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Review Article

Association between fixed night work and obesity: a systematic literature review

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ABSTRACT

This systematic review aimed to evaluate the association between fixed night work and overweight or weight gain. PubMed and EMBASE were searched until October 2021 for studies evaluating the association between fixed night work patterns and the risk of overweight or obesity (for cross-sectional designs) or weight gain (for longitudinal designs). The outcomes extracted were mean body mass index (BMI), mean BMI difference, overweight %, obesity %, odds ratio, relative risk, and prevalence ratio. The quality of the report was evaluated using the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist. The protocol was registered at PROSPERO (# 42017080515). In total, 25 studies met the inclusion criteria. All studies were observational, 16 were cross-sectional, three were cohorts (two also had baseline cross-sectional data), and the other eight were cross-sectional at baseline and had longitudinal follow-up studies (six prospective cohorts, one retrospective, one interventional). Most had good reporting quality. The fixed night work definition and weight outcomes varied according to the different studies. Most of them found an association between fixed night work and overweight, obesity, or weight gain. This systematic review reinforces the evidence that fixed night work is associated with overweight or obesity, and prolonged night work exposure leads to weight gain. Future research should be conducted with more accurate measures and a prospective design. Fixed night workers should be monitored and advised, especially those with prolonged exposure.

Keywords: *Obesity; overweight; weight gain; fixed night work*

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INTRODUCTION

Night work has become increasingly prevalent among workers due to the demand for 24 hours/day products and services in contemporary society. It is estimated that between 15% and 30% of the workforce in the industrialized world involve shift work[1], which is equivalent to more than 700 million workers[2].

Growing evidence shows the adverse effects of night work on human health, especially those that alter the individual's metabolism, such as obesity[3-6]. Obesity is a very prevalent problem in Western societies and is rapidly growing in Eastern societies, such as China[2]. Besides being part of the metabolic syndrome, it is a condition associated with morbidity and cardiovascular mortality and an increased risk of malignancies, such as breast malignant neoplasia[7-11]. Obesity also contributes to the negative effects observed in productivity and capacity, as well as increasing the risk of workplace accidents[5,12-14].

Several studies have been proposed to evaluate the associations between night work and overweight or obesity, including weight gain. Although the causal mechanisms linking night work to obesity are not fully understood, they seem to have a multifactorial origin. Some authors state that the behavioral changes observed in night workers, such as circadian rhythm desynchronization, sleep deprivation, and sedentary lifestyle, may induce metabolic alterations[12,15,16].

One of the problems frequently observed in many studies evaluating night work and health problems is that the authors usually include shift workers (day and night) and not just night workers under the same exposure group. Shift work includes schedules that are different from the usual eight hours per day,

including night shift, rotating shift (in the three 24-hour phases) and irregular or alternative works[17]. Fixed night work means working predominantly at night, at the same time every day. Individuals under this type of work can work for a period (such as for a month or seasonally) or permanently follow this routine[18].

Exposure to fixed night work has few exclusive studies, and growing evidence suggests that health effects may be different among individuals working only at night and those working in alternating shifts[2]. It has already been observed that fixed night work may be more associated with weight gain and increasing smoking habits than alternating shifts[19].

Van Drongelen et al.[20] showed in a systematic review that shift work was associated with weight gain in the raw analyses of some of the evaluated studies, but this association was lost when the possible confounding factors were included in them; Esquirol et al.[21] observed in a systematic review of studies published from 2000 to 2010 a deleterious association between shift work and increased body mass index; and Sun et al.[2] observed in a systematic review with a more recent meta-analysis a higher association between night work and weight gain in cross-sectional studies compared to cohort studies (OR, 1.26 and 1.10, respectively). In addition, they observed a possible dose-association response between night work and the risk of obesity/overweight, that is, the longer the night work, the greater the association with obesity; however, they made no distinction between shift work or night work.

This systematic review aims to study the association between fixed night work and its possible effects on body weight, proposing to identify and better analyze the evidence gap between fixed work and overweight, obesity, and weight gain via the grouping of endpoints and risk estimates of individual studies.

METHODS

Search strategy and inclusion criteria

Two authors (F.F.D.F and M.V.B) searched the literature in the PubMed and EMBASE databases and independently evaluated the studies potentially eligible for inclusion. The discrepancies were solved by the evaluation of a third author (T.C.R). The definition of the research strategy followed the PICOS methodology (Population, Intervention, Comparison, Outcome, Study type), and a search strategy was built, including fixed shift workers whose outcome evaluation included obesity, overweight, or weight gain compared to one control group of day workers, both for observational and experimental studies.

Night work, fixed night work for intervention, overweight, obesity, and weight gain were used for the outcome as terms of interest. The first stage of the evaluation included all studies that: 1 – involved workers at fixed night shifts; 2 – included measures that allowed the evaluation of overweight, obesity, or weight gain; and 3 – comparatively evaluated the outcomes between fixed night work and control groups consisting of daytime work. There was no limitation regarding year, language, or place of publication. All study categories, conference summaries, brief communications, and original articles were included.

Among the definitions of the outcome, overweight was considered as body mass index (BMI) ≥ 25 kg/m^2; obesity as BMI ≥ 30 kg/m^2; and weight gain as an increase over 5 kg in the individuals' follow-up period. For the evaluation of these outcomes, all available information was extracted from the individuals studied, such as mean weight, mean BMI, percentage of individuals with normal weight, overweight or obesity, mean BMI variation, abdominal measurement, and measures of comparison between these available outcomes, such as odds ratio, relative risk, and prevalence ratio.

The following information was extracted from each study: 1 – study title; 2 – first author's name; 3 – year of publication; 4 – type of publication; 5 – place of publication; 6 – study design; 7 – financing; 8 – population of workers and sector of work; 9 – country of study population; 10 – original language of publication; 11 – report quality (STROBE checklist); 12 – number of day workers; 13 – number of fixed night workers; 14 – definition of fixed night work; 15 – length of work in the same shift, in years; 16 – duration of the work shift; 17 – mean age; 18 – outcomes of interest; 19 – measures of association of outcomes (available or estimable); 20 – physical exercises; 21 – alcohol consumption; 22 – smoking; 23 – adjusted variables in the sensitivity analysis of the outcomes. All this information was transferred to a standardized form specially prepared for this purpose (Attachment 1).

Evaluation of publication quality

The quality of the report was evaluated via the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) since all included studies were observational[22]. The STROBE checklist contains 22 items, 34 subdivisions for cohort studies or cases and controls, and 32 subdivisions for cross-sectional studies. Nixdorf et al.[23] used the following methodology to classify the quality of the study with the score obtained in the checklist: studies that filled ≥ 80% of the total items were classified as "good"; those scoring 80–50% were considered "reasonable"; and those that filled < 50% of the items were considered "bad." The scores equivalent to these categories were ≥ 27 items, 17–27 items, and < 17 items for cohort or case-control studies; or ≥ 26 items, from 16 to 26 items, and < 16 items for cross-sectional

studies. The comparative analysis of the publication quality evaluations between the two reviewers did not show significant differences.

RESULTS

Characteristics of individual studies

We found 291 articles using the search strategies (Figure 1): 69 from the PubMed database and 222 from EMBASE. Of these, 43 were duplicates and were excluded, leaving 280 articles. The two reviewers read all the titles and abstracts, excluding those that did not include night workers or did not distinguish between shift work and fixed night work, without outcome measure, or that did not associate with the control group of day workers, totaling 196 excluded articles. Thus, 83 articles were left for complete reading by both reviewers. Of those, 58 articles were additionally excluded for the following reasons: 1 – additional data from the groups could not be obtained, even after contacting the author (period of four weeks between the request and the exclusion). 2 – lack of group of fixed night workers; 3 –group of night workers included was working in alternating shifts; 4 – lack of control group for outcomes comparison; 5 – lack of outcome measure of interest available; 5 – review article; and 6 – work involved animal models. Thus, 26 articles were eligible for the systematic review.

Among the studies evaluated, 15 were cross-sectional in their main design, three were cohorts (two of these had data with a cross-sectional outcome of interest), and eight were cross-sectional studies nested in longitudinal studies (six prospective cohorts, one retrospective cohort, and one interventional study) (Table 1). No case-control studies were identified with the criteria used. Ten studies[14,19,24-31] included health professionals, of which only one[30] excluding nurses, nursing assistants or midwives, but among social workers. Five studies included industry workers[17,32-35]; a study in Italy was conducted with waste collectors[36]; two studies, one in Brazil and one in England, were conducted with bus and truck drivers, respectively[12,37], and a study in the United States was conducted among police officers[38].

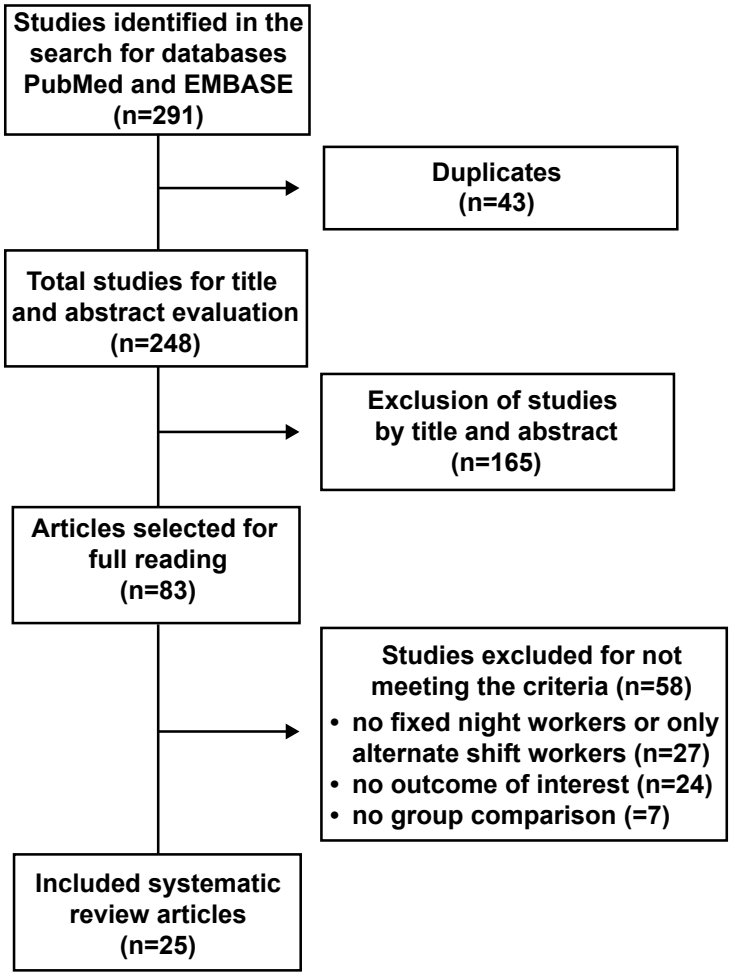

Figure 1: Diagram of search and selection of articles for systematic review.

Table 1 - General characteristics of the studies.

Author (year)	Design	Population (location)	Study duration	Day work population	Night work population	Night work definition	Same shift work duration (years)	Shift duration	Reporting quality (STROBE)
Zhao, Bogossian, and Turner (2012)[24]	Cross-sectional (baseline characteristics of a cohort study)	2,086 female nurses or midwives (Australia, New Zealand, and New England)	Baseline survey April 1, 2006 to March 30, 2008),Nurses and Midwives' e-cohort study (NMeS)	1,212	115	Participants were asked to choose between the categories. Those who chose night shifts only were included in night only shift work.	N/A	Day work: full-time 715 (59); part-time 408 (33,7); casual 85 (7,0); Night work: full-time 30 (26.1); part-time 65 (56.5); casual 20 (17.4)	Reasonable
Fujino et al. (2006)[18]	Cross-sectional (baseline characteristics of a cohort study)	17,649 male mixed occupation workers (Japan)	Baseline survey Japan Collaborative Cohort Study for the Evaluation of Cancer Risk (JACC Study), 1988–1990	14,774	864	Self-administered questionnaire: shift (time of day) worked most	N/A	N/A	Reasonable
Benvegnú et al. (2016)[17]	Cross-sectional	193 paper pulp manufacturing workers, 3 areas: administrative, production, logistics. (Brazil)	45 days	160	33	Night work between 12 AM and 8:30 PM	N/A	08:30h	Good
Peplonska, Bukowska, and Sobala (2015)[25]	Cross-sectional	724 female nurses and midwives (Poland)	2008–2011	370	354	Fast rotating 12 hour-long duties between 7 PM 7 AM;	Night work total duration: mean 25.4 (7.1) years; day work: mean 12.1 (8.2)	12h	Good
Wang et al. (2012)[39]	Cohort	41,652 female mixed occupation workers aged 50-64 years (England and Scotland),	1996–2001, analyzed sample: reported night work in 2009–2010	36,155 "never night workers"	5,497 "ever night workers"	Ever regularly worked at night or on night shifts, at any time between 12 AM and 06 AM, for at least 3 nights per month.	< 10 years: 3,540; 10–19 years: 1,053; ≥ 20 years: 744	"Any time between 12 AM and 6 AM"	Good
Varela-Mato et al. (2017)[37]	Cross-sectional	159 male heavy goods vehicle drivers (United Kingdom)	May and August 2014	42	24	Night work: 10 PM-6 AM	N/A	08h	Good
Brum et al. (2015)[26]	Cross-sectional	178 health professionals of a university hospital (Brazil)	April 2013 and December 2014	108	80	"Night work", definition N/A	N/A	N/A	Poor***

Continue

Table 1 - Continuation

Author (year)	Design	Population (location)	Study duration	Day work population	Night work population	Night work definition	Same shift work duration (years)	Shift duration	Reporting quality (STROBE)
Macagnan et al. (2012)[32]	Cross-sectional	1,206 (35% male, 65% female) poultry-processing plant workers, (Brazil)	January and May 2010	406 (275 female,131 male)	800 (511 female, 289 male)	Night work between 6 PM and 05 PM	Mean years: day work: 3.5; night work: 3.6	11h	Good
Padilha et al. (2010)[33]	Cross-sectional	15 male steel plant workers aged 25-35 years (Brazil)	2 weeks, year N/A	6 early morning shift workers (6 AM to 2 PM)	9 night shift workers	Night work: 10 PM–6 AM	Early morning work: 3.7 (SEM 0.58); Night work: 4.2 (SEM 0.8)	08h	Good
Biggi et al. (2008)[36]	Cross-sectional	488 street cleaning and domestic waste collection male workers (Italy)	1976–2007	157	331	Night work: 11:35 PM – 05:35 AM	Day work: 14.0 (2–27); Night work: 10.1 (1–26.0)	6h	Reasonable
Hansen et al. (2016)[27]	Cross-sectional (baseline characteristics of a prospective cohort study)	19,837 female nurses (Denmark)	1993–2013 (cross-sectional information of 1993 and 1999)	12,414	1,098	Nurses who were working at the time of recruitment were asked to answer following question about shift work: 'Do you normally work in: (a) day, (b) evening, (c) night or (d) rotating shifts?'	N/A	N/A	Good
Peplonska et al. (2016)[28]	Cross-sectional	532 female nurses and midwives (Poland)	2008–2011	269	263	Fast rotating 12 hours night shift followed by a day off, 7 PM– 7 AM.	Premenopausal/ postmenopausal: Day work: 30.4y/12.9y; Night work: 23.4y/11.0y	12h	Good
Ramin et al. (2015)[19]	Cross-sectional	54,724 female nurses (USA)	1989–2009 (NHS II, cross-sectional informations recalled in 2009)	15,391	39,333 "ever night shift work"	Women who reported a primary shift schedule with rotating night shifts or nights only (ie, permanent nights) were categorized as 'ever' night shift workers.	N/A	N/A	Good

Continue

Table 1 - Continuation

Author (year)	Design	Population (location)	Study duration	Day work population	Night work population	Night work definition	Same shift work duration (years)	Shift duration	Reporting quality (STROBE)
Åkerstedt et al. (2015)[8]	Cross-sectional (baseline characteristics of a prospective cohort study)	13,656 female mixed occupation workers (Sweden)	1998 to March 2003 (cross-sectional information at baseline)	10,252	3,404	Nightwork: 10 PM-6 AM	N/A	N/A	Reasonable
Balieiro et al. (2014)[12]	Cross-sectional	150 male bus drivers (Brazil)	April 2012 to December 2012	69	81	Night work (self-administrated questionnaires)	Years (SD): Day work: 13.3 (9.7); night work: 16.1 (9.3)	Daily workload hours (SD): day work: 7.2h (1.3); night work: 7.8h (1.3)	Reasonable
Chen et al. (2010)[34]	Cross-sectional	1,838 female semiconductor manufacturing workers (Taiwan)	August 2006 to November 2006	401 office workers	561	7 PM to 7 AM	All 7.4 (5.2); office worker: 6.6 (5.4); night worker: 6.3 (4.8)	12h	Reasonable
Lasfargues et al. (1996)[40]	Cross-sectional	1,352 male and 1,048 female mixed occupation workers (France)	September 1991 to November 1993	1,200 (524 female, 676 male)	1,200 (524 female, 676 male)	N/A	N/A	N/A	Reasonable
Kawabe et al. (2014)[4]	Cross-sectional (baseline characteristics of an interventional study)	4,427 (81.4% male) full-time mixed occupation workers (Japan)	1999–2000	3,094	73	N/A	N/A	N/A	Reasonable
Bekkers et al. (2015)[5]	Cross-sectional (baseline 2008) and prospective longitudinal, 1 year 2008–2009	5,951 mixed occupation workers (Netherlands)	2007–2009	2,404	2459	Working at night (stable night) in the past year (self-administrated questionnaire)	N/A	N/A	Good
Huth et al. (2013)[29]	Cross-sectional	378 pediatric nurses (USA)	N/A	220	158	"Any shift worked at least 8 hours between 7 PM to 7 AM"	N/A	N/A	Reasonable
Nabe-Nilsen et al. (2011)[30]	Cohort (baseline description 2004)	2,062 female social and healthcare workers (Denmark)	2004–2006	1,096	84	Participants were asked about typical work schedules: "fixed night work". Usual night shift from 11 PM to 07AM.	2004: graduation; 2005 1-year follow-up, 2006: 2 years follow-up	8h	Good

Continue

Table 1 - Continuation

Author (year)	Design	Population (location)	Study duration	Day work population	Night work population	Night work definition	Same shift work duration (years)	Shift duration	Reporting quality (STROBE)
Fekedulegn et al. (2013)[38]	Cross-sectional (baseline characteristics of a retrospective cohort study)	424 (107 female, 317 male) police officers (USA)	2004–2009	191 (67 female, 124 male)	111 (23 female, 88 male)	Night work: work start time between 8 PM and 3 AM, 10-hour permanent (nonrotating) shifts.	Years (SD): Day work: 17.3 (9.3); night work: 12.8 (5.9)	10h	Good
Canuto et al. (2014)[35]	Cross-sectional	905 (63% female) poultry-processing employees (Brazil)	January to May 2010	325	580	Those who worked more than 90% of their hours in the evening or at night (i.e., those who started their shift after 5 PM).	N/A	N/A	Good
Siqueira et al. (2016)[14]	Cross-sectional surveys (S1-2006 and S2-2013), interval of 6.95 years	372 (83.6% female) nursing professionals (Brazil)	2006 (S1)-2013 (S2)	N/A	N/A	Participants were asked “do you regularly work night shifts (once per week/ four times per month at least)?”. Night workers answered “yes” in both surveys, 7 years apart (N/N group).	7 years at least, from survey 1 to survey 2	N/A	Good
Marqueze et al. (2012)[31]	Cross-sectional	446 female nursing professionals (Brazil)	N/A	279	166	To work between 19:00 and 07:00h. Work system: 12-hour on duty per 36-hour off	Years (SD): Day work: 4.5 (4.9); night work: 6 (5.2)	12h	Good
Correia et al. (2020)[41]	cross-sectional	database of the Brazilian National Health Survey	2013–2014	N/A	N/A	N/A	N/A	N/A	Good

In total, six studies reported results with workers of different occupations[4,5,8,18,39,40]. Ten studies included only females[8,19,24,25,27,28,30,31,34,39], whereas five[12,18,33,36,37] included only males. Ten studies included workers of both sexes[4,5,14,17,26,29,32,35,38,40]. A study was conducted in Australia, New Zealand, and also included workers from England[24], whereas two other studies were conducted in the UK alone[37,39]; two studies by Peplonska, Bukowska, and Sobala[25] and Peplonska et al.[28] were performed in Poland, one in Italy[36], two in Denmark[27,30], one in Sweden[8], one in France[40], and one in the Netherlands[5]; two studies were conducted in Japan[4,18], one in Taiwan[34], while three studies were conducted in the United States[19,29,38], and most studies—eight in total—were conducted in Brazil[12,14,17,26,31-33,35]. Regarding the quality of the publication, 15 articles had good report quality according to the STROBE statement; eight were classified as reasonable, and only one as poor, excepting a brief communication, not a full article.

Evaluation of the characteristics of fixed night work

Considering the classification of the International Labour Organization[42], only 13 studies[8,17,25,28-34,36,37,39] clearly defined the duration of night work that included the interval between midnight and 5 AM. Only 10 studies defined (using applied or self-applied questionnaires) the duration as fixed night work[4,5,12,14,18,19,24,26,27,40], without mentioning the shift duration, whereas one study defined the work as 90% performed at night, whose shift start time was after 5 PM[35], and another study considered non-rotating night work as that starting between 8 PM and 3 AM, with duration of 10 hours in a permanent shift.

Regarding duration of the shift, more than half (13 studies) did not report these data[4,5,8,14,18,19,24,26,27,29,35,39,40]. The workers in five studies had an approximate duration of eight hours of work in the night shift[12,17,30,33,37], whereas another five ranged from 10 to 12 hours[25,28,31,32,38]. Regarding the total work time with the same shift in years, these data were available in 14 studies[4,5,8,14,17-19,24,26,27,29,35,37,40], although one of these studies evaluated workers prospectively from undergraduate education to the second year of work after undergraduate educaiton[30].

Outcomes of overweight, obesity, and weight gain

Four studies[12,24-26] found an increased risk of overweight among night workers compared to day workers (BMI 25–29.9 kg/m²). However, Zhao, Bogossian, and Turner[24] identified a 2.0 (CI 0.8–4.7) odds ratio (OR), but also without significance. On the other hand, the study by Brum et al.[26], whose OR was 2.35 (CI: 1.14–4.84), showed a relationship between fixed and overweight work. This result was similar to that of Balieiro et al.[12], with an even higher OR, also significant, of 2.94 (CI 1.14–7.66). One study[34] evaluated the risk of overweight or obesity (BMI ≥ 25 kg/m²) and found an OR of 2.7 (CI 1.6–4.5) among night workers in semiconductor factory production compared to daytime factory office workers. Macagnan et al.[32] evaluated refrigerator workers for being overweight or more (BMI ≥ 25 kg/m²) with a prevalence ratio of 1.27 among night workers with marginal statistical significance (CI: 1.00–1.61) (Table 2).

Table 2 - Outcomes of overweight, obesity, and weight gain.

Author (year)	Mean age	Outcomes	RR, OR, PR mean differences (95% CI)	Adjusted variables
Zhao, Bogossian, and Turner (2012)[24]	Day workers: 45.2 (8.7); night workers: 45.3 (9.0)	RR 1-BMI 25–29.9 kg/m²; 2-BMI ≥ 30 kg/m²	1-BMI 25–29.9 kg/m²: RR 1.004 (0.99-1.02); 2-BMI ≥ 30 kg/m²: RR 1.02 (1.002-1.04)	Diet quality, physical activity, smoking, and alcohol consumption
Fujino et al. (2006)[18]	Day workers: 49.6 (5.9); night workers: 48.5 (5.9)	Mean BMI	1- Daytime: 23.0(3.9); 2-fixed-night 23.3(2.8), mean difference −0.3(−0.56 to −0.04) mean BMI and SD	None. Mean Difference estimated with 95% confidence interval
Benvegnú et al. (2016)[17]	All: 34 (11)	% BMI ≥ 30 kg/m²	1: Day workers BMI ≥ 30 kg/m²:12.5%; night workers BMI ≥ 30 kg/m²: 21.2%.	None.
Peplonska, Bukowska, and Sobala (2015)[25]	Day workers: 50.2 (5.3); night workers: 48.3 (5.2)	OR Current NSW frequency ≥ 8 nights/month: 1-BMI 25–29.9 kg/m²; 2-BMI ≥ 30 kg/m²; 3-WC ≤ 88 cm; WC > 88 cm; 4-abdominal obesity WHR > 0.85	1-BMI 25-29.9 kg/m²: OR 2.0 (0.8–4.7); 2-BMI ≥ 30 kg/m²: OR 3.9 (1.5–9.9); 3-WC > 88 cm: OR 2.4 (1.2–4.5); 4-WHR > 85: OR 2.4(1.2–4.9)	Age, smoking, packs per year, marital status, body silhouette at 20 years, current MHT use

Continue

Table 2 - Continuation

Author (year)	Mean age	Outcomes	RR, OR, PR mean differences (95% CI)	Adjusted variables
Wang et al. (2012)[39]	All: 68,6	1-Mean BMI; 2-OR BMI ≥ 30 kg/m² (ever x never night workers) by work duration < 10y; 10–19y, ≥ 20y	1- NNW: 26.6(4.8); ENW: 27.3(5.2); mean difference −0.7(−0.84 to −0.56); 2-OR BMI ≥ 30kg/m², NNW × ENW: 1.26 (1.15–1.37); < 10 years x ENW: 1.17 (1.05–1.31); 10-19 years × ENW: 1.29 (1.07–1.57); ≥ 20 years × ENW: 1.55 (1.25–1.93);	Age, socioeconomic status
Varela-Mato et al. (2017)[37]	Morning workers: 51.0 (27.0-65.0); night workers: 49.5 (25.0-60.0)	Mean BMI	1- Morning workers: 27.8 (22.0–38.7); 2- night workers: 27.4 (19.6–38.6).	None
Brum et al. (2015)[26]	N/A	1- Mean BMI; 2- Mean WC; 3- OR BMI 25–29.9 kg/m²;	1- BMI (SD): Day workers: 26.8(4.8); night workers: 28.9(4.8); estimated mean difference: −2.1 (−0.70–−3.50); 2- WC (SD): Day workers: 91 (12.3); Night workers: 92.2 (12.3); estimated mean difference: −6.2 (−9.78–−2.62); 3- OR BMI 25–29.9 kg/m²: 2.35 (1.14–4.84)	Age, sex, sleeping less than 5h/24h
Macagnan et al. (2012)[32]	All: 30.5 (8.7)	1- PR BMI ≥ 25 kg/m²; 2- PR WC ≥ 88 cm female; WC ≥ 102 cm male	PR (CI) day × night 1- BMI ≥ 25 kg/m²: 1.27 (1.00–1.61); 2- WC ≥ 88/ ≥ 102 male: 1.45 (1.10–1.92)	Sociodemographic, parental overweight status, behavioral characteristics, and sleep characteristics, including hours of sleep.
Padilha et al. (2010)[33]	Early morning workers: 31.8 (SEM 1.5); night workers: 30.1 (SEM 1.4)	1- Mean BMI; 2- Mean WC	1- BMI (SEM): early morning workers: 27.6 (1.16); night workers: 26.1(1.4); 2- WC (SEM) early morning workers (cm): 92.7 (3.2); night workers: 89.5 (3.2)	None
Biggi et al. (2008)[36]	Day workers: 42.3 (22.7-59.7); night workers: 47.0 (22.5-62.2)	All medical check-ups from 1976 to 2007: 1- mean BMI (range); 2- mean BMI difference	1- day work: 25.3 (17.2–42.2); night work: 27.0 (17.0–44.3); 2- Mean BMI difference (range): 1.25 (0.63, 1.87)	Period, branch, age, latency (2,328 medical check-ups); job (1,599 medical check-ups);
Hansen et al. (2016)[27]	Day workers: 51.3 (5.2); night workers: 54.3 (5.9)	1- n (%) BMI 25–30 kg/m²; 2- n (%) BMI > 30 kg/m²	1- n (%) BMI 25-30 kg/m²: day workers 2723 (21.9%); night workers: 271 (24.6%); 2- n (%) BMI > 30 kg/m²: day workers: 640 (5.1%); night workers: 82 (7.4%).	None
Peplonska et al. (2016)[28]	1- Premenopausal (SD): day workers: 46.4 (3.9), night workers: 45.9 (4.0); 2- postmenopausal (SD): day workers: 55.1 (2.9); night workers: 54.5 (2.8)	Mean BMI	1- Premenopausal: day work: 26.8 (4.5); night workers: 26.2 (4.4). Mean BMI Difference: 0.6 (−0.35– 1.55); 2- postmenopausal day workers: 28.0 (5.1); night workers: 29.4 (5.2). Mean BMI Difference −1.4 (−2.92–0.12)	None
Ramin et al. (2015)[19]	NNW: 56.0 (4.3); ENW: 54.9 (4.4)	1- Mean BMI; 2- OR BMI > 30 kg/m²	1- NNW: 27.0 (6.0); ENW: 28.1 (6.7); mean difference −1.1 (−1.21–−0.99); OR BMI ≥ 30 kg/m²: 1.37 (1.31–1.43)	Age, education level of the nurse's spouse/partner, physical activity and chronotype.

Continue

Table 2 - Continuation

Author (year)	Mean age	Outcomes	RR, OR, PR mean differences (95% CI)	Adjusted variables
Åkerstedt et al. (2015)[8]	Day workers: 51.8 (4.7); night workers: 51.1(4.9)	1- n (%) BMI 25–30 kg/m²; 2- n (%) BMI ≥ 30 kg/m²	1- n (%) BMI 25-30 kg/m²: day workers: 2698 (27%); night workers: 956 (29%); 2- n (%) BMI ≥ 30 kg/m²: day workers: 705 (7%); night workers: 297 (9%);	None
Balieiro et al. (2014)[12]	Day workers: 46.7 (9.9); night workers: 44.0 (8.5)	1- Mean BMI; 2- Mean WC; 3- OR BMI 25–30 kg/m²; 4- OR BMI ≥ 30 kg/m²/ 5- OR WC ≥ 94 cm	1- BMI (SD): day workers: 27.9 (4.2); night workers: 28.9 (3.4); mean difference: −1.0 (−2.23–−0.23); 2- WC day workers: 98.5 (10.7); night workers: 103.2 (9.7); mean difference: −4.7 (−7.99–−1,41); 3- OR BMI 25-29.9 kg/m²: 2.94 (1.14–7.66); 4- OR BMI ≥ 30 kg/m²: 1.47 (0.72–2.99); 5- OR WC ≥ 94 cm: 2.82 (1.20–6.69)	Age
Chen et al. (2010)[34]	All: 33.6 (7.1); office workers: 33.5 (6.7); night workers: 32.7 (6.3)	1- OR BMI ≥ 25 kg/m²; 2- WC ≥ 80 cm	1- OR BMI ≥ 25 kg/m²: 2.7 (1.6–4.5); 2- OR WC ≥ 80 cm: 2.9 (1.7–5.1)	Adjusted for age, smoking, drinking, education, and duration of employment.
Lasfargues et al. (1996)[40]	Day workers: N/A; night workers: male: 39.4 (5.7); female: 38.2 (5.5)	1- Mean BMI male; 2- Mean BMI female	1- BMI(SD) male day workers: 24.8 (3.2); male night workers: 25.3 (3.3); Mean difference: −0,5(−0,85–−0.15); 2- female day workers: 22.7 (3.8); female night workers: 23.7 (4.2); mean difference: −1 (−1.49–−0,51);	None
Kawabe et al. (2014)[4]	Day workers: 42.6 (8.9); fixed night workers 50.8 (6.8)	Mean BMI	BMI (SD): day workers: 22.7 (3.06); night workers: 22.8 (2.91); mean difference: −0,1 (−0,81 to 0.61);	None
Bekkers et al. (2015)[5]	Median (IQR*): night workers: 44.0 (18.0); no night workers: 47.0 (17.0)	1- Mean BMI; 2- % BMI 25-29.9 kg/m²; 3- % BMI ≥ 30 kg/m²; 4- weight change from “day work” to “night work”	1- BMI (SD): stable no night workers: 76 (13.9); stable night workers: 78 (14.3); 2- %BMI 25–29.9 kg/m² stable no night workers: 35.9%; stable night workers: 33.3%; 3-% BMI ≥ 30 stable no night workers: 9.5%; stable night workers: 9.2%; 4- weight change from day work to night workers: 0.6 kg (3.0); β (95% CI): 0.26 (−0.03–0.55)	Sex, age, education, and physical workload.
Huth et al. (2013)[29]	Night workers: 36.56; day workers: 40.25	n (%) BMI ≥ 30 kg/m²	n (%) BMI ≥ 30 kg/m²: day workers: 58 (28.9%); night workers: (25.8%)	None
Nabe-Nilsen et al. (2011)[30]	Fixed day workers: 35.6 (10.1); fixed night workers: 37.0 (9.3)	1- n (%) BMI ≥ 25.0 kg/m² in 2004–2005; 2- n (%) weight gain (from normal weight and overweight) 2004–2006; 3- OR weight gain (from normal weight and overweight) 2004–2006.	1- n (%) BMI ≥ 25.0 kg/m² in 2005: fixed day workers: 491 (48%); fixed night workers: 47 (58.8%); 2- normal weight – fixed night workers: 15 (50.0%); overweight – fixed night workers: 21 (44.7%); 3- OR: normal weight – fixed night workers: 1.41 (0.31–6.46); overweight – fixed night workers: 0.78 (0.27–2.26);	Age, education, general influence, emotional demands, demands for hiding emotions, and social support from leaders and colleagues.

Continue

Table 2 - Continuation

Author (year)	Mean age	Outcomes	RR, OR, PR mean differences (95% CI)	Adjusted variables
Fekedulegn et al. (2013)[38]	Day workers: 44.6 (8.8); night workers: 40.0 (6.2)	Mean BMI	BMI (SD): day workers: 29.1 (5.1); night workers: 29.3 (4.1); mean difference: −0,2(−1,32–0.92);	None
Canuto et al. (2014)[35]	All (SD): 31 (8.7)	% BMI ≥ 30 kg/m²	%BMI ≥ 30 kg/m² (CI): day workers: 9.8% (6.6-13.1); night workers: 11.2% (8.6–13.8)	None
Siqueira et al. (2016)[14]	At baseline survey 1, all: 43.6 (10.6)	OR(SD) day to night work (D/N), survey 1 (S1) to survey 2 (S2): 1: weight gain > E5 kg*; 2: OR(SD) Increase in BMI category	1- OR(CI) D/N: 1.93 (0.93–4.02); 2- 2.28 (1.08–4.78)	Adjusted for sex, race, and age.
Marqueze et al. (2012)[31]	All (SD): 34.8 (9.5)	1- n (%) BMI>25 kg/m²; 2- Adjusted β*, linear regression analysis of BMI (kg/m²): duration of work on night shift (years)	1- n (%) BMI>25 kg/m²: day workers: 126 (33.1%); night workers: 74 (44.5%); 2- β (CI): 0.24 kg/m² (0.12–0.37)	Smoking, physical activity level, education, marital status and second job.
Correia et al. (2020)[41]	aged 25 to 44 years (50.7%)	BMI and WC	Overweight: until 1 night/ week [(OR: 38.9 (CI 95%34.2-43.8); ≥ 2 Night work/week, (OR: 40.0 CI95% (37.3–42.7)]. Obesity: 1 night work/week [(OR:21.6 CI95% (17.5–26.2) and ≥ 2 Night work/week 22.7 CI 95%(20.3–25.3)]	sex, age, self-reported race, and region of Brazil, education, job type, work week hours, and self-rated health, smoking, leisure physical activity, and abusive alcohol consumption

BMI: Body mass index; CI: Confidence interval; OR: Odds ratio; RR: Risk ratio; PR: Prevalence ratio; SEM: Standard error of the mean; IQR: Interquartile range; WC: Waist circumference; WHR: Waist/hip ratio; MHT: Menopausal hormone replacement therapy; NNW: Never night worker; EVW: Ever night worker.

When considering obesity as the outcome (BMI ≥ 30 kg/m²), Zhao, Bogossian, and Turner[24] found an increased obesity risk (RR 1.02, CI: 1.002–1.04) among nursing assistants and midwives compared to day workers, but unlike the risk of overweight, it had a significant difference. Besides this study, other five studies[12,19,24,25,39] also found an increased risk for obesity among night workers, being the highest risk (OR 1.55, CI: 1.25–1.93) reported in the study by Peplonska, Bukowska, and Sobala[25], who found an OR of 3.9 (CI: 1.5–9.9) among Polish nurses and midwives who worked at night compared to those who worked at day.

In total, 10 studies presented a mean BMI and standard deviation (SD)[4,12,18,19,26,28,36,38-40], in which it was possible to estimate the difference between the means with a 95% confidence interval (CI). Expecting one study[28], all studies showed a difference between the means of BMI significantly worse among night workers, the largest of which was reported by Brum et al.[26] (−2.1, IC: −0.70–−3.50). Regarding the study by Peplonska et. al.[28], who found the difference separately between premenopausal and postmenopausal nurses and midwives, the difference between mean BMI of day and night workers was not significant, but showed no tendency for premenopausal female workers to have the increased risk with exposure to night work, unlike postmenopausal women, who had a higher mean BMI than those who worked during the day: 0.6 (CI: −0.35–1.55) and −1.4 (CI: −2.92–0.12), respectively. Lasfargues et al.[40] evaluated the difference between mean BMI separately in male and female workers −0.5 (CI: −0.85–−0.15) and −1 (CI: −1.49–−0.51), respectively.

Dose-response between fixed night work and obesity, overweight, or weight gain

Six studies[5,14,25,30,31,39] evaluated the association between the intensity of nocturnal exposure and the impact on workers' weight. Peplonska, Bukowska, and Sobala[25] evaluated the risk of obesity (BMI ≥ 30 kg/m²) when compared with workers with 2–7 shifts of night work per month and those with ≥ 8 shifts per month. The risk was significantly higher in the group with less shifts per month (OR 1.4, CI: 0.9–2.1), even after adjustment for age (OR 3.9, CI: 1.5–9.9), smoking, number of packs per year, marital status,

body silhouette at 20 years of age, and current use of estrogen replacement therapy.

Wang et al.[39] showed the dose-response effect when comparing the risk of obesity (BMI ≥ 30 kg/m²) in workers who never worked night shifts with those who always worked night shifts, the latter being subdivided into three time categories: < 10 (OR 1.17, CI: 1.05–1.31), between 10 and 19 years (OR 1.29, CI: 1.07–1.57) and > 20 years of cumulative night work (OR 1.55, CI: 1.25–1.93), showing that the longer the exposure time to night work, the greater the risk of obesity.

On the other hand, Bekkers et al.[5] observed the behavior of the weight of Dutch workers (miscellaneous occupations) in 2008 and 2009. Those who switched from fixed daytime work to nighttime work had an incremental mean of 0.6 kilograms (SD 3.6) in weight, but this association was not significant β 0.25 (CI: −0.04–0.54), even when adjusted for sex, age, schooling level, physical activity, occupational demand, β 0.26 (CI: −0.03–0.55), or stratified by BMI.

Nabe-Nilsen et al.[30] also found no risk of weight gain among Danish social workers in fixed shift work when evaluating two years of follow-up, from 2004 (baseline) to 2006. The study found that 60.4% of day workers with normal BMI gained weight, whereas only 50% of those in the fixed night work with normal BMI gained weight. The same occurred when comparing workers who were already overweight at the baseline in 2004, in which 54.7% of daytime workers gained weight, and only 44.7% of fixed night work had the same outcome. Contrary to most studies included in this systematic review, the adjusted risk analysis showed that exposure to night work was not associated with the risk of obesity. Overweight women at baseline had a decreased risk of weight gain at the end of the follow-up (OR 0.78, CI: 0.27–2.26), and night workers with normal BMI at baseline had a higher risk of weight loss (OR 2.64, CI: 0.56–12.44) than weight gain (OR 1.41, CI: 0.31–6.46).

Siqueira et al.[14] evaluated the outcomes of weight gain and change in BMI in workers for a longer period than Nabe-Nilsen et al.[30] and Bekkers et al.[5]. Two cross-sectional studies (S1 and S2) were performed in nursers of a Brazilian hospital separated by a 7-years interval. Analysis by sex, race, and age revealed that workers who switched from daytime to nighttime work had more than doubled the chance of increasing their BMI category (OR 2.28, CI: 1.08–4.78), although weight gain (defined as weight gain greater than 5 kg in the period) had marginal statistical significance (OR 1.93, CI: 0.93–4.02). Finally, Marqueze et al.[31] also analyzed nursers in a Brazilian public hospital, who had an average of six years of fixed night shift work, and identified, after adjustment for marital status, schooling level, smoking, dual employment, and level of physical activity, that each year of night work was associated with a 0.24 kg/m^{2}increase in BMI, whereas for each year of daily work, the adjusted increase was 0.15 kg/m^2 per year.

DISCUSSION

This is the first systematic review to include only studies in which individuals performed fixed night work. Systematic reviews evaluating the association between night work and overweight, obesity, or weight gain included individuals working in alternating or rotating shifts[2,20,21]. The most recent study[2] showed that night work increased the risk of obesity/overweight by 23%, whereas the increase in risk when abdominal obesity was analyzed was even higher, 35%. However, although this was the first systematic review to combine the estimated risk quantitatively, more than half of the included studies did not have a consistent definition of night work. This included 10 studies whose subjects worked in alternating shifts, and the combined risk of these studies (OR 1.14, CI: 1.05–1.23) was lower when compared with the combined risk of only three studies[32,34,43] that specified the risk in permanent night workers (OR 1.43, CI: 1.19–1.71).

Van Drongelen et al.[20] evaluated the impact of shift work in a systematic review of longitudinal studies, including night shifts, on workers' weight change, but did not find significant evidence of an association when adjusted for confounding factors such as age, sex, baseline body weight, and physical activity. In another systematic review, Esquirol et al.[21] identified a trend of association between exposure and changes in blood pressure, profile lipid levels (triglyceride levels), metabolic syndrome, and possibly body mass index when evaluating the association between shift work and outcomes associated with cardiovascular risk in studies published from 2001 to 2011. However, both systematic reviews did not show a clear separation between fixed and alternating shift work.

Fixed night work has some differences compared to shift work regarding consequences to human health. When considering the risk of ischemic heart disease (ICD), many studies have shown that individuals performing shift work have several adverse profile characteristics for increased coronary risk compared to fixed daytime work[44-50]. Fujino et al.[18] showed that the association between shift work and ICD remains significant, even when controlling for confounding factors, as three other cohort studies pointed out[51-53]. Another mechanism behind this association is the influence of work on alternating shifts in the circadian rhythm and physiological functions of the human body, especially those associated with the circulatory system, such as blood pressure, heart rate, and hormone metabolism including catecholamines[44,54]. Fujino et al.[18] attributes this to the possibility that fixed shift workers achieve better balance and adaptation to the circadian rhythm compared to those who alternate shifts.

On the other hand, there is growing evidence that fixed night work is associated with overweight and obesity, and there seems to be a cumulative association

between fixed night shift exposure and increased BMI. Most of the cross-sectional studies in our systematic review showed a significant association between fixed work and overweight and obesity, in agreement with the separate results for fixed night work by Sun et al. Studies evaluating this dose-response suggest a positive association between the time of exposure to night work and progressive weight gain. However, this association is more evident in the studies evaluating longer exposure intervals (at least five years), in agreement with the literature. This may explain why two of the studies included in the dose-response evaluation did not corroborate this association[5,30], since they analyzed only up to two years of exposure, and the results differ completely from those presented by Wang et al.[39], which included a group of workers with more than 20 years of exposure to night work, as well as finding progressively higher odds for the risk of obesity the higher the cumulative night work time.

Many confounding factors may have influenced the association between night work and changes in BMI. First, more than half of the studies included in this systematic review did not describe the work shift duration. For example, Bushnell et al.[43] found that shift workers with different work times had different risks for BMI ≥ 30 kg/m^2, showing that the highest risk was among workers with fixed night work and work shift longer than 10 hours. Among the studies included in this review, for example, Varela-Mato et al.[37] identified that truck drivers who worked for about eight hours, in both shifts, had unhealthy behaviors and life habits and important risk factors for cardiovascular disease, with no significant difference between the BMI of the two groups. In contrast, Macagnan et al.[32] found a significantly increased risk of central obesity in women whose work shift was 11 hours, when adjusting for socioeconomic factors, parents' overweight, behavioral characteristics, habits, and total hours of sleep.

Most studies had a cross-sectional design, and few studies evaluated the dose-response relationship of exposure. In addition, many of the effects were not adjusted for important confounding variables, such as sleep deprivation, with much less homogeneity in these factors among the adjusted ones.

In the case of sleep deprivation, the cross-sectional design of these studies does not allow us to analyze those that emerged first, or how causality occurred, if obesity would lead to sleep deprivation, or sleep deprivation and circadian cycle alterations would cause weight gain in night workers[35]. These and other factors, such as the habit of eating at night, the type of food offered to workers, and the behavioral changes adopted by the fixed night worker should be the object of further longitudinal studies.

As a strength, this systematic review presents evidence suggesting the risk of fixed and overweight night work, obesity, or weight gain. Although only fixed or exclusive night work studies have been included, some limitations should be mentioned. First, the great variability between the definitions of fixed night work: only over half the studies clearly defined the duration of night work, which included the interval between midnight and 5 AM. More than half the studies did not report the duration of the work shift, whereas in those that did, the data showed variability between 8, 10, and 12 hours of shift. The relationship to the total work time in the same shift is similar, with 14 studies not bringing these data. In addition, we could not systematically evaluate the existence of double working hours, which could significantly alter the result found in the individual studies from this adjustment. However, the same problem is also reported by Sun et al.[2], in which more than half of the studies used vague definitions of shift work, making it difficult to define what nighttime work is. Most studies that constitute this review obtained data from self-reported questionnaires or reports, which could, in theory, compromise the accuracy of the exposure factors (shift, shift length, exposure time to night work, night work at a single job). Finally, cross-sectional studies, which were the majority, failed to determine a cause-and-effect relationship, only suggesting an association, and could be compromised by many factors that were not adequately addressed in the individual studies.

Finally, the quality of the publications analyzed via the STROBE statement checklist was considered good for most studies.

This systematic review showed that fixed night work is associated with overweight and obesity among workers, and this risk seems to maintain a dose-effect relationship with longer periods and frequency of exposure to night work regarding increased BMI in workers. Changes in fixed night work may be required, such as reduction of the total shift, and periodic reassessment of fixed night workers regarding weight gain and adverse effects of overweight and obesity, as well as dietary and activity changes for these individuals. Nevertheless, studies with longitudinal designs and with longer follow-up are required to deepen the study of the causal relationship, especially the large-scale prospective longitudinal cohorts, as well as those that present better measurements of exposure to night work, weight-related outcomes, and consider confounding factors

Conflicts of interest

All authors declare no conflicts of interest.

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ATTACHMENT 1

Complete search strategy for PubMed and Embase Database

PubMed

Last Search Date: 06/07/2019

Intervention – 1,336 studies: “night work” or “night worker” or “night workers” or nightwork* or “nocturnal work” or “nocturnal worker” or “nocturnal workers” or “fixed night work” or “fixed shift work”

Outcome – 336,592 studies: “Obesity”[Mesh] OR “Overweight”[Mesh]) OR “Weight Gain”[Mesh] or “obesity” or “Overweight” OR “Weight Gain”

Final strategy – 69 studies: “Obesity”[Mesh] OR “Overweight”[Mesh]) OR “Weight Gain”[Mesh] or “obesity” or “Overweight” OR “Weight Gain”) AND (“night work” or “night worker” or “night workers” or nightwork* or “nocturnal work” or “nocturnal worker” or “nocturnal workers” or “fixed night work” or “fixed shift work”

Embase

Last Search Date: 06/07/2019

Intervention – 3,922 studies: ‘night work’/exp OR ‘night shift’/exp OR nightwork OR ‘night work’ OR ‘night shift’ OR ‘fixed night work’ OR ‘fixed shift work’ OR ‘night shift work’ OR ‘fixed night shift’

Outcome – 573,927 studies: obesity OR ‘weight gain’ OR overweight OR ‘obesity’/exp OR ‘weight gain’/exp

Final strategy – 222 studies: obesity OR ‘weight gain’ OR overweight OR ‘obesity’/exp OR ‘weight gain’/exp) AND (‘night work’/exp OR ‘night shift’/exp OR nightwork OR ‘night work’ OR ‘night shift’ OR ‘fixed night work’ OR ‘fixed shift work’ OR ‘night shift work’ OR ‘fixed night shift’