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Factors Influencing Overweight and Obesity in Nurses: A Systematic Review and Meta-Analysis

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Abstract

Background: WHO reports a high global prevalence of overweight and, which is prevalent amongnurses and results in poorer health, work productivity and patient care. Existing studies have established the relationships between multiple demographic and work-related factors and overweight and obesity, but no review investigated which factors are associated with overweight and obesity in nurses.

Aims: To identify common factors associated to overweight and obesity in nurses.

Methods: Studies were searched for in CINAHL, Embase, Medline, ProQuest Dissertations and Theses, PsycINFO, PubMed, Scopus, The Cochrane Library and reference lists of relevant studiesand relevant journals. The eligibility criteria were as follows: (1) Research articles, dissertations, or theses with epidemiological or observational study designs, (2) studying a factor and its relationship with overweight and obesity in nurses, (3) with an outcome measurement of BMI wereincluded. (4) Studies written in English and published or unpublished between January 2011 and June 2020 were included. Quality appraisal was assessed using the Joanna Briggs Institute CriticalAppraisal tools (2020). Population traits, exposure variables and the outcome measure of BMI were extracted. Critical appraisal and data extraction were conducted independently by two reviewers. Pooled estimates were generated using RevMan 5.4 software.

Results: This review had a total sample of 153,030 nurses from 35 studies. Shiftwork, age, night shiftwork, sex, marital status, hours worked per week and stress levels were found to be positivelyassociated with overweight and obesity in nurses. Negative relationship between educational leveland overweight and obesity in nurses were observed. Study findings for work unit were inconsistent.

Implications and Conclusions: Individual action and workplace interventions are recommended to prevent and minimize overweight and obesity in nurses. Future research can investigate the causality between the exposures and overweight and obesity. Nursing educators should integrate positive health behaviours into existing curricula.

Keywords: Nurses; Overweight; Obesity; Risk factors

Introduction

The fifth leading cause of mortality worldwide, overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health [1,2]. A major public health challenge in developed and developing countries alike, 1.9 billion adults were overweight and 650 million wereobese in 2016 [2]. Global obesity tripled from 1975 to 2016, with global mean body mass index (BMI) increasing from 25.0 kg/m^2 in 1975 to 29.0 kg/m^2 in 2015 [2,3]. Furthermore, overweight and obesity are expected to continue a worldwide upward trend [4].

Overweight and Obesity in Nurses

Despite having work-related knowledge of health promotion, nurses have the same susceptibility to overweight-obesity due to an obesogenic work environment [5,6]. Healthcare employment andan increased prevalence of overweight and obesity are significantly associated, where the prevalence of overweight and obesity in nurses in some countries is higher than the general population [7]. In Malaysia, 50.6% of nurses are overweight and 2.2% more healthcare professionals (HCPs) were overweight or obese compared to the general population [8,9].

Consequences of Overweight and Obesity in Nurses

Overweight and obesity are associated with increased risk of cardiovascular diseases, stroke, type2 diabetes mellitus, musculoskeletal diseases, cancer, and death [10,11]. Overweight and obesity can adversely affect workforce participation and healthcare institutions, by putting nurses at higherrisks of occupational injury, high absenteeism, limited mobility, lower endurance, ultimately resulting in lower workplace productivity and early retirement [12-15]. With the existing global shortage of nurses, the detrimental impacts of overweight and obesity on the nursing discipline areamplified, reducing the capacity of the workforce, and exacerbating the shortage of nurses [16]. Overweight and obesity in nurses affects patients, by compromising the quality of patient care. Ahigh prevalence of overweight and obesity hampers nurses' public health role in influencing patients through role modelling health-related behaviours [16]. Overweight nurses fear judgementfrom patients and feel untrusted as roles models of weight loss [17,18]. Indeed, the public views overweight nurses as less competent in health promotion and are less likely to take advice from anoverweight nurse [19,20].

Various risk factors for overweight and obesity have been identified, including individual behavior,environment, demographic factors [10]. Working in healthcare has been associated with overweight and obesity, and some risk factors are of particular concern to nurses (e.g., shiftwork, age) [21]. Demographic and work-related risk factors will be expounded on in this review.

BMI (weight [kg]/height [m]^2) estimates ideal weight, based on height, and is often used as a screening tool for overweight and obesity [22]. Overweight and obesity are quantified as BMI 25-29.99 kg/m^2 and ≥30 kg/m^2 respectively [2].

Existing Systematic Reviews and Review Gaps

The modern society promotes excessive food consumption and discourages physical activity, andthe problem of overweight and obesity was first recognized in the 1990s, but only ten years agowas when attention was paid to overweight and obesity in nurses [23,24]. Researchers then beganto investigate the irony of overweight nurses who are meant as role models of health behaviour. In 2016, Hruby and colleagues [25] conducted a review on the determinants of obesity and foundassociations between diet, physical activity, genetics, environmental exposures, and obesity.Demographic and work-related exposures were not considered, and review findings were notquantified via meta-analysis. The methodology employed for the review was not reported, whichraises concerns about the validity of the results.

Amani and Gill [26], Buss [27], Nea et al. [28] and Saulle et al. [29] have conducted reviews on the relationship between shiftwork and overweight and obesity in nurses, with all but Amani and Gill [26] not finding a significant relationship between the two.

Methodological concerns of the reviews include few databases searched and inclusion of only published studies, which raise concerns over the validity of the reviews' results.

To our best knowledge, till date, no systematic review has elicited the demographic and work- related factors correlated to overweight and obesity in nurses, which will inform tailoring of individual and organizational action to tackle this problem.

Significance of Review

The increasing prevalence of overweight and obesity in nurses is a burgeoning problem. The healthcare setting has unique factors leading to the high prevalence of overweight and obesity in nurses. Understanding the relationship between demographic and work-related factors and the increased prevalence of overweight and obesity among nurses will contribute towards tackling thisproblem. Improving the health of nurses is paramount in addressing its implications on public health and the workforce. It will reverse the rise in obesity-related diseases, reduce public health expenditure on expensive obesity treatment and enhance the delivery and quality of health servicesto patients. Future research can build on the results of this review to investigate causal relationshipsbetween these factors and overweight and obesity in nurses. Utilising the results from this review,nurses, hospital administrators, nursing educators and policy makers can tailor action to curb thisweight problem. The objective of this review is to assess the demographic and work-related factorscontributing to overweight and obesity in nurses.

Methods

This review is conducted according to the guidelines provided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement and Joanna Briggs Institute (JBI)methodology for systematic reviews of etiology and risk [30,31].

Eligibility Criteria

Eligibility criteria were specified for population, exposure, outcomes, and type of studies [31]. Thefull eligibility criteria can be found in Appendix I.

• Population: Nurses of all BMI groups. Nurses who are pregnant, have given birth in the past one year, or have Prader-Willi syndrome at the time of data collection, were excludedto prevent confounding of data [32]. Studies were excluded if they had mixed samples without presenting independent data for nurses.
• Exposures: Demographic and work-related variables.
• Outcome: Outcome measures of the association between exposure variables and overweight and obesity, measured as BMI 25-29.99 kg/m^2 and ≥30 kg/m^2, respectively [2].
• Type of studies: English articles published or unpublished between January 2011 to June 2020. No restriction on sample sizes were applied to minimize publication bias.

Searching Strategy and Information Sources

The three-step search recommended by JBI was undertaken [33]. An initial search conducted with PubMed and Google Scholar identified suitable keywords and index terms and ensured no similarsystematic reviews were published in the last five years. The search strategy was constructed according to Peer Review of Electronic Search Strategies (PRESS) checklist guidelines [34]. Medical subject headings, related terms and synonyms were identified based on concepts of 'overweight', 'obesity' and 'nurses', and modified according to the syntax rules of individual databases Next, search strategies were applied to eight databases (Table 1). Embase search strategies are shown in Table 2 and full search strategies for all databases are in Appendix II. Lastly,the reference lists of relevant studies and relevant journals, such as Obesity Medicine, were hand-searched to retrieve all eligible studies for inclusion.

Databases searched for published studies	Databases searched for unpublished studies
Cumulative Index of Nursing and AlliedHealth Literature (CINAHL)	ProQuest Dissertations and Theses
Embase	
Medline	
PsycINFO	
PubMed	
Scopus	
The Cochrane Library	

Table 1: Databases Searched

Concept	Index terms and keywords
Concept 1'Nurses'	('nurse'/exp OR 'nursing staff'/exp OR 'nursing'/exp OR 'health care personnel'/exp OR nurse:ab,kw,ti OR nurse*:ab,kw,ti OR midwi*:ab,kw,tiOR 'registered nurse*':ab,kw,ti OR 'nurse* registered':ab,kw,ti (nursing:ab,kw,ti AND (staff:ab,kw,ti OR personnel:ab,kw,ti OR professional:ab,kw,ti)) OR 'health care personnel':ab,kw,ti OR 'healthcare personnel':ab,kw,ti) AND
Concept 2 'overweight'and 'obesity'	('obesity'/exp OR obesity:ab,kw,ti OR overweight:ab,kw,ti OR obese:ab,kw,ti OR fat:ab,kw,ti OR adiposity:ab,kw,ti OR 'bodyfat':ab,kw,ti)

Table 2: Embase Search Strategies

Study Selection

All identified citations were managed using EndNote X9 [35]. Titles and abstracts were screened,and duplicates removed. Full texts of studies appearing to meet the inclusion criteria were assessedby two reviewers (LT and NI) independently. Authors were contacted via e-mail should full-text copies be inaccessible. Studies not meeting the inclusion criteria were excluded and the reasons for exclusion are found in Appendix III. Any disagreements arising between LT and NI were resolved through discussion.

Data Extraction

The data extraction form (Appendix IV) was derived from the Strengthening of the Reporting of Observational Studies in Epidemiology (STROBE) statement [36]. LT and NI pilot tested the formon three studies to ensure its viability and rigour before conducting data extraction independently [37].

Risk of Bias Assessment

The final 35 included studies were assessed independently by LT and NI for risk of bias using theappropriate JBI Critical Appraisal tools (Appendix V) [31]. Any disagreements between LT and NI were resolved through discussion, or a third reviewer (HC).

Data Synthesis

Synthesis and analysis of data from included studies was conducted using RevMan 5.4 [38]. Heterogeneity was assessed with Chi-Square test of heterogeneity (Chi^2) and I^2. Sensitivity analysis was planned if issues of heterogeneity denoted by Chi^2 test with $p<0.1$ or

I^2>50% occurred [39,40]. Pooled results from included studies were quantified in meta-analysis and the overall effect compared using Z-test with significant p-value <0.05 [41]. Narrative synthesis was performed to where meta-analysis was unable to be conducted [42].

Data analysis was conducted with categorical data type under the random-effects model to accountfor the variability between studies [43]. Odds ratio (OR) and confidence intervals were calculated.Standardized coefficients (β) and standard errors (SE) were calculated according to 95% confidence interval (95%CI) with Equations 1 and 2 respectively, with CI lower limit (l) and CI upper limit (u) [44].

$$(1)\ \beta = \log OR$$

$$(2)\ SE = \frac{lollllR - \log(l)}{1.96} \text{ or } SE = \frac{\log(u) - lollllR}{1.96}$$

Continuous variables presented in Pearson's correlation coefficients (r) were converted to the Fisher's z-scale under fixed-effects model through Equation 3, according to the Hedges-Olkin method [45,46]. The variance (V_z) and SE (SE_z) of z were subsequently calculated with Equations4 and 5 respectively, with sample size (n) [47]. The pooled estimate was converted back to r with Equation 6 [47].

$$(3)\ z = 0.5 \times \ln\left(\frac{1+r}{1-r}\right)$$

$$(4)\ Vz = \frac{1}{n-3}$$

$$(5)\ SEz = \sqrt{Vz}$$

$$(6)\ r = \frac{e^{2zz}-1}{e^{2zz}+1}$$

Sensitivity analysis was conducted by unchecking the studies consecutively during meta-analysis.Studies were removed if sensitivity analysis resulted in an enhancement of heterogeneity. Studieswere compared to determine possible causes of heterogeneity.

Results

Summary of Search Results

The study selection process is presented in a PRISMA flowchart (Figure 1) [30]. A total of 15,616 records were identified. Duplicates were removed and the remaining 7090 studies were screened by title and abstract. Studies not meeting the inclusion criteria were removed. 147 studies were eligible for full-text review. The full texts of nine studies were unavailable and were discarded (Appendix III). Evaluation of full texts of the remaining studies and inclusion of six additional studies identified through additional resources, resulted in 35 studies included in this review.

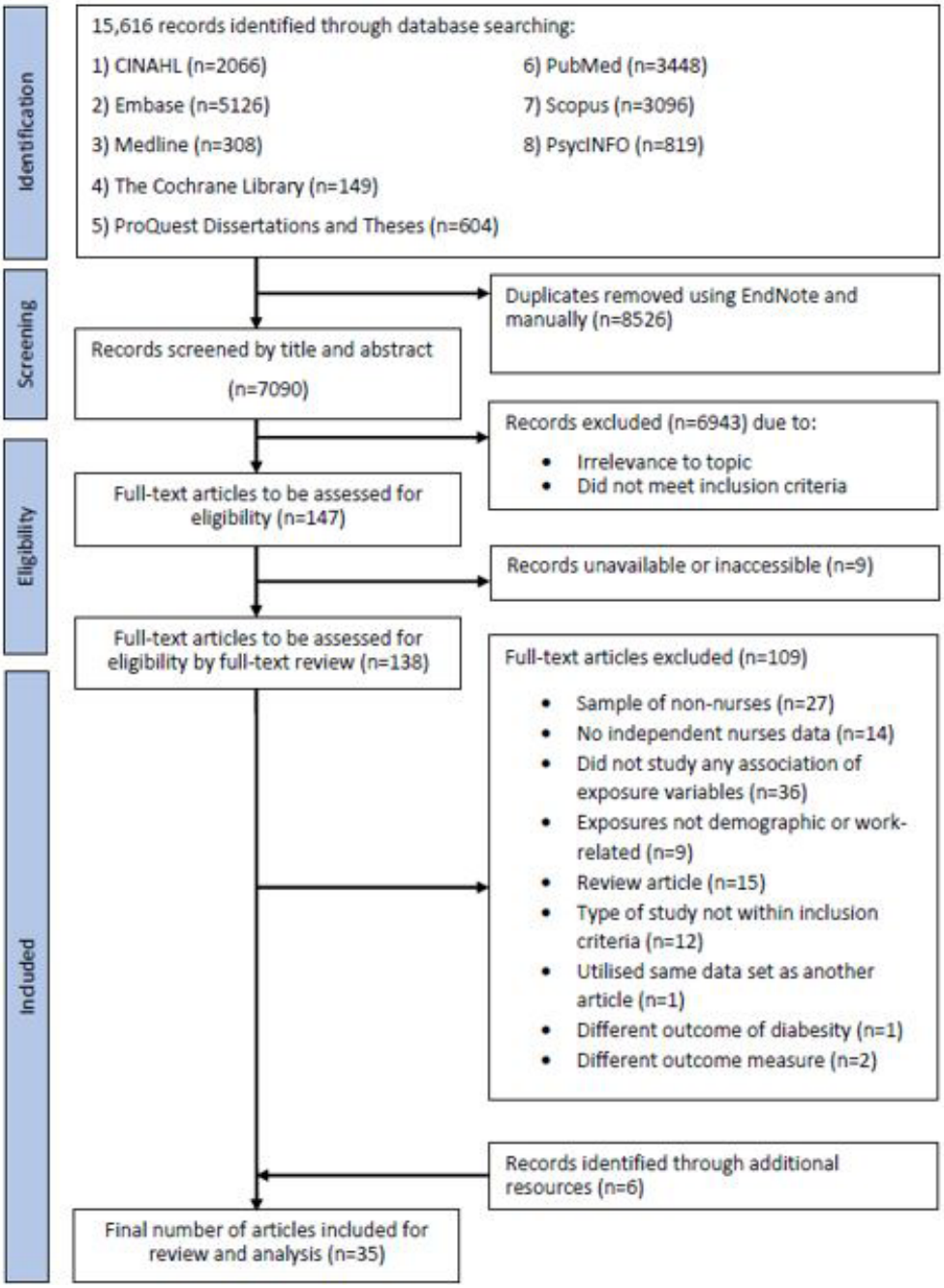

Figure 1: PRISMA Flowchart

Characteristics of Included Studies

Included studies (Appendix VI) and their basic characteristics are listed in Appendix VII. All studies were cross-sectional in design, except for three cohort studies [48-50]. All were journal articles, except one thesis [51].

Demographic Data of Sample

Total sample population consisted of 153,030 nurses from 35 studies. The mean age of the nurses ranged from 26.10 [52] to 48.4 [53] years, with mean age of sample not reported in 13 studies. Four studies did not report the gender of their samples [49,54-56] and 92.97% of the total sample were female. Age and sex distribution of this review's sample is similar to the current nursing workforce [57]. Studies were classified into six geographical regions according to the World Bank Group (WBG) classification (Table 3 and Appendix VIII) [58].

Region	Countries investigated by included studies	No. of studies
North America	Canada, The United Stated of America	12
Southeast Asia & Pacific	Australia, Japan, Korea, Malaysia, New Zealand, Taiwan	9
Europe & Central Asia	Germany, Norway, Poland, United Kingdom	5
Middle East & North Africa	Iran, Lebanon, Saudi Arabia	4
Latin America & the Caribbean	Brazil, Mexico	3
South Asia	India	1
Sub-Saharan Africa	Ghana	1

Table 3: Geographical Regions of Included Studies

Risk of Bias Assessment

The results of risk of bias assessment of each of the included studies are presented in Appendix IX and Figure 2 depicts the number of studies with the overall risk of bias score. Studies were rated for overall risk based on the average rating for individual items. Cross-sectional studies were ratedas "Not Applicable" for Item 4 if participants were included regardless of BMI. Methodological problems such as lack of sample size calculation and strategies to deal with confounders and unvalidated or unreliable methods to measure the exposure resulted in seven studies deemed to beof high risk of bias.

Exposures Associated with Overweight and Obesity in Nurses

The full lists of exposures studied by the included studies are presented in Appendix X. For this review, exposures studied by five or more included studies were expounded on, totaling nine variables.

Shiftwork

Shift work is defined as work performed outside of typical daytime hours, including rotating shifts and night shifts and is necessary for the operations of a hospital [59]. 14 studies analyzed the variable of shiftwork (Appendix X), of which nine studies were combined in meta-analysis by OR, three combined in meta-analysis by mean and SD, and two were not included in meta-analysis due to different effect measures used [49,50].

Meta-analysis of nine studies by OR was conducted (Appendix XI), but heterogeneity was substantial (Chi2=19.28, p=0.01, I2=59%). Sensitivity analysis did not reveal information about outliers contributing to heterogeneity among the studies (Appendix XI). Almajawal [21] (OR=0.459, 95%CI 0.261-0.811, p=0.003), Fang et al. [60] (β=1.096, SE=0.499, p=0.028) and Tada et al. [61] (β=0.051, SE=0.113, p=0.005) found shiftwork to be significantly associated with overweight and obesity in nurses, while Buchvold et al. [48], Chin et al. [53], Han et al. [62], Kimet al. [55], Woynarowska-Soldan et al. [63], and Zhao et al. [64] did not.

Meta-analysis of three studies by mean and SD revealed substantial heterogeneity (Chi^2=6.08, p=0.05, I^2=67%) (Appendix XI). Only three studies were included in the forest plot, hence sensitivity analysis was not conducted [65]. All three studies, Peplonska et al. [66], Roskoden et al. [56] and Terada et al. [67] did not find significant associations between shiftwork andoverweight and obesity in nurses.

Fujishiro et al. [49] found that cumulative period of shiftwork was significantly and positively associated with overweight and obesity (F(4)=6.74, p<0.001). Zhao et al. [50] found that nurses who maintained shiftwork had an increase in BMI by 0.56kg/m^2 (p<0.001).

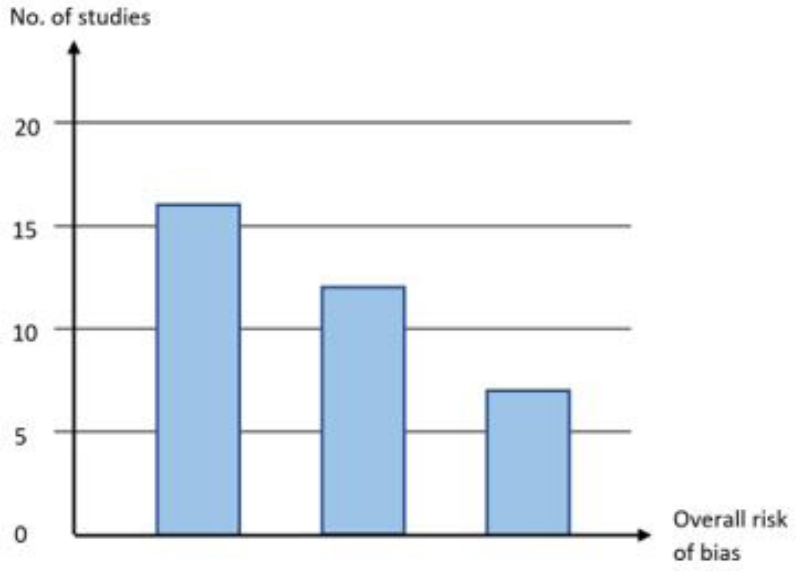

Figure 2: Overall Risk of Bias for Included Studies

Age

The variable of age was analysed by 12 studies, of which four studies were combined with meta- analysis by r and eight studies were not combined in meta-analysis due to different effect measures used by the studies. Meta-analysis of four studies by r had significant heterogeneity between the studies (Chi2=18.57, p=0.0003, I2=84%) (Appendix XII). Sensitivity analysis was performed. Removal of Aryee et al. [68] during sensitivity analysis resulted in an enhancement in heterogeneity (Chi2=1.79, p=0.41, I2=0%) (Figure 3), though comparison of studies did not reveal explicit causes for heterogeneity. Resulting pooled estimate was significant with positive relationship between variable of age, and overweight and obesity in nurses, with small effect size (r=0.139, Z=0.14, p=0.001) [69].

Age was found to be positively and significantly associated with overweight and obesity in nursesby Bogossian et al. [70] (p<0.001), Han et al. [71] (t=-5.76, $\chi\chi^2$=38.55, p<0.01), Letvak et al. [72] (MD=1.94, p=0.00), Perry et al. [73] (p<0.001), Tada et al. [61] (β=0.175, p<0.05) and Wornarowska-Soldan et al. [63] (OR=1.067, 95%CI 1.047-1.088, p<0.001). However, age was not found to be significantly associated with overweight and obesity by Buchvold et al. [74] and Fang et al. [60].

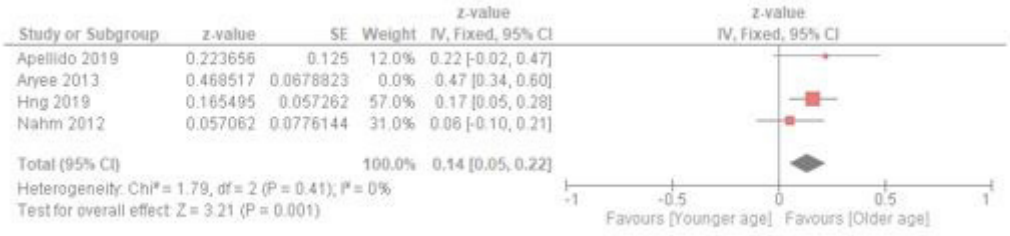

Figure 3: Forest Plot Assessing Correlation between Age and Overweight and Obesity in Nurses, After Sensitivity Analysis

Night Shiftwork

The International Labour Organisation defines night shiftwork as work performed in a period of not less than seven consecutive hours, including the interval from midnight to 5a.m. [75]. The variable of night shiftwork was analysed by seven studies. Narrative synthesis was conducted dueto different definitions of the exposure variables and different effect measures used by the includedstudies. Significant and positive relationships between night shiftwork and overweight and obesitywere found by three studies. Peplonska et al. [66] and Sanchez-Jimenez et al. [76] found that nursesworking night shifts were 1.35 times (95%CI 0.9-2.0, p=0.048) and 2.03 times (95%CI 0.96-4.27,p=0.0319) more likely to be overweight or obese than those who did not, respectively. Ramin et al. [77] found that nurses who ever worked the night shift were 1.26 times (95%CI 1.20-1.32, p<0.05) likely to be obese than those who did not. Apellido [78], Akbarzadeh et al. [79], Huth et al. [32] and Zhao et al. [64] did not find significant relationships between night shiftwork and overweight and obesity in nurses.

Sex

A total of six studies analysed the variable of sex. One study was not included in the meta-analysisdue to different effect measure used [68], which found that female sex was significantly associatedwith overweight and obesity in nurses (MD=3.0, p<0.001). Meta-analysis of five studies produced statistically significant results that male nurses are 1.22 times (95%CI 1.10-1.35, p=0.0003) morelikely to be overweight or obese than female nurses (Figure 4). Heterogeneity between studies wasunsubstantial (Chi^2=1.31, p=0.86, I^2=0%).

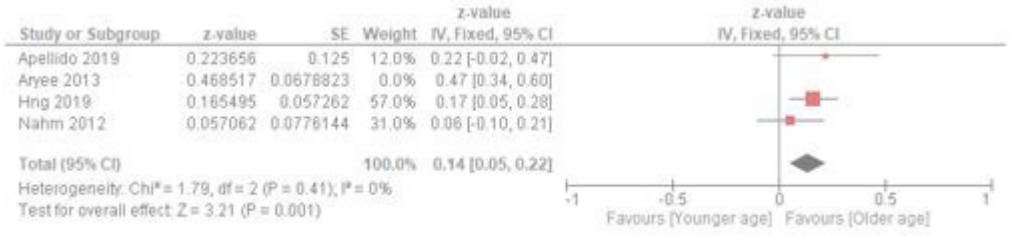

Figure 4: Forest Plot Assessing OR between Male Gender and Overweight and Obesity in Nurses

Marital Status

Narrative synthesis was conducted for all six studies that analysed the variable of marital status due to insufficient data reported or different effect measures used by studies. Apellido [78] (F(3,63)=7.09, p<0.001), Aryee et al. [68] (p=0.048) and Bogossian et al. [70] (p=0.009) found thatbeing married was significantly associated with overweight and obesity in nurses, while Fang et al. [60], Han et al. [71] and Sanchez-Jimenez et al. [76] did not have significant findings.

Hours Worked per Week

Six studies analysed the variable of hours worked per week with two not included in meta-analysisdue to different definitions of the exposure variable [71] or different effect measure used [32]. Meta-analysis of four studies revealed that nurses who work more than the recommended hours per week, usually 44 hours, are 1.42 times (95%CI 0.96-2.11, p=0.08) more likely to be overweightor obese than those who do not (Figure 5). Heterogeneity between the studies was unsubstantial (χ^2=4.70, p=0.20, I^2=36%). Han et al. [71] reported that nurses working long hours per week were 1.23 times (95%CI 1.08-1.40, p<0.001) more likely to be overweight and obesity than those whodid not. Huth et al. [32] found that hours worked per week was positively associated with BMI (p=0.012). BMI increased an average of 0.116 for every hour worked per week over the mean hours (M=33.37, SD=7.436).

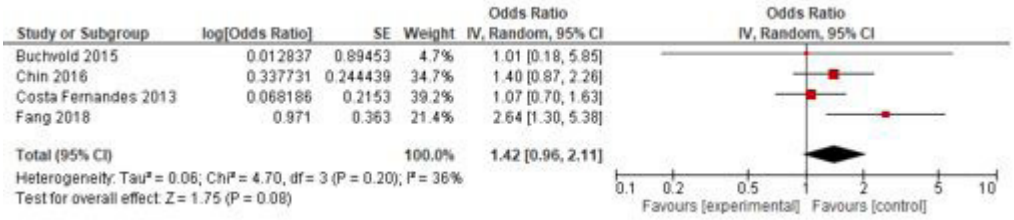

Figure 5: Forest Plot Assessing OR Between Hours Worked Per Week and Overweight andObesity in Nurses

Educational Level

Narrative synthesis was conducted due to insufficient data reported or different effect measures used. Four out of five studies found educational level to be significantly associated with overweight and obesity in nurses. Chin et al. [53] (OR=1.77, 95%CI 1.007-3.105, p=0.0236), Fanget al. [60] (OR=1.72, 95%CI 0.949-3.113, p=0.0368) and Han et al. [71] (χ^2=25.97, p<0.01) found an inverse relationship between educational level and overweight and obesity, while Huth et al. [32] found educational level to have a U-shaped relationship with overweight and obesity in nurses(p=0.01), where nurses with the lowest and highest educational levels had the highest rates of overweight and obesity compared to those with middle educational level. Sanchez-Jimenez et al. [76] did not have significant findings.

Work Unit

Five studies analysed the exposure variable of work unit and overweight and obesity. Narrative synthesis was conducted due to different effect measures used and insufficient data reported. Bogossian et al. [70] (p=0.002) and Ross et al. [80] (OR=1.74, 95%CI 0.991-3.069, p=0.026) found that work units associated with overweight and obesity in nurses were aged care and non- direct patient care areas, respectively. Apellido [78], Fang et al. [60] and Sanchez-Jimenez et al. [76] did not find nurses' work unit to be significantly associated with overweight and obesity.

Stress

Five studies analysed the exposure variable of stress, four were combined in meta-analysis by r. Campbell [51] was not included in the meta-analysis due to different effect measure used, and did not find stress and overweight and obesity to be correlated. Meta-analysis demonstrated that though statistically significant, correlation of stress to overweight and obesity in nurses was of small effect size (r=0.0896, Z=0.09, p=0.01) with unsubstantial heterogeneity (χ^2=2.74, p=0.43, I^2=0%) across four studies (Figure 6) [69].

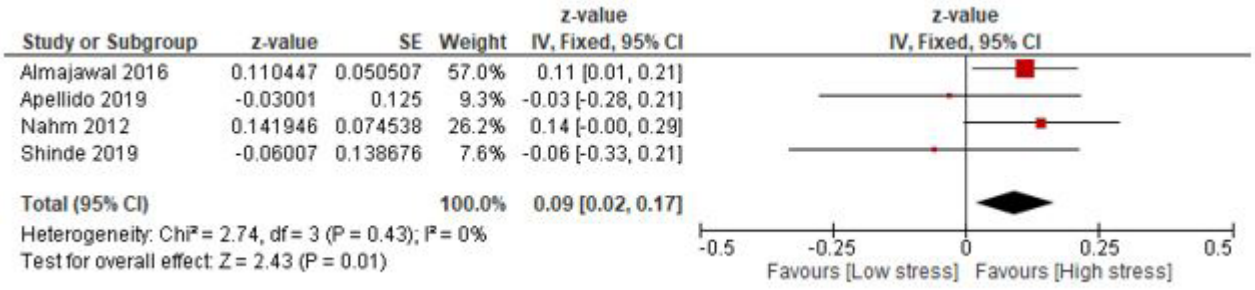

Figure 6: Forest Plot Assessing Correlation Between Stress and Overweight and Obesity in Nurses

Discussion

To our best knowledge, this is the first systematic review and meta-analysis of demographic and work-related risk factors of overweight and obesity in nurses on a global scale. Overall, 35 studiescomprising of 153,030 nurses, conducted in 19 countries were included in this review. Shiftwork,age, night shiftwork, sex, marital status, hours worked per week and stress levels were found to be positively associated with overweight and obesity in nurses. Negative relationship betweeneducational level and overweight and obesity in nurses was observed. Evidence for variable of work unit was inconsistent.

Associated Factors

Shiftwork

Shiftwork is a possible risk factor for overweight and obesity in nurses. This parallels the findingsby Amani and Gill [26] and Zhao and Turner [81], who reported that shift workers of other professions were at higher risk of overweight and obesity. Shiftwork causes circadian disruption and disturbed socio-temporal patterns, where both can lead to changes in dietary intake and duration and quality of sleep [82,83,84]. In turn, these changes cause irregulating of glucose and lipid metabolism, contributing to overweight and obesity [85,86].

Age

A positive relationship was found between age and overweight and obesity in nurses. The results agree with Hu et al. [87], which reported that older age is correlated with overweight and obesity.Increased age causes biological changes that favour increased fat mass and reduced fat-free mass[88]. Older adults have reduced physical activity, shorter sleep duration and poorer sleep quality, which all have been linked to overweight and obesity [61,89,90].

Night Shiftwork

Night shiftwork is a possible risk factor for overweight and obesity in nurses. This finding confirmsthat of Liu et al. [91] and Sun et al. [92], where night shift workers were at higher risk of overweightand obesity. Like shiftwork, night shiftwork's obesogenicity can be attributed to circadiandisruption [85]. In particular, the production of melatonin, a critical mediator between night shiftwork and O/O, is inhibited by light during night shifts [93]. Additionally, nurses consume food during night shifts, desynchronizing internal metabolic rhythms and causing energy imbalance and weight gain [94].

Sex

Male sex is associated with overweight and obesity in nurses. Literature on the correlation of sex and overweight and obesity varies, where the findings agree with Shinde [51], who found male HCPs to have higher rates of overweight and obesity than female HCPs. However, the findings contradict that of Hu et al. [87] and Jafari-Adli et al. [95] who report that female sex is associatedwith overweight and obesity. These inconsistencies are due to biological and social causes of overweight and obesity, which vary between the sexes. For example, the sexes tend to have different food preferences. Men consume more alcohol than women, but sex-specific differences in alcohol metabolism suggest that alcohol consumption and BMI are inversely related in men butnot women [96,97]. On the other hand, women tend to consume more dairy products than men, which was inversely associated with weight gain [98].

Marital Status

Being married is a possible risk factor of overweight and obesity in nurses, confirming the findingsof Erem [99] which found married individuals to be at higher risk of overweight and obesity. Married individuals expend additional energy and time caring for family outside of job responsibilities, leaving them with less time and energy for leisure-time physical activity [21]. Marriage also facilitates fecundity in women, which is culturally linked with increased food consumption [68]. Hence, it is no surprise that being married is a risk factor of overweight and obesity in nurses.

Hours Worked per Week

Hours worked per week are positively associated with overweight and obesity in nurses. This confirms the results of Kim et al. [100] who reported that working hours is positively associated with overweight and obesity. Working many hours, a week leaves nurses with less time, energy and resources to maintain a healthy lifestyle through regular exercise, a healthy diet and sufficientsleep [101].

Educational Level

Educational level was inversely associated with overweight and obesity in nurses. This agrees withErem [99], who reported an association between low educational level and overweight and obesity.This finding was unexpected as individuals of higher educational levels tend to work in higher echelons of the occupational hierarchy, such as administrative or managerial roles, and are likely to be the most sedentary, which have been associated with overweight and obesity in nurses [102-104].

Work Unit

As educational level is negatively associated with overweight and obesity in nurses and is linked to nurses' work units, it was expected that type of work units will also have a negative with overweight and obesity. However, there was insufficient evidence to conclude. Two studies finding administrative or managerial work to be positively and significantly associated ($p<0.05$) to overweight and obesity in nurses. It should be noted that among the remaining three studies, only one included administrative and/or managerial work units in their analyses ($p>0.05$) [76]. Administrative and managerial roles have been associated with overweight and obesity as these roles tend to be less physically demanding, even sedentary, and more stressful which have all beencorrelated to overweight and obesity in nurses [59,104].

Stress

Stress is a possible risk factor of overweight and obesity in nurses. This parallels the findings of Cuevas et al. [105], reporting a positive relationship between stress and overweight and obesity. Stress stimuli cause the activation of the neural stress-response network and induction of eating without hunger [106]. Stress also causes the secretion of glucocorticoids and insulin, resulting in an increased intake of calorie-dense food [107].

Strengths of Review

The large sample size of 153,030 significantly enhances this review's statistical power. Furthermore, this review used a comprehensive search strategy, including published and unpublished articles from eight major databases, to maximize coverage and inclusion of all relevant studies. The use of two independent reviewers demonstrates the transparency of the synthesis process as well.

Limitations of Review

Limitations at Study Level

This review has limitations. Most included studies utilized self-reported height and weight for thecalculation of BMI. However, evidence supports the reliability of self-reported height and weightin Western and Asian countries [108,109]. Furthermore, nurses possess the knowledge on how toaccurately take measurements of their height and weight, reducing the potential for reporting bias [110]. 22(62.9%) studies either did not report the sampling method or utilized a non-random sampling method, increasing the uncertainty of estimation and weakens the significance ofcorrelation between the exposure and overweight and obesity in nurses [111].

Limitations at Review Level

Firstly, while BMI is the most widely used measure of obesity, it is critiqued for its inability to distinguish between overweight due to muscle or fat tissue and is less accurate in measuring bodyfat in elderly than middle-aged individuals [112,113]. Secondly, causality cannot be established through the results of this review. Hence, the results of this review should be used as criteria whentrying to draw conclusions about causality later, to prevent misleading causal associations [114]. Lastly, publication bias, such as non-reporting of insignificant results, was not assessed as no meta-analysis had ten or more studies, to prevent misinterpretation [115].

Recommendations Recommendations for Future Clinical Research

Future research should investigate the association between exposures and overweight and obesity with alternative methods of measurement, such as waist circumference [113]. To determine causality between exposures and overweight and obesity in nurses, further research can utilize more robust observational study designs such as cohort and case-control study design [116].

Recommendations for Policy, Practice and Nursing Education

Obesity is difficult to treat, and prevention is the key. Our findings suggest that nursing educatorsshould promote healthy behaviours and inculcate healthy habits for future nurses to reverse the trend of overweight and obesity. Health-related behaviours of nursing students are generally worsethan registered nurses, proving value in implementing such a component in existing nursing curricula [117].

Using this review's results, nurses can understand how these factors can affect their weight and hence, health, and adjust their behaviour to prevent weight gain, such as not consuming food duringnight shifts. The results of this review will aid the development of effective workplace interventions, working around the risk factors highlighted in this review. Two-pronged workplaceinterventions targeting both diet and physical activity of nurses are recommended and can include exercise sessions and a ban on sugar-sweetened beverages within hospital grounds [118,119]. Relaxation therapies such as meditation and massage can be provided to complement other interventions and reduce stress among nurses [120].

Conclusion

Overweight and obesity in nurses is a concerning phenomenon with dire consequences. The healthcare work setting is fraught with exposures leading to weight gain, resulting in poorer health,reduced work productivity and ineffective patient care, aggravating the global nursing shortage problem. In view of this phenomenon and its implications, this review was undertaken to better understand the risk factors of overweight and obesity in nurses, in hopes to contribute to knowledgeabout and the development of effective individual and workplace interventions for overweight andobesity in nurses.

This review and meta-analysis of 35 studies revealed that shiftwork, age, night shiftwork, sex, marital status, hours worked per week, stress levels and educational level of nurses are correlatedto overweight and obesity in nurses. The exposure of work unit was considered but there was insufficient evidence.

Considering the consequences of overweight and obesity on nurses, patients and healthcare organisations, this review recommends policymakers, hospital administrators, nursing educators and nurses to take action to prevent and minimize overweight and obesity among nurses. This review recommends future research into determining causality between the exposures and overweight and obesity, to develop effective evidence-based interventions and policies.

Supplementary

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