Sleep Medicine 57 (2019) 100–106

Contents lists available at ScienceDirect

Sleep Medicine

journal homepage: www.elsevier.com/locate/sleep

Review Article

Association between socioeconomic status, belonging to an ethnic minority and obstructive sleep apnea: a systematic review of the literature

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ARTICLE INFO

Article history:
Received 10 September 2018
Received in revised form
18 October 2018
Accepted 15 January 2019
Available online 12 February 2019

Keywords:
Obstructive sleep apnea
Socioeconomic status
Race/ethnicity
Systematic review

ABSTRACT

Obstructive sleep apnea (OSA) is a highly prevalent sleep disorder associated with obesity, hypertension and metabolic syndrome. People with low socioeconomic status (SES) who are socially disadvantaged (eg, people belonging to an ethnic minority) have worse health outcomes. Thus, consequently, social inequality may potentially be a risk factor for OSA. This systematic review aims to summarize previous studies from the literature which investigate the association between SES, race/ethnicity and obstructive sleep apnea (OSA).

This review was performed in accordance with the PRISMA statement. A literature search in Medline, PubMed, PsycINFO, Scopus, and Web of Science was conducted. Articles published in English, Spanish, French, Italian and Portuguese, without publication date limits, and that aimed to analyze the association between OSA diagnosis and social disadvantage, were selected.

In sum, 17 articles met the inclusion criteria. One was a longitudinal study, and the remainder were cross-sectional research. Low SES was indicated as a risk factor for the presence of OSA in most of the articles. Concerning racial/ethnic groups, a clear association with OSA does not emerge, since, in a few articles, the relation disappeared after controlling for variables such as obesity, comorbidities, and SES; suggesting that there may be differences only in OSA severity and sleep apnea phenotypes.

The results of this systematic review point out that low SES could be a risk factor for OSA. Obesity, SES and disparities in health care could mediate the association between OSA and racial/ethnic minorities. Socioeconomic circumstance should receive more attention in sleep medicine research.

1. Introduction

Obstructive sleep apnea (OSA) is a chronic condition characterized by sleep-related pauses in respiration, arousals, unrefreshing sleep, and excessive daytime sleepiness (EDS) [1]. OSA is the most common sleep disorder in industrialized countries, affecting between 24% [2] and 49,7% of the population, especially men of middle age and older [3].

OSA is associated with cardiovascular diseases, including hypertension, coronary artery disease, stroke and cerebrovascular disease [4,5] as well as diabetes [6] and metabolic syndrome [7]. Obesity and large neck size, in addition to the instability of the respiratory control system and craniofacial structure, are the main risk factors for developing this syndrome [8,9].

As the prevalence of obesity and other diseases associated with OSA are higher in people with low socioeconomic status (SES), especially in high-income countries [10–12], individuals with low SES are potentially more likely to suffer from OSA. In the literature, associations between sleep problems and several indices of SES have been observed in many studies. Stringhini et al. [13], observed that participants in the CoLaus study who were in a low occupation

Abbreviations: OSA, Obstructive Sleep Apnea; EDS, Excessive Daytime Sleepiness; SES, Socioeconomic Status; AA, African American; CA, Caucasian; BMI, Body Mass Index.

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https://doi.org/10.1016/j.sleep.2019.01.042
1389-9457/

position suffered from poor sleep quality, longer sleep latency, insomnia, and shorter sleep duration. Links with SES and sleep disturbance have been observed for household income and educational attainment [14,15]. Low SES was also found to be a risk factor for cardiovascular disease among OSA patients requiring treatment [16].

Racial disparities exist regarding general health. For example, African Americans when compared to Caucasians, have a greater incidence of various adverse health conditions, including heart disease, stroke, diabetes, and hypertension, that contribute to life years lost [17]. Some authors have suggested that racial/ethnic minorities and socioeconomically disadvantaged groups may be more likely to experience poor sleep and that sleep disturbance might explain part of the socioeconomic gradient in other health outcomes [18–20]. The analysis of the National Health and Nutrition Examination Survey data revealed a stronger relationship between OSA symptoms and hypertension in AA and Hispanic individuals than in non-Hispanic Caucasians [21].

Health inequality persists despite improvements in medical care and disease prevention in the last few decades. Eliminating disparities in health due to ethnicity and socioeconomic position is a social challenge and an ethical imperative involving the World Health Organization's Commission on Social Determinants of Health as well as many other national and international organizations [22]. Associations between SES, belonging to a racial/ethnic minority and OSA have received less attention than other sleep disorders and results in this area, to the best of our knowledge, have never been systematically reviewed. The objective of our review is to systematically analyze the literature for an association between OSA, SES and race/ethnicity in adults.

2. Methods

This report follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [23].

2.1. Literature search

The databases Medline, PubMed, PsycINFO, and Web of Science were searched to select articles relating to OSA, SES and race/ethnicity for all years up to June of 2018. A combination of keywords, such as obstructive sleep apnea, sleep apnea, sleep-disordered breathing, socioeconomic determinants, socioeconomic factors, socioeconomic status, racial-ethnic disparities or race/ethnicity, black or African American or Hispanic or Asian) were used. An example of the search terms used for PubMed is given here:

(racial-ethnic disparities or race/ethnicity) or (black or African or Hispanic or Asian) and (sleep apnea or obstructive sleep apnea or sleep disordered breathing), (obstructive sleep apnea or sleep disordered breathing) AND (socioeconomic determinants OR socioeconomic factors or socioeconomic status).

Reference lists of studies found through databases were also searched.

2.2. Inclusion and exclusion criteria

Peer-reviewed articles, published in English, French, Spanish, Italian, and Portuguese, without limitation of the year of publication, focusing on the association between OSA and SES or race/ethnicity in adults, were included. Only articles in which OSA was assessed by objective measures (PSG, polygraphy) were included. For an article to be included, it must have focused on the association between an explicit measure of SES, or a variable related to race/ethnicity, and OSA diagnosis. We included original articles from observational studies. In addition, we did not consider case reports, reviews, editorials or letters. Studies were excluded if the OSA diagnosis was confirmed using instrumental techniques (polygraphy or polysomnography). Studies carried out with only one racial/ethnic group were also excluded.

2.3. Study selection, data extraction, and quality evaluation

For the study selection, two authors (OG, SG) independently screened titles, abstracts, and full-texts and decided on the eligibility of articles. Any disagreement was resolved by discussion and consultation with the third author (PL).

The following data were extracted from each eligible article: author, year, study location, study design, population type, sample size, the percentage of females, mean age and range, the method of assessment of OSA, SES factor evaluated or races/ethnicities involved and main results obtained. We also collected the main covariates employed in each study's analysis.

The methodological quality of all included studies was assessed by two authors (OG and SG) using the Joanna Briggs Institute critical appraisal tools for use in JBI systematic reviews [24]. The checklist for analytical cross-sectional studies explores different domains of quality: namely, (1) definition of the criteria for inclusion in the sample; (2) the completeness of the description of the study subjects and setting; (3) method of measurement of the exposure; (4) objectiveness of the measurement of the condition; (5) identification of confounding factors; (6) use of strategies to deal with confounding factors; (7) method of measurement of outcomes; and (8) the appropriateness of the statistical analyses. Disagreements on quality assessment were resolved by discussion and consensus.

3. Results

The results of the search strategy can be found in Fig. 1. The search was completed in June of 2018. Seventeen studies met the inclusion criteria for this review.

The characteristics of the studies which were included are summarized in Table 1.

The 17 included studies were published between 1995 and 2016. The majority were carried out in the USA, two in Brazil [31,39], one in Greece [28] and one in India [37]; all research used a cross-sectional design, except for the longitudinal study by Pranathiageswaran et al., [36]. The studies involved a total of 18,362 subjects, with an average age between 44 and 72 years. The majority of the studies included a clinical population, and only a few were population-based [27,29,30,33,37,39,41]. Concerning the study quality appraisal, reported in Table 2, the median was six and, based on the scores computed; the overall quality was judged medium–high.

Several studies focused on race and ethnic group aspects [25,26,29–31,33,35,36,38,40,41], of which five used SES index as a covariate [26,29,30,33,38]. Other authors investigated the association between SES variables and OSA [27,28,32,34,37,39], of which two employed race/ethnic groups variables as covariates.

The racial/ethnic groups involved in the studies were mostly Caucasian (CA) and African American (AA) [25,26,30,36,38]. Groups other than CA and AA included Hispanic [33,40], Chinese [29], American Indian [41] and Asian groups [35]. Genta et al. [31], studied OSA differences between Caucasian and Japanese descendants in Brazil.

A wide variety of SES indices were analyzed across the studies. In most, where SES was assessed, research was based on occupational status and income variables [30,37], income and educational attainment [26,33], marital and occupational status [28], or median household income [36,38]. Billings et al. [27], and Johnson et al.

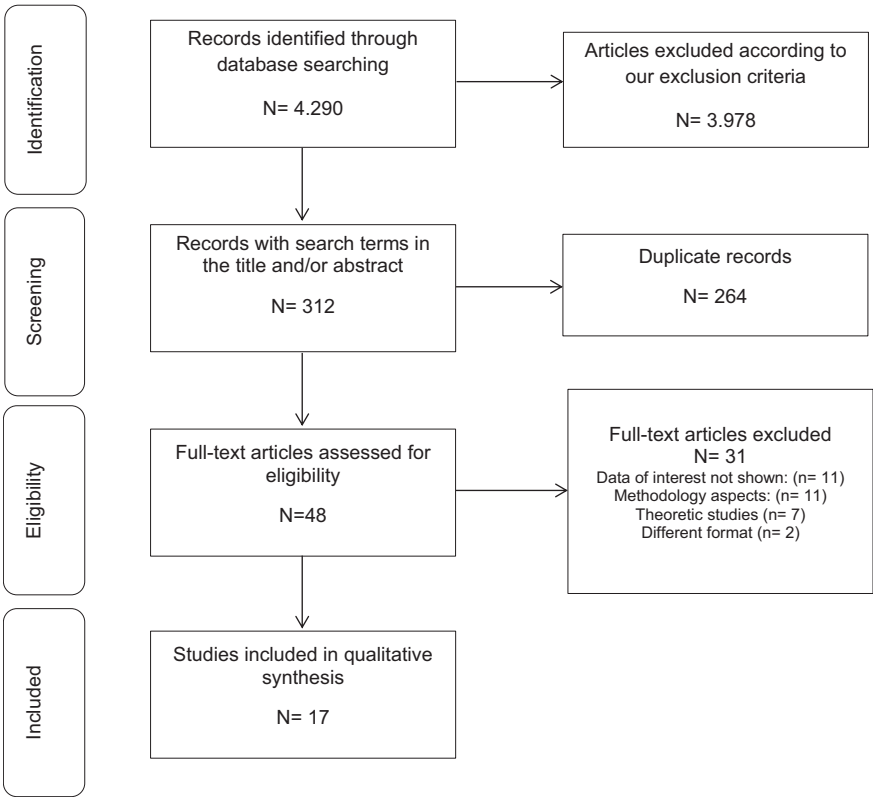

Fig. 1. Article selection algorithm.

[34], focused on neighborhood aspects, specifically walking environment and level of crowding, respectively.

In the subgroup of studies in which the association between racial/ethnic groups was assessed, mixed results were obtained. A few studies showed that belonging to an ethnic minority group such as AA [29,36] or American Indian [41] was a risk factor for OSA. In other studies, no association between belonging to a racial/ethnic group and OSA risk was observed [25,31,40]. No differences in the apnea-hypopnea index (AHI) were found between CA, AA or Chinese groups in the SWAN Sleep study [33]. Fiorentino et al. [30], compared polysomnographic outcomes of AA and CA patients and, after controlling for SES and health covariates, did not observe any difference in AHI. Similar results were obtained by Scharf et al., [38]. Ong et al. [35], found that, even though the percentage of OSA patients was quite similar in Asian and CA groups, there were significantly more Asian than CA patients with severe OSA, defined as a respiratory disturbance index (RDI) > 50. Similar results were obtained by Ancoli-Israel et al. [26], who observed that the prevalence of OSA was similar between AA and CA groups, but in the logistic regression, AA patients had a severe OSA odds ratio of 2.55, even after controlling for body mass index (BMI), age, and sex.

A positive association was observed between SES variables and risk for OSA in several studies. Billing et al. [27], noted that living in a neighborhood with a low walking environment score is associated with greater severity of OSA, even after controlling for race, educational level, household income, and neighborhood socioeconomic status. In a broad sample of the general population, after adjusting for race, age, marital status, and gender, neighborhood-level crowding was shown to be associated with OSA, but the association disappeared after controlling for BMI [34]. In a study by Charokopos et al. [28], marriage, self-employment or being outside the workforce were shown to be risk factors associated with OSA. A significant linear trend in the prevalence of OSA was observed when subjects were stratified by SES [37]. Similar results were obtained by Tufik et al. [39], in females, but not in males. Greenberg et al. [32], compared OSA and health outcomes of patients diagnosed in minority-serving institutions and voluntary hospitals and despite not encountering any significant difference in AHI, patients from the first type of institution showed a higher number of comorbid medical conditions.

4. Discussion

Our study is among one of the first systematic reviews of research studies focused on the association between SES, belonging to a racial/ethnic group and OSA. We include in the analysis the most important and rigorous studies of OSA, race/ethnicity and socioeconomic factors published in the last 20 years, in different languages and carried out in various contexts. Although a high heterogeneity exists in the indices of SES analyzed, and results from the different studies are mixed, many authors observed an association between socio-economic factors and OSA. Less evidence points to the association between belonging to an ethnic minority and risk for OSA.

The studies included in this review focused on the association between OSA and race/ethnicity; in the majority of them, one may observe that ethnic minorities, such as African Americans, Asians or Hispanics in the USA or Brazil, do not show an increased risk for OSA. We utilize the concept of belonging to a racial/ethnic group by considering race as a social construct. Race/ethnicity is a concept employed in biomedical research as a proxy for several social, environmental, and cultural factors related to exposure to racial discrimination and health disparities [20]. The race concept cannot be considered a biological category, since mixing of the human genetics pool has occurred for a long time in human history, blurring presumptive race separations. There are cases where there is

Table 1
Characteristics of the studies included in the systematic review.

ID (Country)	Study Design (Population Type)	Sample Size (% Female)	Mean Age or Range (SD)	Sleep Outcome Evaluated (Methods)	SES Factor/Racial/Ethnic Minority Evaluated	Outcome Obtained
Alkhazna et al., 2011 (USA)* [25]	Cross-sectional (Clinical Pop.)	318 (55.7%)	51 (10)	PSG (AHI>5)	Racial/ethnic groups (CA, AA)	Race is not a predictor of OSA severity after controlling for age, sex, and BMI.
Ancoli- Israel et al., 1995 (USA)* [26]	Cross-sectional (Clinical Pop.)	400 (53.4%)	72 (6.1)	PSG (RDI> 15)	Race/ethnicity (CA, AA). SES: income, educational level.	There are no significant differences in the prevalence of OSA; however, AA race was a risk factor for RDI ≥30, also after controlling for income or education (p).
Billings et al., 2016 (USA)** [27]	Cross-sectional (Pop. Study)	1,896 (54.4%)	68.5 (9.1)	PSG (AHI ≥ 5 plus sleepiness)	Perceived neighborhood walking environment	Living in the lowest quartile walking environment neighborhoods was associated with higher AHI, even after controlling for race/ethnicity, education, household income, and neighborhood socioeconomic status.
Charokopos et al., 2007 (Greece)* [28]	Cross-sectional (Clinical Pop.)	362 (16.6%)	19–83 Yrs.	PSG	Marital Status Occupational Status	The OR of married subjects to singles was 2.30 (CI = 1.01–5.32), those outside the workforce was 3.85 (CI = 1.16–12.74) and that of the self-employed was 1.70 (CI = 0.70–4.10) compared to a a reference group of clerks/employees.
Chen et al., 2015 (USA) ** [29]	Cross- sectional (Pop. Study)	2,230 (53%)	54–93 Yrs.	PSG(AHI ≥ 5 plus sleepiness)	Racial/ethnic groups (Caucasian, AA, Hispanic, Chinese)	Compared with CA, AA subjects had higher odds of sleep apnea syndrome (not controlled for SES).
Fiorentino et al., 2006 (USA)* [30]	Cross-sectional (Pop. Study)	140 (57.1%)	65–75 Yrs.	Polygraphy	Occupation, income, grade, racial/ethnic group (AA and CA)	No association between racial/ethnic group and OSA (even after controlling for SES).
Genta et al., 2008 (Brazil)* [31]	Cross- sectional (Clinical Pop.)	520 (0%)	51 (13)	PSG	Racial/ethnic groups (CA, Japanese descendant)	No association between race/ethnicity and OSA.
Greenberg et al., 2004 (USA)* [32]	Cross-sectional (Clinical Pop.)	303 (32.7%)	49 (no data)	PSG	Minority serving hospital/voluntary hospital. Racial/ethnic groups (CA, AA)	No association between SES and OSA.
Hall et al., 2008 (USA)* [33]	Cross- sectional (Pop. Study)	368 (100%)	50.7 (2.2)	PSG	Educational attainment, financial strain, racial/ethnic group (CA, AA, Chinese)	No association between race/ethnicity and OSA (even after controlling for SES)
Johnson et al., 2015 (USA)** [34]	Cross-sectional (Clinical Pop.)	1789 (38%)	54.2 (no data)	PSG	Neighborhood-level crowding, racial/ethnic group (AA, non-Hispanic Caucasian)	After adjusting for race, age, marital status, and gender, neighborhood-level crowding was associated with AHI. The association disappeared after also controlling for BMI.
Ong et al., 1998 (USA)* [35]	Cross-sectional (Clinical Pop.)	204 (22.5%)	41.3 (15.3)	PSG (RDI)	Racial/ethnic groups (CA, Asian)	Percentage of OSA were similar in Asian and CA groups (p not shown), but there were more Asian than CA with severe OSA (RDI>50) (p = 0.03).
Pranathiageswaran et al., 2013 (USA)** [36]	Longitudinal (Clinical Pop.)	867 (48%)	49 (no data)	PSG	Median income (home address zip codes), racial/ethnic groups (AA, CA)	AHI was higher in AA males aged ≥39 or 50–59 years, even after controlling for BMI.
Reddy et al., 2008 (India)* [37]	Cross-sectional (Pop. Study)	360 (no data)	44 (9)	PSG	Kuppuswamy's socioeconomic status scale	A significant linear trend in the prevalence of OSA was observed when subjects were stratified by SES.
Scharf et al., 2004 (USA) * [38]	Cross-sectional (Clinical Pop.)	233 (46.8%)	46.8 (10.5)	PSG	Median household income (MHI) code, racial/ethnic groups (CA, AA).	After adjustment for BMI and MHI, differences between AA and CA in RDI were not significant.
Tufik et al., 2010 (Brazil)* [39]	Cross-sectional (Pop. Based)	1,042 (no data)	20–80 Yrs.	PSG	SES	Low SES was a protective factor for males (OR = 0.4) but was an associated factor for females (OR = 2.4).
Yamagishi et al., 2010 (USA- Japan)* [40]	Cross-sectional (Clinical Pop.)	1,435 (54.3%)	50–74 Yrs.	PSG (RDI≥ 15)	Racial/ethnic groups (CA, Hispanic, Japanese)	No association between racial/ethnic differences and SDB after controlling for BMI.
Young et al., 2002 (USA) ** [41]	Cross-sectional (Pop. Based)	5,615 (53%)	63.5 (10.7)	PSG	Racial/ethnic groups (CA, AA, American Indian)	Compared with CA, American Indians were more likely to have an AHI> 15 or greater (OR = 1.7).

Notes: * = Low quality of evidence; ** = Medium quality of evidence; *** = High quality of evidence. SES: Socioeconomic Status; CA: Caucasian; AA: African American; Clinical Pop.: Clinical Population-based Study; Pop. Study: Population-based Study; PSG: Polysomnography; BMI: Body Mass Index; SDB: Sleep Disordered Breathing; AHI: Apnea Hypopnea Index; RDI: Respiratory Disturbance Index; MHI: Median Household Income.

Table 2
Quality assessment of the studies included in the systematic review.

ID (Country)	1	2	3	4	5	6	7	8
Alkhazna et al., 2011 (USA)* [25]	yes	yes	NA	NA	yes	no	yes	yes
Ancoli- Israel et al., 1995 (USA)* [26]	yes	no	NA	NA	yes	yes	yes	yes
Billings et al., 2016 (USA)** [27]	yes	yes	yes	yes	yes	yes	yes	yes
Charokopos et al., 2007 (Greece)* [28]	no	no	NA	NA	no	yes	yes	yes
Chen et al., 2015 (USA)** [29]	yes	yes	NA	NA	no	no	yes	yes
Fiorentino et al., 2006 (USA)* [30]	yes	yes	NA	NA	yes	yes	yes	yes
Genta et al., 2008 (Brazil)* [31]	yes	yes	NA	NA	no	yes	yes	yes
Greenberg et al., 2004 (USA)* [32]	yes	yes	yes	yes	no	no	yes	yes
Hall et al., 2008 (USA)* [33]	yes	yes	NA	NA	yes	yes	yes	yes
Johnson et al., 2015 (USA)** [34]	yes	yes	yes	yes	yes	yes	yes	yes
Ong et al., 1998 (USA)* [35]	yes	yes	NA	NA	no	no	yes	yes
Pranathiageswaran et al., 2013 (USA)** [36]	yes	yes	NA	NA	yes	yes	yes	yes
Reddy et al., 2008 (India)* [37]	yes	yes	yes	yes	no	yes	yes	yes
Scharf et al., 2004 (USA)* [38]	yes	yes	NA	NA	yes	yes	yes	yes
Tufik et al., 2010 (Brazil)* [39]	yes	yes	no	no	no	yes	yes	yes
Yamagishi et al., 2010 (USA- Japan)* [40]	yes	yes	NA	NA	yes	yes	yes	yes
Young et al., 2002 (USA)** [41]	yes	yes	NA	NA	yes	yes	yes	yes

Notes: NA: not applicable. 1: Were the criteria for inclusion in the sample clearly defined?; 2: Were the study subjects and the setting described in detail?; 3: Was the exposure measured validly and reliably?; 4: Were objective, standard criteria used for measurement of the condition?; 5: Were confounding factors identified?; 6: Were strategies to deal with confounding factors stated?; 7: Were the outcomes measured validly and reliably?; and 8: Was appropriate statistical analysis used?.

more genetic variation among individuals within a so-called ethnic group than between ethnic groups [42]. As highlighted in the review by Villaneva et al. [43], genetics may partially explain some of the ethnic clustering of the phenotypes that characterize OSA. The authors conclude that the racial variation in the prevalence of OSA may be related to ethnic differences in risk for obesity, craniofacial morphology and ventilation control, factors that are heritable and modulated by cultural and environmental influence. Nevertheless, more experimental evidence is needed to establish whether an increased susceptibility to hypocapnic-apnea, associated with male sex in combination with ethnic group differences in upper airway mechanics, could result in a risk of OSA that is greater than either risk factor alone [36].

In some studies, the association between OSA and belonging to a minority group was explained by BMI and obesity. The Multiethnic Study of Atherosclerosis compared Hispanic, Caucasian and Japanese groups and the difference in OSA prevalence was explained by a difference in BMI distribution [40]. Alkhazna et al. [25], suggest that race is not a predictor of OSA severity after controlling for age, sex and BMI. After controlling for BMI and median household income, RDI differences between AA and CA groups were not significant in a study by Scharf et al., [38]. Similar results were obtained by Genta et al. [31], in a comparison of Caucasian and Japanese descendants in Brazil; they concluded that ethnicity was not associated with OSA severity when an ethnic difference in obesity criteria was applied. Similar results were obtained in an update about OSA and its risk factors, in which the authors concluded that the racial/ethnic differences in the prevalence and severity of OSA could be due to environmental factors, like lower SES, obesity and neighborhood disadvantage [44].

Nevertheless, some authors obtained results that support the hypothesis that belonging to an ethnic minority poses a risk factor for OSA. AA subjects younger than 39 years and between 50 and 59 years showed higher AHI than Caucasian men in the same age ranges, even after controlling for BMI and median income [36]. In the Sleep Heart Health Study, a community based study carried out with a sample comprising participants from eight established cohort studies (including the Atherosclerosis Risk in Communities Study, the Cardiovascular Health Study, the Framingham Heart Study Offspring and Omni Cohorts, the Strong Heart Study, the New York Hypertension Cohorts, the Tucson Epidemiologic Study of Airways Obstructive Diseases, and the Tucson Health and Environment Study) American Indians showed higher odds of having an AHI of $\geq$15, compared with Caucasians and African Americans, after controlling for age and sex [41]. The Multi-Ethnic Study of Atherosclerosis Sleep Cohort (MESA) study compared Caucasian, African American, Hispanic and Chinese groups for variation in sleep disturbances [29]. African Americans reported the highest prevalence of OSA diagnosis, defined as having an AHI >5 and an Epworth Sleepiness Scale (ESS) score >10, while Chinese and Hispanic subjects were more likely to demonstrate a severe syndrome compared to Caucasian subjects. These results did not control for SES. In several studies carried out in the last few decades, it has been argued that AA subjects reported more sleep complaints than CA subjects. In a broad sample of African American, Hispanic and Caucasian adults, discrimination was associated with shorter sleep and sleep difficulties, independent of SES and other stressors [45]. These differences have also been observed in samples of African American, Hispanic and Asian children and were partially, but not entirely, explained by social-contextual variables [46]. Ruiter et al. [47], in a recent meta-analysis, recorded several differences between AA and Caucasian groups, indicating that sleep in African American subjects was less long, less deep and less restful. Petrov and Lichstein [48] suggested that these differences could be attenuated by some relevant confounders such as SES, comorbidities, neighborhood context and occupational factors.

Our results suggest that the association between OSA and belonging to an ethnic minority is not entirely understood. We can argue that in most of the articles in question, ethnic minorities did not show a higher prevalence of OSA although in some cases they presented a more severe syndrome. This data merits attention. An explanation could be found in the limitation of access to affordable and high-quality health care, especially in the USA, where most of the studies included in the systematic review were carried out. Williams et al. [49], explain that disparities in minority health can be explained by patient-, provider- and health care system–level factors.

On the one hand, culture, attitude toward the illness, past experience, language barriers, provider communication and prejudice, and the geographical distribution of resources could augment sleep health disparities. Moreover, in several studies, results indicated that adherence to continuous positive airway pressure treatment is highly influenced by ethnicity, educational levels, SES and neighborhood of residence [50–52]. On the other hand, the possibility of identifying different pathophysiological traits of OSA in different phenotypes could better explain the association between OSA, comorbidities, long-term compliance with

CPAP therapy and belonging to an ethnic minority [53]. Other factors to consider are the presence of several loci which have been implicated in inflammation and are associated with a sleep apnea phenotype and a low respiratory arousal threshold that may vary across racial groups [53,54].

Significant associations were observed between individual SES indices and OSA in several studies included in the systematic review. Marriage, self-employment, being outside the workforce [28], and SES score [39] were associated with risk for OSA. In a study by Tufik et al. [39], this association was observed in women but not in men. In a study carried out in India, the percentage of subjects with OSA was proportionally higher in the lower socioeconomic strata [37]. In the few studies that have analyzed the association between individual SES indices and OSA, a social gradient in health can be observed. The two studies that evaluated the association between OSA risk and neighborhood disadvantage found that high neighborhood crowding [34] and living in the least walkable neighborhoods [27] was associated with greater severity of OSA, even after controlling for race/ethnicity, education, household income, and neighborhood socioeconomic status. Nevertheless, in a study by Johnson et al. [34], the association disappeared after controlling for BMI. Although our review focuses on studies performed with adult samples, it was observed that in a sample of children aged 8–11 years, residence in a neighborhood of severe socioeconomic disadvantage was significantly associated with OSA, after adjusting for the effects of premature birth, obesity, and AA ethnicity, indicators of household-level SES or other health characteristics [55]. Similar results were obtained by Bruillette et al. [56], where residential census tract metrics were compared in Montreal, Canada, for 436 children aged 2–8 years who were evaluated for OSA. Compared with the children without OSA, those with OSA were more likely to reside in disadvantaged neighborhoods. A growing literature in health sciences documents that a correlation exists between subjective and objective socioeconomic status and health. The results of this systematic review seem to point in this direction since an association between OSA and SES has been observed in many studies.

To the best of our knowledge, this is the first systematic review on this topic. Our study focuses on summarizing and discussing the results of research studies published on OSA and social disadvantage. Our study has several strengths, as its novelty and its inclusion of articles from multiple languages with no time limits allowed a comprehensive coverage of the literature. Furthermore, the inclusion criteria allowed us to obtain a group of studies in which participants were diagnosed with instrumental methods. Because of the high heterogeneity of the factors analyzed, especially regarding SES indices, it was not possible to perform a quantitative synthesis of the results. However, we note that some association between OSA and socioeconomic factors was observed, suggesting that OSA also demonstrates a social gradient. There is no apparent connection between OSA and belonging to an ethnic minority. A further limitation of the review was the lack of studies from Europe. Since most of the studies included here were carried out in the USA, future research should focus on analyzing sleep health disparities in other countries, for example, in Europe and Asia. Scientific evidence for this association can be strengthened with additional prospective studies. Further research in this field may allow us to understand in more detail the relationship between race/ethnicity, SES and OSA phenotype. A deeper understanding of these phenomena would enable us to develop programs promoting health and intervention to reduce any health inequalities, especially concerning sleep. It would also be possible to identify potential disparities in access to health care with positive consequences for the health of the whole society.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2019.01.042.

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