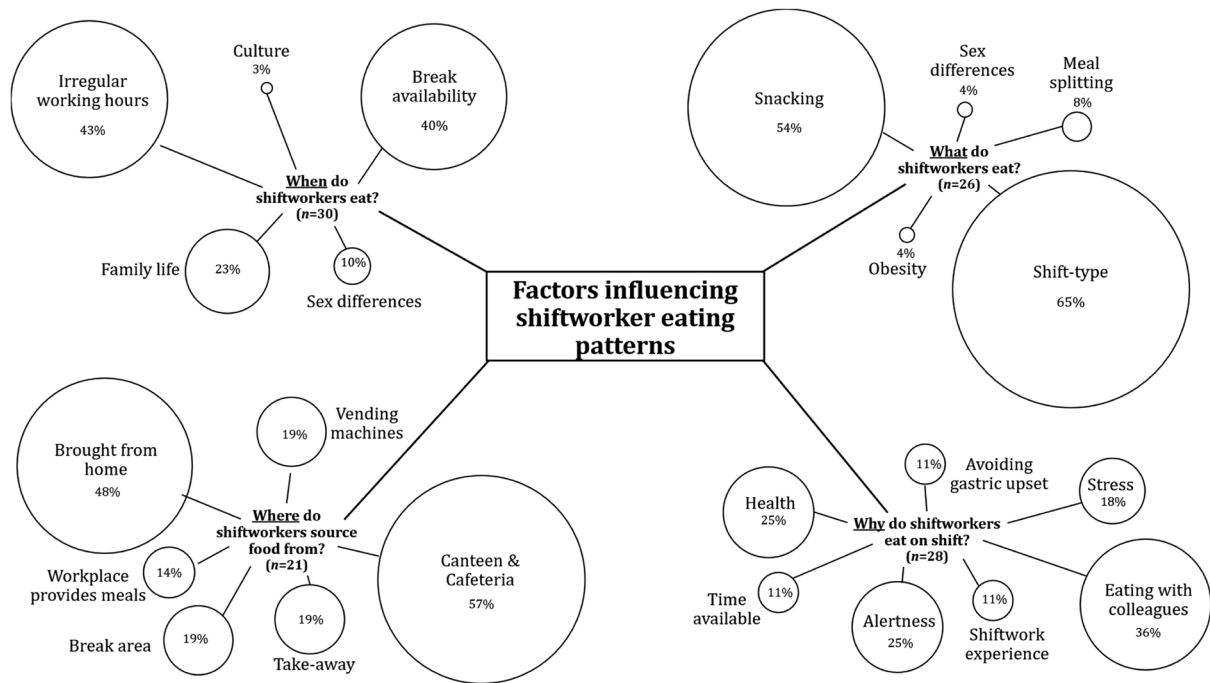


Fig. 2. The four themes (When, What, Where and Why) of this literature review, and the factors identified from the literature that influence each theme. Bubbles are sized according to the number of articles mentioning this factor in each theme, with a larger bubble representing a larger percentage of articles on this factor, as a percentage of total articles in the theme. Within each theme, articles may fit into more than one factor.

study were from multiple industries, including middle management, healthcare and police, suggesting that sex differences may impact eating across industries. This should be considered in future research.

Break availability

In some workplace settings there are set break times in which workers can consume food³⁴. However there is growing evidence that these breaks are not always associated with food consumption. Workers, particularly in care settings, often sacrifice break opportunities and skip meals to care for their patients or undertake other tasks^{65, 73, 79}. In a sample of 20 nurses, all participants reported not being able to take their full breaks, largely due to prioritizing patient care⁶⁵. Of this sample, 75% attributed taking a break to better eating habits as when they were unable to take full breaks they often chose to eat snacks. This suggests that when workers eat can influence what they are eating. Further, a study of American nurses found that 10% had no opportunity during their shift to have a break or meal due to the relentless workload of the shift⁶². Of the 393 participants, 43% had time for a break to eat a meal but were not relieved from patient care responsibilities⁶³. Similarly in a study in the UK it was found that 6%

of a sample of 126 nurses never took meal breaks, 15% almost never and only 16% sometimes took breaks⁴³. The workers suggested that they were too busy to take a break because of the workload, and if breaks were taken, they were only able to be short which did not allow enough time to purchase or prepare food^{43, 63}. Of concern, nurses in Australia have reported overeating during breaks as they would want to eat as much as they could when given the opportunity to eat⁶⁴. Due to this demanding environment and subsequent lack of breaks workers in the health and social care sector have suggested a need for protected times to eat^{65, 74}. Taken together, these findings indicate that, for those in the healthcare industry, the timing of eating during the nightshift and the opportunity to eat is heavily influenced by the availability of breaks in the work schedule.

Recent research has also revealed that break availability also influences the timing of eating in other industries. For example paramedics reported eating whenever there was an opportunity between emergency call-outs⁴². For flight attendants, there was also no choice about when to eat on shift and eating was based on the demands of the flight⁶⁰. These workers characterised eating on shift as irregular and unpredictable, and often involved eating while stand-

ing up, in order to fit in the meal between various work duties. Similarly, long-distance truck drivers, a group of workers who were working unpredictable and varied hours, reported eating whenever was convenient in case they didn't get another chance to eat⁴⁴). This could mean eating food whenever it was available, such as during gaps between deliveries⁴⁴). Break availability was also reported as a factor influencing healthy eating in a sample of retail workers⁶⁶). Breaks were short and interrupted and this made it difficult to eat healthy⁶⁶). In summary, the nature and demands of the work can have a large influence on when workers choose to or can eat. Considering this, an area for possible improvement of shiftworker health is on the organisational level, with employers working to increase time available to eat on shift.

The interaction between shiftwork and family life on meal timing

It's not only in the workplace that shiftwork has an impact on meal timing. When 44 rotating shiftworkers and their spouses were interviewed to examine how the work routines impacted family life, meals arose as a main aspect of conflict between the couples when integrating a shiftwork routine into the family lifestyle⁶⁸). Families were required to alter the timing of the family meal to fit the shiftworkers schedule, and this disrupted the family routine. Dinner preparation was also frequently disrupted, as workers had to choose between sleeping and assisting with or sharing the family dinner⁸⁰). This could be a factor influencing the extended time awake prior to a nightshift¹), as some workers may prioritise family life, including family meals, over sleeping. The interaction between meal timing and family life was also identified by police, with 80% of meals taken with the family on free days compared to only 38% of meals taken with the family on nightshift days⁶⁷). Rather than skipping meals with the family, firefighters reported eating a dinner meal with the family before a nightshift and then eating again at the firehouse⁶⁹). This would have an impact on the total energy consumed within a 24 h period with a nightshift. Similarly, in studies of nurses⁶⁵) and in train drivers⁷⁰) work hours were reported as conflicting with their families' eating habits. In emergency service on-call workers, a largely under-represented workforce in the shiftwork literature, workers are often called to work during non-standard hours. A sample of 24 on-call emergency service workers highlighted the impact of this on meal timing with family, as they could be called to work during family dinner⁷¹). Importantly, this sample reported pre-planning meals as a

strategy to deal with this disruption to meal timing. Within the studies that have reported an impact of shiftwork on family life, rarely are the strategies used to cope with this explored. Together, these findings demonstrate the relationship between family meal timing and shiftwork and highlight the difficulty in aligning shift schedules with life schedules. Future research should be mindful to explore the family context of shiftworkers as a potential influence on the worker's eating patterns, as well as any coping strategies to deal with this disruption.

Cultural influences on meal timing at work

Culture has been identified as another important factor for meal timing⁷²). During Ramadan, Muslims fast between sunrise and sunset and this fasting regiment applies to about 18% of the world's population⁸¹). During Ramadan those that are on nightshift may take their main meals during the night while at work, however this has not been explored in shiftworking populations. In Spain the workday is characterised by a common split work schedule that allows for a long lunch break and siesta as, culturally, the lunch meal is large and considered the main meal⁸²). These cultural variations in main meal timing could have interesting benefits but also unexpected impacts for shiftworkers, and should be considered when developing eating guidelines. The majority of studies included in this current review had samples from Western populations ($n=38$). More diverse populations should be sampled in future studies to capture these potential cultural influences.

What Do Shiftworkers Eat?

Results

From the literature search, 26 articles were identified that fit into the theme of what shiftworkers eat (Table 2). These studies were split into 2 factors, what sized meals shiftworkers eat and what types of foods, including different macronutrients, shiftworkers eat. As can be seen in Table 2, healthcare is again the most prominent industry sampled ($n=10$). The majority of studies were quantitative ($n=18$), with four qualitative studies, two mixed-methods and two observational studies. Of the 17 studies that provided information on shift-type, nine had samples of rotating shiftworkers and eight had samples of fixed shiftworkers (day, morning, evening and night). A variety of methods were used to capture what food was eaten, with 24 h dietary recalls and food diaries frequently used^{46, 54, 83–89}). These allow researchers to capture specific food types and analyse macronutrient content. Of note, only 2 studies

utilised more than one method^{46, 90}). This mixed-methods approach allows for greater detail on what the sample are eating, as patterns emerging from the 24 h recalls can be elaborated on in subsequent qualitative exploration. Longitudinal methodologies were effective in studies within this theme ($n=11$). Food-diaries and dietary recalls ranged from repeated 24 h recalls⁸⁴) to 56-d⁸⁹) recall comparisons and the analysis of changes in what shiftworkers ate over time⁸⁵).

Discussion

This section explores the theme of ‘What shiftworkers report eating’. Understanding what shiftworkers eat is important for identifying areas of change, particularly in the context of improving shiftworker health. Understanding what shiftworkers eat involves exploring what size meal is eaten, for example do workers eat meal sized portions or snack sized portions. For this review, snacks are considered to be discretionary foods, such as potato chips, chocolate, lollies and muesli bars. It is also important to explore the types of food (including different nutrient profiles) that shiftworkers consume during the nightshift. The amount of food, and the type of foods and macronutrients that shiftworkers eat can differ based on shift-type and among industries, and this is clear from the studies shown in Table 2.

Meal size

During the day, shiftworkers report eating full meals, however at night snacking is more common^{75, 94}). This has been reported in samples of nurses^{50, 54, 64, 73}), transport workers⁹³), airline crew⁹²), slaughterhouse workers⁴⁷) and oil refinery workers⁸⁹). In addition, nurses have also reported consuming less kilojoules at dinner when working the nightshift compared to working other shift types⁹⁴). Perhaps workers are compensating for this loss of kilojoules at dinner by snacking during the nightshift. Future research should consider measuring what shiftworkers are eating during the 24 h before starting shift, as changes in meal size during the day prior to a shift may be associated with increased food on shift. Interestingly, nurses have reported ‘meal splitting’ as a strategy for eating⁴¹). Half of the portion of food was eaten during regular break time and the other half was eaten later during the shift. This would split a meal sized portion into two smaller snack-sized portions. While this strategy has not been explored in other literature, perhaps more snacks are reported during the nightshift because workers are splitting a main meal into smaller portions. This would impact the way in which research captures the size of the meals and snacks eaten, as

a worker may report eating one meal across the nightshift, but has consumed this one meal in three snack sized portions across the shift. Rather than forcing a choice between a snack and a meal, quantities of foods could be recorded and classified as a snack or meal, as well as recording the timing of food intake¹⁰⁰).

Type of foods and nutrient profiles

A range of foods are eaten by shiftworkers. Sandwiches, fruit, cake, potato chips, and biscuits are commonly reported, and these are characterised by high carbohydrate and fat content^{89, 90}). Nurses have reported significantly more carbohydrate consumption compared to non-shiftworkers⁸⁸), with 30% of a sample of 340 Korean nurses reporting carbohydrate heavy snacks every day⁵⁰). Similarly, in a study of nurses in Brazil, an increased consumption of fried foods was associated with longer work hours⁹⁶). Much like in the ‘When’ theme, this study demonstrated sex differences in the eating behaviours of shiftworkers, with this increase in the consumption of fried foods not found in the male nurses. However the authors were unclear as to why this difference was reported and concluded that qualitative studies are needed to understand these differences between male and female workers and how factors, such as domestic duties, may play a role⁹⁶).

Shift-type can also have an impact on what is eaten. Nurses in India reported less meals and more snacks per 24 h with significantly less carbohydrate, protein, and fat intake during the nightshifts than during other shift types⁹⁴). Although shiftwork didn’t influence the 24 h intake of nutrients for industrial workers, significantly less protein, total carbohydrates, sucrose, total fat and calcium was consumed during nightshifts compared to afternoon shifts^{85, 89}). Differences in nutrient content was also reported in a cross-sectional study that included shiftworkers from postal, printing, nursing, and oil and gas industries⁹⁷). Across industries, nightshift workers consumed the greatest percentage of saturated fat and 12 h rotating shift workers consumed less carbohydrates than morning workers⁹⁸). In a study of male oil refinery operators more milk and milk products, non-alcoholic beverages and yellow and green vegetables were consumed during the nightshift than during day or afternoon shifts⁹⁰). Interestingly, milk consumption also differed between female in-flight workers (flight attendants and pilots) and shift workers (aircraft service and customer service), with more high-fat milk products consumed by in-flight workers than by shiftworkers⁷⁸). Fruit and vegetable intake is also influenced by shiftwork, with garbage collectors consuming less fruit

on nightshifts than on morning and afternoon shifts⁸³), resident physicians consuming less fruit as the number of hours of additional work increased⁸⁷), nurses consuming less servings of fruit and vegetables compared to government guidelines⁹⁹), and nightshift working bus drivers eating less vegetables compared to dayshift drivers⁹⁵). Of note, in a study of nurses, overweight participants consumed fewer fruit and vegetable servings than those who perceived themselves as just right or underweight⁹⁹). Given the high rates of obesity in shiftworking populations^{13, 101}), the role of obesity in the food choices of shiftworkers should be a focus of further research.

In firefighters, there was no difference in energy intake between day or nightshifts, but a significantly higher percentage of energy from sugar was consumed on 24 h periods with a nightshift than with a dayshift⁴⁶). It is important to note that drinks high in sugar, such as soft-drinks and energy drinks, in addition to hot beverages such as tea and coffee that sugar may be added to, are frequently reported by nightshift workers^{41, 46, 64}) and may partly explain increases in sugar intake reported by nightshift workers.

Where is Food Sourced from while on Shift?

Results

There were 21 articles found that discuss the source of food for shiftworkers (Table 3). Overall the common themes that were identified from these articles were canteen/cafeteria^{41, 43, 44, 56, 61, 63, 65, 75, 83, 92, 103, 107}), vending machines^{43, 59, 75, 103, 105}), food brought from home^{41, 42, 44, 46, 60, 63, 70, 74, 90, 103}), purchasing take-away^{42, 44, 70, 74}) and food in the break area^{64, 65, 104}). There were nine qualitative, eight quantitative and three mixed-method studies included in this theme. The majority of samples did not provide details on the shift-type of the samples ($n=8$) and the remaining articles had fixed shift samples ($n=7$) or rotating shift samples ($n=6$). One article included a sub-sample of non-shiftworkers as a comparison to the fixed nightshift workers⁷⁵). This allowed for a comparison of eating habits and highlighted the impact of shiftwork on where food is sourced from. As can be seen in Table 3, nine of the 16 articles fit into more than one of the themes. This indicates that shiftworkers often source food from multiple places. These studies were in different workplaces, suggesting that this is common across industries and this has implications for future research, as research into what shiftworkers are eating should take into account these multiple sources for food.

Discussion

This section explores the theme of ‘Where do shiftworkers source their food from.’ Eating habits may be largely shaped by the availability of certain foods³⁴). Where shiftworkers source their food from during shifts and the availability of certain foods is a key factor contributing to what is eaten during the nightshift.

Canteen/cafeteria

Many workplaces will have a canteen or cafeteria service available for staff members during the day, however the availability over the nightshift can vary^{43, 107}). It is common in hospitals for the canteen to be closed at night, and this limits food options for nightshift workers^{41, 61, 63}). In settings where the canteen is open during the night, there is evidence that it isn’t the main source of food for workers, due to reasons such as cost, choice, location and opening times^{43, 63}). In one study, although the canteen was open at night until 2,330 h, the hot food options were limited⁷⁵). Nurses still relied on vending machines or ordering hot meals to be delivered, such as pizza. Similarly, although a hospital cafeteria may offer healthy options, healthcare workers have reported time constraints on shift as a barrier to walking there to purchase food^{63, 65}). In industrial settings, canteen services were available on all shifts, including overnight¹⁰²). However this was mostly utilised by day shift workers, with nightshift workers preferring vending machines. This is concerning when we consider that 13% of the sample of 267 steel plant workers were reporting their principal eating occasion during the nightshift, meaning that these main meals consisted of food bought from vending machines. This food is typically processed, and high in saturated fat, sugar and sodium which are nutrients that should be consumed in moderation¹⁰⁶).

Workplace providing meals

Workplaces may also provide food for shiftworkers, for example some airlines provide crew meals on flights⁹¹). Similarly, garbage collectors in Brazil were provided a dinner meal during the nightshift⁸³). This was a traditional Brazilian meal consisting of meat, rice, beans, roots and or/pulses and vegetables, and usually fruit for dessert. This standardises what the workers are eating, and the workers are not required to provide their own food, however the nutritional content of the food is not controlled by the shiftworker. An under-researched shiftworking industry, the accommodation and food-services industry, also provides meals for workers⁷⁴). However, this was considered

a major barrier to healthy eating for the workers, as they had easy access to foods throughout their shift. This can promote continuous snacking rather than eating at regular meal times³⁴).

If workplaces are providing food for workers, then consideration of healthy options, portion sizes and time of night are important to consider. Recent evidence suggests that workers will respond positively to workplaces implementing strategies to improve healthy eating^{107–110}). In a feasibility study¹⁰⁷), five workplaces were provided with a healthy intervention in which free fruit was available for workers. This led to an increase in fruit and dietary fibre consumption for these workers, compared to three workplaces that were not provided this healthy intervention. Another strategy for workplaces is providing healthy labels for existing canteen food¹⁰⁸). In a hospital setting, this led to decreases in fat and energy density of the consumed meals and an increase in fruit and vegetable consumption. Taken together, these findings demonstrate a positive influence of workplace strategies for healthy eating, however neither of these studies accounted for differences among shift-types. As previously discussed, there is a difference in what workers consume on a day shift to a night shift⁹⁴), and we may expect a difference in the response to a healthy food intervention amongst shiftworkers. One study has assessed the effects of an intervention in shiftworkers compared to day workers¹⁰⁹). Healthy pre-packaged lunch meals were provided for 59 hospital workers (16 shiftworkers) and there was an overall decrease in daily fat intake and an increase in carbohydrate, fibre and water intake after the intervention compared to a control period where workers followed their habitual eating patterns. However, when the shiftworkers in the sample were analysed separately, the only significant difference in dietary consumption from the intervention was an increase in total water¹⁰⁹). This suggests that the efficacy of a healthy food intervention may differ for shiftworkers and dayworkers, and further research is needed in shiftworking samples, and particularly among different shift-types.

Vending machines

Vending machines may seem more feasible and convenient in 24 h workplaces than cafeteria and canteen services, as they don't need to be staffed at night¹¹¹). However, if this is a major source of food for workers^{43, 59, 75, 103}), then it is important to consider the contents of the vending machines. In one study nurses reported that vending machines stocked cold and hot drinks, chocolate bars, potato chips and similar junk food snacks⁷⁵). These are high in fat,

sugar and sodium, and not considered healthy^{106, 112}). Further, in an article assessing the work settings of truck drivers it was found that only 23% of non-refrigerated snacks available were healthy¹¹³). This lack of healthy vending machine options is a concern among workers, with nurses reporting a perceived lack of healthiness and attractiveness of the foods available in the vending machines⁴³). To improve healthy eating habits at work, nurses in the UK have asked for vending machines to be stocked with healthy options, such as nuts, fruit and low-sugar drinks⁵⁹). When healthy options such as these were included in vending machines for manufacturing workers, purchases increased, however satisfaction and willingness to pay for healthier options varied among different worksites¹⁰³). This study did not differentiate between shift-type, and we may expect differences between the likelihood of engaging with the healthier machines between a day and nightshift, due to differences in cravings¹¹⁴). It would appear that despite vending machines being a common source of food, the perceived healthiness of the food is a concern for workers. The availability of only smaller unhealthy snack foods in vending machines may account for the frequency of snacking behaviour during the nightshift^{75, 94}). To improve eating habits for workers, the contents of vending machines is an important issue to consider.

Food from home

Workers also bring foods from home. In steel plant workers, the majority of food was brought from home, irrespective of shift type¹⁰²). This was also seen in the healthcare⁴¹) and transport industry, with train drivers required to bring food on shift^{70, 115}). However, in a sample of truck drivers in Australia, although the participants saw the importance of planning ahead to bring food, factors such as roster changes and prioritising sleep prevented them from doing this⁷⁰). Furthermore, in a sample of firefighters, ingredients were brought from home to cook communally during shifts, with a large focus on co-workers cooking and eating together⁴⁶). This indicates a potential social function to bringing food from home.

An important consideration for workers bringing their own food on shift is the provision of facilities, such as microwaves, that allow for the preparation of food. In the study of oil refinery workers, facilities to prepare and heat pre-cooked frozen meals were available on all shifts⁹⁰). This allowed workers to bring their own food. However, healthcare workers have expressed disappointment over a lack of adequate storage facilities^{63, 74}). Additionally, on airplanes there was a lack of storage options, refrigeration

and heating facilities, and consequently flight attendants were bringing small snack items such as canned food, fruit and nuts to eat on shift⁶⁰. Paramedics reported similar issues, as they were unable to store perishable foods in the ambulance, so were required to bring small, transportable and pre-packaged foods on shift⁴². This was also reported by truck drivers¹¹³, who were reluctant to bring food as they had no way to maintain the quality of food in warm truck cabins⁴⁴. Together, these results suggest that what is eaten can be influenced by what is feasible to bring to the shift. This demonstrates the interaction between what is eaten on shift and the sources of food.

Take-away

An alternative to bringing food from home is purchasing take-away. Truck drivers sourced food from motorway service areas, truck stops and filling stations⁴⁴. Due to the demands of the shift, paramedics were required to source food from convenient locations, and reported buying take-away on shift⁴² and this was also reported by firefighters⁴⁶. Although train drivers can't buy foods on shift, it was reported that for convenience, food was often purchased before a shift from places such as service stations⁷⁰. As noted previously, take-away has also been reported by nurses as the only option due to canteen facilities closing at night⁷⁴. It is important to note that these studies were conducted prior to the introduction of instant food delivery services, particularly phone applications¹¹⁶. This expands food choice and creates more convenient opportunities to have meals delivered to workplaces. These delivery services should be explored as a source of food in future studies.

Food in the break area

Another source of food that has been reported in nursing samples is the presence of food in the ward break areas^{64, 104}. In multiple studies, nurses have felt that their food intake was influenced by what was available and accessible in the wards^{64, 65}. Nurses reported continuously snacking on chocolates because they were there, rather than because the nurses were hungry⁶⁴. Whilst this source of food has not been frequently reported in the current literature, it is an important factor to consider for nursing populations given the frequency of receiving food, particularly chocolates, as gifts from patients^{65, 104}. In a sample of 128 nurses, an average of 5.4 chocolates given to the ward were eaten per day¹⁰⁴. Further in a sample of 20 nurses, 75% reported that food donated from patients' families was often high in sugar and fat, and included

cookies, donuts and cakes. Nurses reported eating this food because it was the only option available in the break room⁶⁵. These findings suggest that the availability of food at work, particularly gifts given by patients, is an important factor to consider when understanding the source of food for this population. Having these types of foods (chocolate, cookies, donuts and cakes) constantly on the wards^{64, 65} may also explain the frequency of nurses reporting snacking during the nightshifts^{50, 54, 94}. Future research in healthcare worker populations should be mindful to explore food received as gifts from patients and the availability of this in the wards as a potential influence on the food intake of those in the healthcare industry.

Why Do Shiftworkers Choose to Eat during Their Shifts?

Results

There were 28 articles identified that explore why shift workers choose to eat on shift (Table 4). The key themes common amongst the literature were eating with colleagues^{42, 46, 61, 64, 69, 93, 117, 118}, improving health^{42, 46, 60, 61, 70, 73, 117}, staying alert^{41, 51, 64, 74, 89, 117, 119, 120}, avoiding gastric upset^{60, 117}, stress eating^{50, 64, 65, 121–123} and years of shiftworking experience^{73, 86, 98}. There was a mix in industry types sampled in these studies, with healthcare the most represented ($n=16$). Thirteen of the studies included in this theme were quantitative and thirteen were qualitative, with two studies utilising a mixed-methods approach. The majority of studies did not provide information of the shift-types of the samples ($n=11$), and the remaining were rotating samples ($n=8$) or fixed shift samples ($n=9$). The articles included in the discussion of this theme are relatively recent, and although there was one article from 1990 by Kräuchi, Nussbaum, 1990⁵¹, the motivations for eating emerged as a secondary result, rather than the main focus. This suggests that exploring why workers eat is a more recent area of importance and should continue to be considered in future research.

Discussion

This section explores the theme of 'Why do shiftworkers eat on shift.' In order to make meaningful and effective changes to eating behaviours, the motivations behind why workers are choosing to eat are important to explore.

Time available

A main theme emerging from the literature that influ-

ences the choice to eat on shift is having time available to eat. One study that has explored the motivations for eating used a questionnaire that was designed to identify the role of habits, desire, food availability and social factors on eating during the shift⁷⁵). For healthcare workers, schedule was the most common reason for choosing to eat and time available was the most common reason for the type of food chosen. This has also emerged as a motivator for food intake for firefighters⁴⁶) and truck drivers⁹³). Taken together, these findings suggest that choosing to eat on the nightshift may be a function of time available to eat and the constraints of the shift. This has previously been discussed as a major influence on when shiftworkers eat at night and where food is sourced from, and this must be considered when recommending dietary patterns for shiftworkers. If we want to influence shiftworkers to consume certain foods, then there must be time available to source and eat these foods.

Eating with colleagues

The eating patterns of shiftworkers may be heavily influenced by the eating patterns of their colleagues³⁴). Eating together increases cooperation and work group performance and serves an important social function⁶⁹). For nurses, eating together was a way to spend time with colleagues, and this was a huge motivator for eating on shift, regardless of hunger¹¹⁷). This may be why time available and break availability emerge as a key factor in the previous themes, as break times are when workers can sit together^{43, 117}). Similarly, in a group of firefighters, the choices and attitudes of co-workers had a large influence on individual food choice⁴⁶). As a group, the workers decided on whether take-away food was purchased or food was cooked, rather than making individual choices. Encouragement and bonding with colleagues was reported by nurses in South Africa, with these workers motivated to choose healthier foods because of their colleagues⁶¹). However, feelings of guilt emerged in this sample, with nurses feeling guilty if they didn't make the same food choices as their colleagues.

This social pressure may make it harder for workers to make individual food choices, and indicates that perhaps for some industries such as healthcare, group level changes would be the most effective when recommending changes to eating habits. For example, in a sample of nurses in Australia, nurses felt they would be able to reduce their intake of unhealthy snacks during the nightshift if there was a group commitment to this goal⁶⁴). This was also reported in a sample of healthcare workers and retail workers, who

suggested that their ability to initiate and maintain healthy eating behaviours would improve with social support and accountability to colleagues⁶⁶).

Improving health

The short- and long-term negative health impacts of shiftwork are well established in the literature and these shiftworkers are particularly vulnerable to higher rates of obesity^{7, 125}). It is therefore not surprising that health may motivate eating choices on shift. For example, drivers have agreed that they should eat healthier on the roads, but were not able to due to a lack of availability of healthy food⁹³). This suggests a discrepancy between what shiftworkers want to be eating, and what is available to choose from. Similarly, nurses have reported health as the motivator for choosing a balanced diet at work⁶¹) and have been inspired or pressured to start a diet or eat healthy foods because a colleague is¹¹⁷). This social impact on healthy food choices has also been reported in train drivers, however in this group of workers the opposite effect was found, where workers experienced judgement and negative reactions from colleagues when they wanted to eat healthier⁷⁰). Together, this demonstrates an effect of social factors interacting with health to motivate food choice during the nightshift. This has also been observed in firefighters, with workers describing a move towards healthier choices, including bringing in home-cooked meals or healthy ingredients to prepare a meal as a group⁴⁶). In a sample of nurses, healthy eating was considered a self-care activity to prepare for a shift⁷³). From these studies, workers are conscious of their health when choosing to eat during the nightshift. Therefore, the barrier to these choices may be environmental and relate to where shiftworkers are getting their food, such as a lack of healthy food options available to buy from the canteen⁴³).

Interestingly, health factors influenced the decision of flight attendants to avoid eating on shift⁶⁰). On the other hand, in a sample of paramedics there was concern that not eating for an extended period during the shift could be detrimental to health⁴²). These conflicting strategies for maintaining health during the shift may result from the lack of general recommendations and guidelines about eating during the nightshift. Despite recent literature demonstrating a clear impact of eating large meals during the night on health outcomes^{126, 127}), we are yet to determine what recommendations to make about eating on shift. Future research should prioritise investigating the ideal meal size, meal type and meal timing for shiftworkers, and whether this differs based on industry.

Staying alert

Across the nightshift workers experience an increase in sleep pressure and a decrease in alertness¹. Napping and caffeine are the most common shiftwork countermeasures emerging from the literature¹²⁸. However, eating appears to be another strategy that workers are using to stay alert during the night. Nurses have reported eating unhealthy foods, such as chocolate, as a way to stay awake on shift^{51, 64, 118, 121}. Similarly, a sample of oil refinery workers reported eating biscuits, candy bars, seeds, nuts, sweets and sandwiches during the night to stay awake during the monotonous nightshift⁸⁹. In contrast, airline pilots chose to eat healthier foods, rather than sweet foods, to promote alertness¹²⁰. Some shiftworkers also report refraining from eating during the nightshift to stay alert⁴¹, with heavy foods linked to not feeling well and feeling less alert¹¹⁸. Taken together, it is clear that, as with napping and caffeine¹²⁹, there are individual differences in the effectiveness of eating as a countermeasure. Individuals may have developed specific strategies that involve eating or not eating to maximise alertness on shift. These individual differences must be acknowledged in any eating recommendations.

One factor that may affect food choice is the extent of sleepiness. In laboratory-based studies, sleep restriction has been shown to influence food consumption^{97, 130, 131}. After a simulated nightshift participants chose more high-fat breakfast options, compared to after a night of regular sleep at home¹³⁰. Further, severe sleep restriction (4 h sleep per 24 h) has been shown to increase the likeliness of snacking on sweet foods^{97, 131}. Shiftworkers often report sleep restriction¹, and perhaps shiftworkers are choosing foods to attempt to feel more alert after restricted sleep.

Avoiding gastric upset

Shiftwork has been linked to increased gastrointestinal distress^{9, 132}. However very few studies have reported gastrointestinal distress in the context of eating behaviours. Nurses have reported maintaining a healthy diet during shifts as a strategy to reduce gastrointestinal symptoms^{41, 94, 117}. Flight attendants similarly reported gastric upset after eating during the nightshift, however the impact of this on food choice and eating habits on shift is unknown⁶⁰. The influence of gastric upset on food choice is an important focus for future research.

Stress eating

Shiftwork is associated with increased work stress, exhaustion and burnout²². Nurses may cope with this

work-related stress by consuming more food than usual, such as increasing junk food consumption^{50, 64, 65, 122}. Further, in Saudi Arabia, nurses experiencing high-stress were more likely to report abnormal restrained eating, associated with binge eating¹²¹. This lack of self-control when feeling stressed was also reported by nurses in Australia, who reported that feeling stressed or fatigued undermined attempts to diet and led to emotional eating⁶⁴. Similarly, nurses in Hong Kong working shiftwork at least four times per month were more likely to report abnormal emotional eating, which is eating in response to emotional arousal states such as stress and anxiety¹²³. An increase in state anxiety has also been found to influence food intake, with security guards reporting a decrease in hunger before breakfast and before lunch, and less enjoyment of eating foods at lunch on days after a nightshift¹²⁴. This suggests that an emotional state resulting from a nightshift may impact food consumption not only on-shift but on the day after. Given that stress eating is a common phenomenon^{133, 134} and shiftwork is associated with high amounts of work stress¹³⁵, these findings are unsurprising. What is surprising is that stress eating does not appear more frequently in the shiftwork literature as an influence on food choice. Greater understanding of work stress and its influence on shiftworker eating patterns would be beneficial. Recommendations for eating behaviours may not be followed if workers are eating to cope with stress.

Shiftwork experience

The number of years working as a shiftworker also impacts what shiftworkers eat⁹⁸. In a sample of manual workers, those in the 50–59 age group had the highest energy intake on nightshifts, those in the 40–49 yr old age group had a lower intake of vegetables, meat, fat and oil, and those in the 20–29 yr old age group had a lower intake of dietary products when working nightshifts, compared to the other shift types. Overall, the 50–59 yr old workers with more experience than the 20–29 yr old workers (10.8 yr vs 2.6 yr) ate more during the nightshift. This indicates some differences in what workers choose to eat based on their experience with nightshifts. It is possible that older workers have developed eating strategies to cope with the shift. It is also important to consider the impact of individual energy requirements and changes in energy needs with age¹³⁶. Further support for the influence of shiftwork experience was reported by a sample of medical residents, a group of workers with minimal previous shiftwork exposure⁸⁶. Unhealthy eating habits were common in this sample, with only 7% of the sample

of 72 residents reporting a good-quality diet. Of further concern, 80.5% of the residents reported negative changes in eating habits after beginning their residency⁸⁶). Taken together, this suggests that there may be an acute effect of working nightshifts on what the workers are choosing to eat, and this period of transitioning onto a shiftwork schedule should be a focus of future research. In a study of experienced and inexperienced nurses, the less experienced nurses reported that the more experienced nurses would allow them to take breaks and eat on shift⁷³). This demonstrates a positive aspect of shiftwork experience, as the more experienced nurses protected the time of the less experienced nurses. The more experienced workers ensured the less experienced nurses took breaks and had time to eat.

Conclusion

This review has examined the current literature on the range of factors influencing shiftworker eating patterns and has identified the four main themes that are important to consider; What, When, Where and Why. These factors are complicated and interact with each other to influence the eating behaviour of workers.

As can be seen in Fig. 2, different factors influence each theme and the weight of evidence from the literature for each of these themes varies. To understand when shiftworkers eat, it is necessary to investigate the influence of irregular work hours. However family life and culture has emerged as a potentially major influence and area of future research^{68, 72}). When exploring what shiftworkers eat, shift-type was found to be the biggest influence. Notably, meal splitting was reported in one study and is an area of further discussion amongst shiftworkers⁴¹). Sex differences in both what and when workers eat on shift were identified from the literature⁹⁶). This was also identified as influencing when workers ate on shift, suggesting that in samples of male and female shiftworkers possible differences in eating habits between the groups should be investigated. Canteen/cafeteria services were the largest source of food reported in the literature^{41, 43, 44, 56, 61, 63, 75, 83, 92, 102}), however rarely did shiftworkers only report one source. The biggest reason why workers chose to eat was for social reasons^{42, 46, 61, 64, 69, 93, 117, 118}). This may be due to the large representation of healthcare amongst the literature, as this is a workforce with a large team focus¹³⁷). Time available and health were important motivators for eating for those in the transport industry^{93, 118}), and this industry should not be overlooked in the literature. In a

previous review of barriers to healthy eating for nurses⁴⁰), many of the factors in the current review, including brining food from home, social barriers and long working hours were identified as impacting the eating patterns of nurses. The current review has demonstrated that these factors are common across industries.

This is a scoping review with a systematic search and narrative analysis, allowing for a thorough search of the literature and a discussion of the themes that emerged as influencing the eating behaviours of shiftworkers. This approach is designed to overcome the evidence bias that may be present in a pure narrative review⁴⁵). There are several limitations of this review that should be mentioned. A systematic search of the literature was conducted, and the search was widened to include health behaviours to capture studies where eating behaviours emerged as a secondary health outcome rather than a primary variable. While it may be possible that studies have been missed, given that, after widening the search, the new articles did not identify any new factors within each theme, but rather, added evidence to further strengthen the argument for the factors, we can be confident that the key factors influencing eating behaviours have been identified. Further, limiting articles to English may have limited the cultural diversity in the studies included in the review. Cultural differences were found to influence the eating behaviours of shiftworkers, and therefore this exclusion criteria may have limited the discussion on cultural factors. Future research should be mindful of this.

When understanding the eating patterns of shiftworkers, integrating these themes and adopting a holistic approach is key. This review has highlighted how each theme influences the others, and the decision to eat or not to eat on shift is the product of a range of factors within both individual and organisational contexts. Overall, 33 of the 62 articles in this review covered one theme only, with 27 papers covering 2–3 themes and only two papers addressing all four themes. Although the factors have been discussed separately in this review, it is clear that in future research, each of the themes must be acknowledged together in order to fully capture the reasons for eating behaviours. For example, what shiftworkers reported eating is related to where the food is sourced from and why they are choosing to eat, and when workers choose to eat may be influenced by why workers are motivated to eat. However despite clear relationships between these themes and the influence of factors on multiple aspects of eating behaviours, rarely are these factors looked at together. If a worker is eating chocolate ('what') during a nightshift ('when'), this

may be influenced by the stress of the shift ('why') and the availability of chocolate in the break room ('where'). This demonstrates that if a study was to only measure what food is being consumed, then the contextual factors influencing this behaviour would be missed. While some articles fit into more than one theme, only two articles fit into all four themes^{46, 64}. Moving forward, research should prioritise this holistic approach and ensure that each theme is considered when understanding eating behaviours.

The information presented in this review can be used as a basis for implementing studies aimed at improving the eating habits of shiftworkers and there are numerous recommendations for future research that will build on the limitations of the current studies. The industry types sampled should be increased, as the majority of studies include in this review are in healthcare workers (48%) and workers in areas such as social care, hospitality, emergency service, military, and mining are under-represented.

Further, cross-sectional approaches across industries should be conducted to explore differences. There is a lack of longitudinal data on shiftworkers and how eating patterns change and develop with shiftworking experience. The literature would benefit from a greater understanding of how these patterns may evolve over time. The studies with qualitative approaches often uncovered unique influences and eating behaviours that quantitative methods did not, and in the future these qualitative methods, such as interviews and focus groups, are encouraged. Some influences were under-represented in the literature, including the impact of culture on when shiftworkers are eating.

Given the recent literature that suggests an alarming impact of eating during the nightshift on performance^{138, 139} and health, particularly glucose metabolism^{126, 140}, altering shiftworker eating patterns is a priority. However, altering the dietary behaviours to improve these outcomes may be a challenge for workplaces to implement and workers to adhere to^{64, 141}. This review has highlighted the key factors that for any change to eating patterns to be successful, an awareness of multiple factors is crucial. For example, shiftworkers were reporting snacking on unhealthy foods such as chocolates and sweet pastries⁴⁶, however a suggestion to eat healthier foods must take this integrative approach and account for where food is sourced from and when food is eaten. If there isn't adequate break time to prepare healthy food, or if healthy food isn't provided in vending machines, then workers may not be able to change what they are eating. Further, given the social function of eating during the nightshift, particularly in team environments, a recommendation to avoid eating at night may

have negative consequences for the morale of the workers.

To make the most beneficial recommendations to shiftworkers, studies are needed that consider diet content as well as food timing, with mixed methods approaches that take into account the social and environmental factors in the workplace. This will allow interventions to present goals for change that are achievable and sustainable.

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