

The impact of shift work on people's daily health habits and adverse health outcomes

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KEYWORDS

shift work, diet, BMI, smoking, exercise, alcohol

ABSTRACT

Objective

To review the published scientific literature for studies analysing the association between shift work and people's daily health habits (as measured by diet, exercise, smoking or alcohol consumption) and adverse health outcomes such as obesity.

Methods

The following selection criteria were used to systematically search the literature: the studies were to be primary observational or analytical in design; targeted populations were working adults engaged in shift work; and outcome measures were the association between shift work and either diet, exercise, BMI, smoking or alcohol consumption. Data extraction and quality assessment were performed independently by the two authors using a standardised procedure. Synthesis of data is presented in text and tabular format. Meta-analysis was not possible due to the heterogenic nature of the studies reviewed.

Results

This review retrieved seventeen studies that met all inclusion criteria. The majority of the studies found that shift workers had more adverse lifestyle behaviours. Compared to non-shift workers, the nutritional intake of shift workers is less healthy and they are more likely to smoke when compared to non-shift workers. Shift workers also tend to be overweight. The impact of shift work on exercise patterns and alcohol consumption could not be ascertained because of the paucity of high quality studies.

Conclusions

Shift work impacts negatively on daily health habits and can lead to adverse health outcomes, such as poor dietary intake, smoking, and becoming overweight. The majority of Australian health care workers, and in particular nurses, work rotating shifts. It is important to have a greater understanding of the impact of shift work on our health care workforce.

INTRODUCTION

Modern society is moving toward a pattern of working twenty-four hours a day. Essential services provided by police departments, fire brigades, ambulance officers and hospital employees have traditionally always operated throughout a twenty-four period. Increasingly other services such as restaurants, petrol stations, and grocery/convenience stores are open twenty-four hours in order to accommodate night workers (Geliebter et al 2000). Over the last several decades, there has been a rapid increase in the number of shift workers worldwide (Sudo and Ohtsuka 2001). In Australia in 2003, a national survey found that over one million employees (14%) had worked shift work in the previous four weeks. Of these shift workers, 46% had worked a rotating shift (ABS 2004). Health and community services have the second highest proportion of shift workers of any industry in Australia (32.3%: ABS 2004). The health workforce is estimated to be about 7% of the entire Australian workforce and nurses comprise the single largest health professional group (54%: Productivity Commission 2006).

As people work irregular hours, their daily routine is interrupted. Regular eating and exercise habits are difficult to maintain (Geliebter et al 2000). Consequently, shift workers have a higher prevalence of being overweight (Chee et al 2004; Sudo and Ohtsuka 2001). In addition, shift workers also have more adverse life-style behaviours, such as higher tendency to smoke (Reeves et al 2004) and drink alcohol (Nakamura et al 1997). These daily habits (diet, exercise, smoking and alcohol consumption) and their immediate consequences (eg obesity) are the fundamental causes of many chronic diseases (McGinnis and Foege 1993). An unhealthy diet often leads to being overweight and contributes to circulatory diseases, diabetes mellitus and various forms of cancer (Vuori 1998). Lack of exercise is closely associated with food-related ill health (Nestle and Jacobsson 2000). A person who is obese is at greater risk of cardiovascular risk factors (Orzano and Scott 2004). Cigarette smoking has been identified as a classical risk factor for coronary heart

disease (Kannel et al 1987). Alcohol consumption also increases the risk of chronic disease (Rehm et al 2006). The impact of shift work on people's daily health habits and adverse health outcomes should be well understood.

The majority of nurses in Australia are working rotating shifts in order to provide twenty-four hour health care. Current nursing shortages warrant investigation of all possible factors that affect nurses' health and daily lives. Nursing workforce shortages are acknowledged globally. In Australia, there was an estimated shortfall of between 10,000 to 12,000 nurses in 2006 and between 10,000 and 13,000 in 2010 (Productivity Commission 2006). One of the factors associated with nursing retention is shift work, particularly night shift (Cooper 2003). The aim of this paper is to systematically review the evidence in the published scientific literature that quantifies and examines the association between shift work and daily health habits that lead to adverse health outcomes.

METHODS

Electronic databases were searched using EBSCO host as a search engine for CINAHL (1982-2006), pre-CINAHL (2006), Health Source: Nursing/Academic Edition (1975-2006), and MEDLINE (1966-2006). The following six separate search terms were used: shift work AND health; shift work AND diet; shift work AND exercise; shift work AND BMI; shift work AND smoking; shift work AND alcohol.

The combined effort of the above searches produced 601 abstracts. On examination of the study titles and abstracts by the two authors, 33 articles were retrieved. Rejected abstracts did not meet the study selection criteria. The references of these retrieved articles were also examined. A 'snowballing' strategy of reference titles was used and related abstracts and/or full text articles were accessed.

Other databases were searched using the above terms (except the first one) including: PubMed, PsycInfo and Proquest health and medical complete. However only Proquest health and medical complete yielded another two relevant articles. The Cochrane library was also searched with no relevant literature identified.

Overall, 35 full text articles were retrieved and assessed by the two authors independently, using the following selection criteria for this study:

1. Studies were to be published, primary research;
2. Study designs were to be observational and/or analytical (cross-sectional; case-control or prospective cohort studies);
3. The targeted populations were working adults engaged in shift work; and

4. Outcome measures were the association between shift work and either diet, exercise, BMI, smoking or alcohol consumption.

Seventeen studies met all the inclusion criteria for this review. Assessment for the quality of the methodology of these studies was based on a standardised abstraction procedure (Centre for Reviews and Dissemination 2001). The eighteen excluded articles are shown in table 1 with the reasons for exclusion. The results of selected studies are outlined in table 2.

Table 1: Studies retrieved but not selected

First author (year)	Reason for exclusion
Fujino et al (2006)	Outcome measure was the risk of ischemic heart disease rather than the association.
Ostry et al (2006)	No report of outcome measure of the association between shift work and BMI.
Persson and Martensson (2006)	Not a primary analytical study. A qualitative descriptive design with a Critical Incident Technique approach.
Higashikawa (2005)	A retrospective cohort study examining the health influences of alcohol consumption, smoking and eating habits on increased serum GGT. It is unclear whether the subjects were engaged in shift work.
Janzon et al (2005)	Exposure measure was smoking status rather than shift work.
Kageyama et al (2005)	Exposure measures were sleep problems and recent life events rather than shift work.
Love et al (2005)	Not a primary analytical research. An experimental study on the effects of shift workers' consumption of test meals on alertness scores.
Lamberg (2004)	Not a primary analytical research. A review of literature.
Portela et al (2004)	Outcome measure was the association between different working schedules and sleep complaints.
Hughes and Stone (2004)	Not a primary analytical research.
Wilson (2002)	Not a primary analytical research. A review of the literature.
Keating (2001)	Not a published article. A PhD dissertation.
Shields (1999)	Outcome measure was the association between long working hours and health rather than the association between shift work and health.
Tenkanen et al (1998)	Outcome measure was the joint effect of shift work and certain adverse life-style factors on coronary heart disease rather than the association between shift work and those adverse life-style factors
Chou (1997)	Not a published research article. A PhD dissertation.
Paz and Berry (1997)	Not an observational study. A serial repeated-measures design whereby each subject served as his own control.
Lennernas et al (1995)	An intra-group comparison of the 24 hour nutrient intake and the intake of coffee and tea between days off and work days in day workers; or between days in shift cycle in two-shift workers; or between days in shift cycle in three-shift workers. No inter-group comparison between these three subgroups.
Skipper et al (1990)	Outcome measure was the association between shift work and physical health and mental depression.

RESULTS

This review found seventeen studies that met all inclusion criteria. Five studies examined the association between shift work and diet (Bilski 2006; de Assis et al 2003a; de Assis et al 2003b; Sudo and Ohtsuka 2001; Lennernäs et al 1993). Four studies analysed the association between shift work and BMI (Chee et al 2004; Parkes 2002; Karlsson et al 2001; Niedhammer et al 1996). One study reported the association between shift work and smoking (Knutsson and Nilsson 1998). Some studies measured several health outcomes. Smoking, BMI and exercise were used as outcome measures in a study by Fernández Rodríguez et al (2004). Reeves et al (2004) used diet, smoking and BMI as their outcome measures. Geliebter et al (2000) measured diet, BMI, smoking, and exercise. Di Lorenzo et al (2003) measured smoking and BMI. Two cross-sectional studies measured exercise, BMI, smoking and alcohol consumption as the outcomes (Kivimäki et al 2001; Nakamura et al 1997). Among the selected articles, there is one study that has covered all five health outcomes (van Amelsvoort et al 2004).

Studies examining the association between shift work and diet

A cohort study investigated the influence of shift work on energy and nutrient intake in workers with very high levels of energy expenditure (de Assis et al 2003a; de Assis et al 2003b). The sample population were garbage collectors of the city of Florianopolis in the South of Brazil. Equal numbers of subjects were selected from each shift (morning, afternoon, and night). The subjects were 30.2 ± 0.8 years old and had a BMI of 24.1 ± 0.3 kg/m². Age, body weight and BMI were not statistically different among shifts. Using one 24 hour recall and two 24 hour records (Gibson 1990) during three non-consecutive days, this study measured the intake of energy and macronutrients, the frequency of ingestion and the energy derived from foods and circadian variations in energy and nutrient intake of each shift (de Assis et al 2003a); percentage of eating events and frequency of intake

and so on (de Assis et al 2003b). The results of this study found no significant effects of shifts on the total, protein, carbohydrate and fat calories. However shifts were found to significantly influence intake of starches, alcoholic drinks, and sweets. In different periods of the day, food and nutrient intake were also affected by shifts (de Assis et al 2003a). Different work schedules affected the daily distribution of eating events as the total number of eating events per day was significantly higher for night shift workers.

In Japan, a cohort study aimed to clarify the effects of shift work on nutrient intakes in association with food consumption patterns (Sudo and Ohtsuka 2001). The study population were female workers in a computer factory, consisting of 44 daytime workers and 93 weekly-rotating shift workers (of whom 47 and 46 were engaged in early-shift work and late-shift work respectively). The mean age of daytime, early-shift and late-shift workers was 28, 26 and 25 years respectively. Height was significantly greater in daytime workers than in the other two shift workers; however no significant differences were found in body weight and BMI among the work groups. The intakes of energy, protein, fat, carbohydrate, calcium and iron for three working days and an off day were estimated by self-registered food consumption records with the aid of a photographic method. The mean commencement time and percentage distribution of frequencies of meals and snacks, mean energy and nutrient intakes, and mean nutrient adequacy rate (NAR) by three work groups were measured on working days; and the latter two were also measured on the off day. The results showed that the shift workers, particularly the late-shift workers, consumed smaller amounts of energy and nutrients than the daytime workers. This finding implied that shift workers' nutritional status was worse, which was attributable to lower meal frequency and poor meal quality.

In contrast, Lennernäs et al (1993) argued that rotating 3-shift work did not affect the nutritional quality of diet or the frequency of different types of meals and snacks.

Sixteen healthy, male shift workers, age 34.8 years \pm 3.0 were recruited into this cross-sectional study. They were interviewed five times each to reflect their twenty-four hour consumption of food on morning, afternoon and night shifts, as well as a twelve hour shift and one day off. Outcome measures included the intake of energy and nutrients, the total number and mean frequency of types of meals and snacks, and total intake of energy, nutrients, and the content of energy and nutrients for types of meals and snacks as a function of work schedule.

Another non-English published study examined this research topic (Bilski 2006). This study involved a population of 171 nurses on shifts and at night and 70 non-shift nurses. The study aimed to assess the quality of meals consumed at night and nutrition habits among nurses. The mean age of the study population was 34.1 years, and their working experience ranged from 1 to 31 years (mean, 12.5 years). Bilski (2006) concluded that nurses on night shifts were more likely to consume cold meals and drank more cups of coffee everyday.

Studies examining the association between shift work and body mass index (BMI)

Chee et al (2004) conducted a cross-sectional survey to examine the socio-demographic and lifestyle factors that are associated with being overweight among 1612 female workers from 10 large electronics assembly factories in Peninsular Malaysia: 70.7% of the subjects were below 35 years old and 78.5% of them were Malay. More than half of the women (57.6%) worked three shifts, rotating every seven to ten days. Data were obtained by self-administered questionnaires and anthropometric measurements. BMI was calculated to determine the overweight status. The results revealed that working in rotating shifts including nights was significantly associated with being overweight after adjusting for age.

A cross-sectional study investigated the effects of age and shift work exposure and their interactions with

shift pattern (day shifts versus day-night rotation) as predictors of BMI (Parkes 2002). Data were collected from offshore personnel working on oil and gas installations in the United Kingdom. There were 1,574 male workers in this study population, consisting of 787 dayshift workers and 787 day-night shift workers. Subjects were asked for information about demographic factors, height, weight, shift pattern, years of shift work exposure and smoking habits. This study reported that continued exposure to day-night shift work was significantly associated with increases in BMI, and the effects of shift pattern on BMI depended significantly on both age and years of exposure to shift work.

Karlsson et al (2001) conducted a cross-sectional study involving a working population of 27,845 people from the Västerbotten intervention program in Sweden. The authors analysed whether shift work was associated with the metabolic syndrome, which included obesity, hypertension, and high triglycerides and so on. The study population consisted of day and shift workers in 30, 40, 50, and 60 year age groups. Data were obtained by taking blood samples and answering questionnaires. The prevalence of obesity in shift workers was higher than that in day workers.

A longitudinal observational study conducted in a nurses' cohort (Niedhammer et al 1996), involved 469 female nurses (mean age of 30 years) working in acute care in public sectors in France. The purpose of the study was to examine the prevalence of being overweight and weight gain in relation to night work. Demographic characteristics: exposure to night work, age, parity, smoking, and sports activities in 1980, 1985 and 1990 were collected from self-administered questionnaires. Weight and height was taken by occupational physicians to calculate BMI. From the results listed in table 2, the authors concluded that exposure to night work could lead to weight gain.

Table 2: Studies of associations between shift work and either diet or exercise or smoking or BMI or alcohol consumption

Authors (year)	Study design	Study population	Outcome measures	Exposure measures	Results
de Assis et al (2003a)	Cohort	Garbage collectors - city of Florianopolis (south of Brazil) during March and April 1999 (n=66 male)	Energy and macronutrients intake Frequency of ingestion and energy from food groups	Morning shift (0700-1300h) Afternoon shift (1500-2100h) Night shift (2100-0300h)	No significant differences among the three shift groups for the total, protein, carbohydrate, and fat calories intake. Night shifts had a significantly higher frequency of starches and alcoholic beverages intakes ($p=0.0001$; $p=0.0003$ respectively). Morning shifts took sweets more frequently ($p=0.0001$).
de Assis et al (2003b)	Cohort	Same as population above	Percentage of eating events Energy per eating event (%) Energy per period (%)	Morning shift (0700-1300h) Afternoon shift (1500-2100h) Night shift (2100-0300h)	The total number of eating events per day was higher for night shift workers (6.2 ± 1.2) compared to morning shift workers (5.3 ± 0.2) and afternoon shift workers (5.5 ± 0.9) ($p=0.004$).
Sudo and Ohtsuka (2003)	Cohort	Female workers in a computer factory in Yamanashi Prefecture, Japan (44 daytime workers 93 weekly-rotating shift workers n=137)	Mean nutrient adequacy rate (NAR) on 3 working days and the off day Mean Commencement time and frequencies of meals and snacks	Daytime workers (0830-1715, 60 mins for rest) Early-shift workers (0600-1345, 45 mins for rest) Late-shift workers (1340-2225, 45 mins for rest)	All nutrient intakes and mean nutrient adequacy rate on working days were the highest in daytime workers and the lowest in late-shift workers. On the off day, only carbohydrate intake was significantly larger in daytime workers than in late-shift workers ($p<0.017$). The percentage of the subjects who took breakfast 3/3 times was the lowest in late-shift workers and non-meal frequency played a principal role in the low NAR energy of the late-shift workers.
Lennernas et al (1993)	Cross-sectional	Male shift workers age 34.8 years \pm 3.0 (24-62 years) (n=16)	Frequency of types of meals and snacks Content of energy and nutrients for types of meals and snacks	Morning shift (0600-1400) Afternoon shift (1400-2200) Night shift (2200-0600) 12h shift (0600-1800 or 1800-0600)	The frequency of meals and snacks across shifts showed no significant variation. No significant variation across shifts for the content of energy and nutrients of each type of meal and snack.
Bilski (2006) [study not published in English]	Unable to ascertain from English abstract	171 nurses working in shifts and at night and 70 non-shift nurses (n=241)	Unable to obtain information	Unable to obtain information	Only 17(9.9%) nurses consumed a warm meal at night. As many as 13(7.6%) consumed no meals and 17 (9.9%) drank only coffee.

Table 2: Studies of associations between shift work and either diet or exercise or smoking or BMI or alcohol consumption continued...

Authors (year)	Study design	Study population	Outcome measures	Exposure measures	Results
Chee et al (2004)	Cross-sectional	Female workers from 10 large electronics assembly factories in Malaysia (n=1612)	Body Mass Index (BMI)	Age group; ethnic group marital status; education; income; staying in hostel; exercise; rotating shift work including nights (3 shifts or 2 shifts)	In a logistic regression model with all variables included as covariates, working in rotating shifts was significantly associated with being overweight ($p<0.001$). Shift workers including nights faced significantly higher odds of being overweight even after adjusting for age and other variables ($p<0.001$, adjusted OR: 1.6, 95% CI: 1.28-2.06).
Parkes (2002)	Cross-sectional	Male offshore personnel from 17 oil and gas installations in the United Kingdom sector of North Sea (n=1574)	Body Mass Index (BMI)	Age; years of shift-work exposure; educational level; smoking habits; job type; shift pattern (day shift: 0700-1900; day- night shift: 0700-1900 and 1900-0700)	Over successive age points and years of exposure, the increase in BMI was more marked in day-night shift group. Exposure years were correlated significantly with BMI ($r=0.19$, $p<0.025$).
Karlsson et al (2001)	Cross-sectional	Subjects were recruited from Västerbotten intervention programme in the north of Sweden (n=27,485)	Metabolic risk factors (obesity, hypertension, and high triglycerides) Total cholesterol HDL cholesterol	Day workers and shift workers in 30, 40, 50 and 60 year age groups	Increased odds ratios in being obese (Women: OR: 1.39, 95% CI: 1.25-1.55; Men: OR:1.44, 95% CI: 1.27-1.64); low HDL cholesterol (Women: OR: 1.26, 95% CI: 1.03-1.53; Men: OR: 1.15, 95% CI: 0.96-1.38); high triglycerides (Women: OR: 1.13, 95% CI: 1.02-1.25; Men: OR: 1.12, 95% CI: 1.01-1.24) for both women and men shift workers after adjusting for both age and socioeconomic factors.
Niedhammer et al (1996)	Cohort	Female nurses working in acute care in public sector hospitals in France (n=469)	Overweight (BMI>26.9kg/m ²) Weight gain of more than 5kg or 7kg	Current exposure to night-work Exposure to night-work during the previous 10 yrs Number of children Tobacco Sports activities Job strain level	Prevalence of being overweight was associated with exposure to night work in 1980 (OR: 3.3, 95% CI: 1.3-8.2). After adjustment for confounding variables, between 1985 and 1990, more nurses on night work exhibited excessive weight gains than nurses on day work(>5kg, OR: 1.9, 95% CI: 1.0-3.6; >7kg, OR: 2.9, 95% CI: 1.2-6.9).
Knutsson and Nilsson (1998)	Cross-sectional	Swedish 1990 Census. 2584 men, 2836 women (n=5420)	Prevalence of smoking; Prevalence of exposure to environmental tobacco smoke	Day work Shift work Asthma/ non -asthma	The results of multiple logistic regression modelling showed that smoking was associated with shift work (OR: 1.3, 95% CI: 1.1-1.6).

Table 2: Studies of associations between shift work and either diet or exercise or smoking or BMI or alcohol consumption continued...

Authors (year)	Study design	Study population	Outcome measures	Exposure measures	Results
Di Lorenzo et al (2003)	Cross-sectional	Subjects were randomly selected among workers involved in the production process of a chemical industry in Apulia, Southern Italy. (n=319)	BMI; waist hip ratio (WHR); systolic blood pressure (SBP); Diastolic blood pressure (DBP); Fasting glucose; Total cholesterol/high density lipoprotein (HDL) - cholesterol/triglycerides/insulin	Day workers (0700-1600) Shift workers (3 regular rotating shifts)	Obesity was more prevalent in shift workers than in day workers ($p<0.05$), whereas body fat distribution was not different between the two groups. Shift workers were more frequently smokers (40%) or non-smokers (38.4%) than day workers (34.3% and 32.1% respectively), even though this difference did not reach statistical significance ($p=0.058$). There was a significant relationship between shift work and BMI, even after taking into account fasting insulin levels ($p<0.05$).
Reeves et al (2004)	Cohort	Subjects recruited from residential nursing homes and hospitals, 20 females (10 day shift workers 10 night shift workers) 16 males (8 day shift workers, 8 night shift workers) (n=36)	Total dietary intakes of night and day- shift workers Energy intakes of female and male night-shift workers on work and rest days over 24h Macro-nutrient composition of the diets consumed by male and female night-shift workers on work and rest days Demographics	Male day workers Male night workers Female day workers Female night workers	There were no significant differences in dietary intakes between night and day- shift workers. Day staff were more likely to consume more meals per day ($p<0.05$) and consume fewer snacks than night-shift workers. Female night-shift workers drank more cups of tea and coffee than female day-shift workers ($p<0.01$). Night-shift workers were more likely to smoke than day-shift workers and smoked significantly ($p<0.01$) more cigarettes per 24 hours.
Geliebter et al (2000)	Cross-sectional	85 nurses, nurse's aides or security personnel (36 on day shift, 49 on late shift)	Work and weight history Health/medical history Sleep and meal pattern	Day shift (8am to 4pm), evening shift (4pm to 12am), night shift (12am to 8 am)	Late-shift group reported gaining more weight than the day-shift group ($p=0.02$) since starting the job on current shift. There were no significant differences in current BMI, years on the current shift or smoking prevalence between groups. After statistically adjusting the mean weight change for the covariates of age, years on the shift, and smoking, the results showed a significantly higher weight gain in late shift than the day shift ($p=0.008$).

Table 2: Studies of associations between shift work and either diet or exercise or smoking or BMI or alcohol consumption continued...

Authors (year)	Study design	Study population	Outcome measures	Exposure measures	Results
Fernández Rodríguez et al (2004) [study not published in English]	Unable to ascertain from English abstract	207 permanent morning-shift workers and 210 shift workers(3-shift system) (n=417)	Dietary intake Body Mass Index Blood lipid levels Physical activity	Morning-shift workers 3-shift workers	Shift workers showed higher intakes of red meat, eggs, fruit juices and pasta. No differences were observed in lipid levels, weight status and physical activity in relation to shift working status.
Kivimäki et al (2001)	Cross-sectional	Female nurses currently working shifts, always been a shift worker OR currently a permanent day worker with no history of shift work during career as a nurse (n=689)	Smoking Alcohol consumption Overweight Sedentary lifestyle	Permanent day shift 3-shift schedule Permanent night shift	There was a significantly higher tobacco consumption in shift workers (p=0.027). The prevalence of heavy drinkers (OR: 1.50, 95% CI: 0.63-3.53) and the prevalence of non-drinkers (OR: 1.23, 95% CI: 0.68-2.21) were higher in shift workers than in day workers, but the difference did not reach statistical significance. Shift workers (OR: 1.54, 95% CI: 1.06-2.25) were more often overweight than day workers and the difference between these two groups increased with age. Sedentary lifestyle was not significantly more prevalent in shift workers (OR: 1.3195% CI: 0.81-2.12) compared to day workers.
Nakamura et al (1997)	Cross-sectional	Industrial male, blue-collar workers at a personal computer and printer manufacturing company. (60 shift workers, 239 day workers, n= 299)	Demographic and anthropometric characteristics Blood pressure and serum lipid concentrations of shift workers and day workers	3-shift workers (morning: 0815-1515; afternoon: 1515-2230; night: 2230-0815) 2-shift workers (day: 0815-1815/1715; night:1915-0805) Day workers (0815-1715)	3-shift and 2-shift workers had greater values of abdominal to hip girth ratio (AHR) and subscapular skin fold thickness than day workers, with statistically significant differences in AHR between 3-shift and day workers (p<0.05). There were no statistically significant differences in BMI. About 69% of shift workers did not exercise at all, while 50% of the day workers did (p<0.05). More than 70% of all groups of workers smoked everyday and the differences among the three groups were not statistically significant. The highest alcohol consumption every day was in 3-shift workers (54%). Frequency of no drinking habits also tended to be greater in the 3-shift workers, but the differences were not statistically significant.
Van Amelsvoort et al (2004)	Cohort	Subjects were from: (1) persons undergoing a pre-employment medical examination in two occupational health services; (2) all workers in a newly built waste incinerator plant; and (3) nurses, starting with practical in hospital training. (n=396)	Job-related factors Diet Anthropometry Blood lipids Lifestyle	Day workers Shift workers	Compared with baseline, the percentage of smokers and the number of cigarettes smoked per day (in smoker only) increased more in shift workers compared with daytime workers. BMI decreased significantly in shift workers compared with their own baseline values (compared with the increase in the day workers p=0.004). Comparing the 1-year change in energy intake between the shift and daytime workers, both groups displayed a decrease but the decrease in the daytime workers was significantly higher (p<0.001). Energy from fat and cholesterol intake were reduced in both groups, but the difference between the two groups was not significant (p=0.8). There was a decrease in alcohol consumption in shift workers compared to an increase in daytime workers, but the difference was non-significant (p=0.4). Analysis of respondents changing from a daytime job to a shift work job between baseline and the 1 year of follow-up (n=32) revealed a significantly higher decrease in BMI compared with daytime workers (p=0.05) and a higher increase in number of cigarettes smoked per day in smokers (p=0.02). For respondents changing from shift work to a daytime job (n=34), there was a greater decrease in the amount of physical activity during sport (p=0.04).

Association between shift work and smoking

Knutsson and Nilsson (1998) conducted a cross-sectional study to measure the prevalence of tobacco use and passive smoking in different occupations. The subjects were obtained from the Swedish 1990 Census, including 2,584 men and 2,836 women randomly selected from 63 occupations. The mean age was 42.5 in females and 41.5 in males. Data on personal habits and exposure to environmental tobacco smoke were obtained by questionnaire, and job strain was assessed using a four-item job demand scale and a four-item job decision latitude scale. The results indicated that current smoking was significantly associated with shift work.

Associations between shift work and smoking and BMI

One cross-sectional study conducted in Apulia, Southern Italy, was to examine the effect of shift work on metabolic and cardiovascular risk factors in blue collar workers (Di Lorenzo et al 2003). The subjects were glucose tolerant males, who were all Caucasians, aged 35-60 years. All subjects underwent clinical examination and measurements of anthropometric parameters. The results showed that shift workers had higher BMI and they were more frequently smokers or non-smoker than day workers.

Associations between shift work and diet, BMI and smoking

Reeves et al (2004) conducted a cohort study to investigate the effect of shift work on food intake and eating patterns. There were 20 female and 16 male shift workers in this study. Weight was measured anthropometrically; lifestyle factors were established using a questionnaire; and food intake was recorded using six-day food diaries. The results found that night shift workers did not eat more than day workers. There were significant differences in food intake patterns on work and rest days for night-shift workers as shift work is a factor in the timing of food consumption. No significant differences were identified in the weights and body mass indexes of night and day-shift workers; however no statistical

results were reported. Night-shift workers were more likely to smoke and smoked significantly more cigarettes per 24 hours.

Associations between shift work and diet, BMI and exercise

Another non-English published study by Fernández Rodríguez et al (2004) evaluated the nutritional status, food habits and physical activity in health shift workers. Permanent morning-shift workers (n=207) and shift workers (3-shift system n=210) were randomly selected from 2,100 workers of the North Area of the Canary Island Sanitary Health System. Dietary intake was assessed by a self-registered food frequency questionnaire. Other outcome variables included BMI, blood lipid levels, physical activity, age and sex. The results showed that shift workers had a higher intake of red meat, eggs, fruit juices and pasta. There were no significant differences found in lipid levels, weight status and physical activity in relation to shift work.

Associations between shift work and diet, BMI, smoking and exercise

Geliebter et al (2001) conducted a cross-sectional survey involving 85 hospital workers to determine whether weight gain was more prevalent in late-shift workers than in day-shift workers. The mean age and years on current shift were 43.1 years and 8.6 years respectively. The questionnaire used in this survey covered demographics, work and weight history, health/medical history, and sleep and meal pattern. The results yielded that late-shift workers reported greater weight gain than day workers. Late-shift workers had a higher food intake than day workers when combined with those reporting exercising less. However late-shift workers reported eating fewer meals. In addition, late-shift workers reported eating the last daily meal later than day workers.

Studies examining the associations between shift work and smoking, BMI, alcohol consumption and exercise

Kivimäki et al (2001) conducted a cross-sectional study to examine the associations between shift work and health habits as measured by smoking, alcohol consumption, sedentary lifestyle and being

overweight. Study subjects were obtained from the 'Work and Health in Finnish Hospital Personnel' project, which involved 689 female nurses from 10 hospitals in two Finnish health care districts. The mean age of the study participants was 41.6 years. According to the results, shift workers were found to smoke more and to be overweight more often than day workers; however shift work was not associated with alcohol intake or sedentary lifestyle.

In Japan, Nakamura et al (1997) conducted a cross-sectional study to compare serum total cholesterol, serum triglyceride, body fat distribution, blood pressure and ways of living of 3-shift and 2-shift workers with those of day workers. Subjects were all blue-collar male workers and the average length of shift work was 9.2 years. The average age of shift workers and day workers was 34.5 and 32.7, respectively. Anthropometric measurements, blood collection and blood pressure were taken and a self-administered questionnaire was administered to elicit demographic characteristics. The study did not find any significance differences in BMI between the three working groups; however 3-shift workers had a higher tendency to central obesity, which was characterised by a higher waist to hip ratio. More than half the shift workers did not exercise at all. Over 70% of the blue-collar workers smoked every day and 3-shift workers had the highest daily alcohol consumption; however the differences in these two aspects were not statistically significant.

Association between shift work and smoking, BMI, alcohol consumption, exercise and diet

Van Amelsvoort et al (2004) conducted a one-year cohort study to compare changes in cardiovascular risk factors between shift and daytime workers to identify possible factors that might explain the elevated cardiovascular disease risks among shift workers. Among 239 shift and 157 daytime workers, one-year changes in biological and lifestyle cardiovascular risk factors were monitored between the start of a new job and one year later. At baseline, the mean age of shift workers was significantly older than that of day workers (26.8 and 24.1 respectively). All participants were asked to complete

a questionnaire about personal characteristics, current job title and job history and any objections against shift work. Anthropometric measurements and plasma cholesterol measurements were taken. A self-administered food-frequency questionnaire was filled out for dietary assessment. Job strain was assessed using a validated Dutch version of the self-administered Job Content Questionnaire (Karasek 1985; Houtman 1995). The results revealed that BMI decreased significantly in shift workers compared to day workers; there was a higher decrease of physical activity for respondents changing from a shift work to a day job; energy intake as well as the energy from fat and cholesterol reduced in both groups; there was a decrease in alcohol consumption in shift workers as compared to an increase in day workers; and cigarettes smoked per day increased significantly in shift compared with day workers.

DISCUSSION

Whilst overall research findings indicate that shift work impacts negatively on daily health habits, the methodological quality of the studies reviewed should be assessed objectively in order to acknowledge the strengths and limitations of these findings. However the strengths and limitations of the two non-English articles could not be analysed due to the inability to interpret information from the original reports.

The study by de Assis et al (2003a; 2003b) was limited by gender bias and a small sample. Furthermore, the subjects volunteered to participate in this study which may underestimate some adverse results. Due to the male only sample, the external validity and generalisability to all shift workers are questionable. Drawing conclusions from the study conducted by (Sudo and Ohtsuka 2001) should also be done with caution due to the relatively small, gender biased study sample. There was a lack of internal validity as there was no adjustment for confounding factors. External validity and generalisability were also limited due to the female only sample. Findings of Lennernäs (1993), which is the only study reporting that shift work did not affect the nutritional intake or the frequency of meals and snacks, should be

interpreted with caution as the sample size was very small, recruiting only 16 male workers. The study is also limited by the cross-sectional design as is the survey conducted by Chee et al (2004). The subjects participated in the latter study voluntarily, so the subjects may have a greater health consciousness which could have led to biased results. Confounding factors such as age, socioeconomic factors and exercise were adjusted in this study; however it did not include dietary assessment, which could have been a significant factor when determining BMI. Generalisability of the study results is limited due to the female only study population.

The subjects in the study by Parks (2002) were male offshore workers who, on employment, were required to meet rigorous standards of physical and mental health, so their health status was more favourable than in the general working population. In multivariate analysis, job type, education and smoking were controlled; however no odds ratio was reported. In addition, physical activities were not taken into account when adjusting for confounders.

The research quality of the Karlsson et al (2001) study is high due to the large representative study population. In the multiple regression analysis, age and socioeconomic situations were adequately adjusted to control confounders. On the other hand, there are still some limitations. Firstly, the cross-sectional study did not follow the subjects for a period of time to estimate chronic diseases. Secondly, the definition of exposure to shift work was weak and imprecise and did not provide information about day to day patterns of shift work, frequency of night work, type of rotation, or duration of shift work. Thirdly, exercise was not adjusted for, which could affect the research results.

The 10-year cohort study of Niedhammer et al (1996) may have been biased in several aspects. Firstly, this is a female nurses' cohort study and after 10 years, 16% of the sample had been lost to follow up. Secondly, the respondents in the study for 10 years could be healthier than the non-respondents, because the healthiest nurses may have been selected for night work and those nurses who left the

hospital may have done so because of health reasons. These biases may have led to underestimation of the association between night work and being overweight. Thirdly, this study did not evaluate the duration of night work exposure throughout follow up, which could be a more accurate indicator to assess the association between night work and being overweight. Fourthly, potential pregnancies were not taken into consideration. Lastly, the author argued that eating habits were intentionally not taken into account to avoid underestimating the association. However there was no statistical evidence in the study to prove this underestimation. Despite all the limitations, the confounders were well controlled for, such as age, weight at baseline and regular sport activities.

Knutsson and Nilsson (1998) conducted a high quality study. The study subjects were randomly selected from 63 occupations in Sweden consisting of large numbers of males and females. Confounding variables, such as occupation and other determinants were adjusted for. However two limitations may affect the validity of the results. One is that the response rate, especially in occupations with a lower educational level, was low. The other one is about the reliability of data, which were all reported by the individuals themselves.

The sample size was very small ($n=36$) in Reeves et al (2004). The author mentioned there were no significant differences in weights and body mass indexes of night and day shift workers in discussion, nevertheless no statistical results were reported. The strength of this study is that it made an effort to eliminate the possibility of under-reporting. If energy intakes were less than 1.5 times Basal Metabolic Rate, this suggested under-reporting unless there was a loss in body weight.

Several limitations existed in the study by Geliebter et al (2000). Firstly, the sample size was relatively small and it was also limited by its cross-sectional study design. Secondly, the weight data relied on self-report; especially the subjects were required to recall the weight data when they first started on shift work, which was more than eight years ago.

However the authors argued that the data obtained were reliable as the number of years did not differ significantly between shift groups, so the accuracy of data among the three groups could be regarded similar. Thirdly, the results showed that late-shift workers took more and longer naps; and the authors indicated that more weight gain could result from a decrease in energy output in the form of naps. However it was not adjusted for as a confounder in the results and neither was exercise.

Two cross-sectional studies recruited only males in the study population (Di Lorenzo et al 2003; Nakamura et al 1997). Both studies' subjects were blue-collar male workers, which led to selection bias and the generalisability was also limited. In the study of Di Lorenzo et al (2003), fasting insulin levels were controlled as confounders; however exercise was not taken into account. The second one (Nakamura et al 1997) adjusted age, exercise, smoking, drinking and snacking to determine the association between three-shift work and serum total cholesterol concentration, though no odds ratios were reported.

Kivimäki et al (2001) recruited a large number of study subjects however it only involved female participants. Those subjects who drop out of work are typically less healthy, which is called the healthy worker effect and this may lead to under-evaluations of the associations. This study is also limited by its cross-sectional data and generalisability of the research results.

In the prospective cohort study (van Amelsvoort et al 2004), the authors planned to follow the subjects for one year to assess the impact of shift work on cardiovascular disease risk factors. However at the end-point of the study, only the data from workers not changing work schedule were presented (264 out of 396). No comparison was performed to ascertain sample bias between those who remained in the same work schedule and those lost to follow-up or changed work schedule or on sick leave or became unemployed. Selection bias could have occurred due to self-selection effect, which might be influenced by job availabilities. People who assume they are

not capable of working shift work are less likely to apply for a shift work job. Also, companies may use different criteria when employing shift workers. These selection biases could lead to an underestimation of the results. Measurement biases could have occurred. First, the measurements taken in different phases of the circadian rhythm may cause biased results. Second, as the baseline measurements were taken between 1 and 8 weeks after the start of a new job, a short-term effect of shift work cannot be excluded. Work related confounders such as job strain, physical activity at work and noise were adjusted for. The author indicated no different results were generated after adjustment, nevertheless no results were reported. More importantly, the mean age of shift workers was significantly older than that of day workers, but it was not adjusted for as a confounder. Another issue of concern is that this cohort study only lasted for one year, which might not be long enough to show significant changes in cardiovascular disease risk factors.

CONCLUSION

To our best knowledge, this is the first systematic review examining the effects of shift work on various daily health habits and body mass index. One limitation of this review is the introduction of possible biases through the search strategies. The individual authors may have different interpretations in the review process, nevertheless both tried their best to search the published scientific literature on this topic comprehensively and exhaustively. In addition, the inclusion criteria guided the independent reviewers through the review process, so that the validity of the conclusions could be strengthened and possible biases could be minimised. Another limitation is the inability to interpret two non-English articles retrieved, despite the efforts made. The results from these articles could not be analysed and strengths or limitations could not be concluded.

This review has unfolded a number of research studies in the literature from which evidence quantifying the association between shift work and people's daily health habits and adverse health

outcomes could be obtained. Despite various research on the diverse aspects of diet, most of the results indicated that shift work affected nutritional intake in a negative way. As for BMI and smoking, most of the researchers agreed that shift work was associated with high BMI and a high prevalence of smoking. This review retrieved only a few studies that examined the association between shift work and exercise or alcohol consumption; as a result, conclusions on these outcomes could not be drawn and further research should be directed into these two areas.

In addition, the review did not find any studies conducted with Australian working populations. Australia has a large proportion of shift workers in its labour force; and undoubtedly, shift workers' health and well-being require due consideration. Particularly, as the majority of Australian nurses work rotating shifts, understanding the impact of shift work on daily health habits that lead to adverse health outcomes is important.

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