

***SLEEP DISORDERS AS A MEDIATOR BETWEEN SOCIOECONOMIC STATUS AND  
HEALTH OUTCOMES: A REVIEW OF DIFFERENT THEORIES***

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**SUMMARY**

The variations in socioeconomic status (SES) between different social classes of a population correspond to differences in accessibility to all resources available and able to improve global health. While SES is now known as one of the main determinants for a good health and a good aging, its influence on sleep disorders (SD) is not well understood. SES is a concept, not directly observable but estimated using indicators like income, education, occupational status and area of living. This theoretical review explores some theories linking environment of people with occurrence of SD, with different patterns associated to SES. A model of interaction is proposed to summarize and conceptualizes these interactions and to promote more research on the topic.

**Keywords:** circadian rhythm; sleep disorders; socioeconomic status; stress; allostatic load; health outcome

## **INTRODUCTION**

Sleep disorders (SD) are among the most studied neurological outcomes since the last 20 years. They have many psychosocial aetiologies like lifestyle, night shift, sporadic daily stressors or environmental stress; and obviously they are linked to physiological dysfunctions of internal clock, circadian cycle or hormonal systems involved, like dopaminergic system and melatonin (Baron and Reid, 2014, Borbely, 1982, Diez-Garcia and Garzon, 2017, Ferri et al., 2017, Leger and Ogrizek, 2012). SD are often associated with comorbidities depending of age. For children and adolescents, they are associated for example with poor school performance and breathing abnormalities (Felden et al., 2015, Panossian and Daley, 2013, Friberg et al., 2015), for adolescents an association was reported between SD and anxiety (Kliwer and Lepore, 2015); and for adults literature on sleep found a strong association between SD and other neurological outcomes like depression, cognitive impairment and circadian disruption (Jagannath et al., 2017, Etindele Sosso and Raouafi, 2016, Sosso, 2017). Current literature did not really focus on socioeconomic factors associated with the trajectory of sleep disorders. Actual literature have a lack of data on the interaction between macroenvironment of the individual and his effect of health outcomes, even if health inequities existed and are described in many situations. Socioeconomic status (SES) and his different indicators (i.e. income, household, education, neighborhood, lifestyle) affects global health prognostic of a community, city or country, as reported by few authors (Phelan et al., 2010, Grandner et al., 2015, Grandner et al., 2016, Perales and Plage, 2017). That may also mean that SES can silently and progressively influence the development of SD in the same community. The variations in SES between different social classes of a population correspond to differences in accessibility to all resources available and able to improve global health (Phelan et al., 2010, Piccolo et al., 2013). While SES is now known as one of the main determinant for a good health and a good aging, its influence on sleep disorders is not well understood. The impact of SES can not be

observed or measure directly, it is estimated by different markers like income, education and occupational status (Phelan et al., 2010). This characteristic of SES makes it difficult to predict its influence on clinical outcomes, such as sleep impairment, on a quantitative basis. This theoretical review explores some theories linking environment of people with occurrence of sleep disorders, with different patterns associated to SES and specifically the socioeconomic gradient. A model of interaction is proposed to summarize and conceptualize these interactions and to promote more research on the topic.

### **1- Influence of objective and perceived low socioeconomic status on sleep disturbances**

Previously we talked about influence of socioeconomic gradient existing and driving the development of social inequalities, but also health inequalities. Few researchers explored this theories in the last decade and tried to understand if an association exists and whether this association become deleterious for the individual or the community. While assessing psychological and socioeconomic health status of community-dwelling older adults in Taiwan and comparing the psychological and socioeconomic health inequalities among people of different age, gender, marital status, and exercise habits, Chen et al. found that the major psychological and socio-economic health concerns were sleep disturbances and financial burden for all the groups where they performed their investigation (Chen et al., 2013). Younger old adults had better psychological and sociological health, but findings did not clearly establish why. It may be because they just started their adult life, or they did not have too many burden like a credit for a house or expenditures for children. Their findings were in line with those initiated by Van Cauter and Spiegel, who discussed in 1999 the hypothesis that the adverse impact of low SES on health may be partly mediated by decrements in sleep duration and quality (Van Cauter and Spiegel, 1999). Van Cauter and Spiegel also thought that chronic sleep debt caused by lowSES is partially associated with metabolic diseases that increase comorbidity. Their

theories merged with those of Hall and Bromberger, who published the same year an investigation on the first piece of the stress–sleep–health relationship, that is, the impact of the chronic stress of lower SES on subjective sleep complaints (Hall et al., 1999). Hall and Bromberger found that poverty is associated with subjective sleep complaints in middle-aged irrespective of age, race and education. Chronic stress associated with lower SES mediate the association of poverty with poor sleep. A gradient of health exists and is influenced by the perceived or the contextual low SES of an individual or a category of people. The manifestation of this gradient may be physical, psychological or cultural. Associations between objective and subjective SES were compared with psychological and physical variables by Adler et al., who conclude that psychological perceptions of lower social status contribute to the SES-health gradient and have significant relationships with stress, sleep disturbances and metabolic diseases (Adler et al., 2000). At the end, regardless if low SES is a perception of an individual or an objective evidence, low SES drive a global decrease of health. The future studies on the subject just confirmed this theory. Friedman et al. tested the hypothesis that SES would be associated with objectively measured sleep quality, even after controlling for related covariates (health status, psychosocial features) (Friedman et al., 2007). They found that, there are behavioral and biological implications of social ladder and sleep quality in health processes, and a negative association exists among sleep disorders, low SES and chronic morbidities. Confirmation comes later with Goodin et al., Green et al. and Okun et al. Goodin et al. showed that low perceived social status, often associated in some societies like USA with ethnicity, has a negative influence on sleep quality in poorer social class mainly represents in his study by African and Asian Americans (Goodin et al., 2010). Their results was verified by Green et al. who studied longitudinally patterns of insomnia symptoms as people age and examines how they vary according to gender and profession. They found that chronic symptoms of stress expressed by difficulties in maintaining and initiating sleep are influenced by social factors (Green et al., 2012). Okun et al. completed the reflexion when they evaluated the effect of SES on measures of sleep

quality, continuity, and quantity in a large cohort of one hundred and seventy pregnant women at 10-20 weeks gestation. They concluded that low SES was associated with poorer sleep quality and fragmented sleep (Okun et al., 2014). In summary, when you are at the bottom of the social ladder with lower income, difficulty to access health resources and you become old; low SES increases the risks of sleep disturbances.

## **2- Influence of sleep disturbances on health outcomes**

Experimentally induced sleep loss and sleep fragmentation can have both short and long term health consequences, mainly by altering the activity of major neuroendocrine systems, such as the autonomic sympatho-adrenal system and the hypothalamic-pituitary-adrenal (HPA) axis, affecting the mechanisms regulating stress responsivity<sup>26</sup>. Irwin et al. showed that nocturnal awakening and decreased slow wave sleep are associated with significantly increased levels of catecholamines<sup>27</sup>, while Vgontzas et al. found that chronic insomniacs had elevated levels of ACTH and cortisol compared to healthy controls<sup>28</sup>. Ekstedt et al. further linked microarousals with elevated levels of cortisol, lipids, heart rate, and blood pressure, as well as self-reported work-related stress, showing possible metabolic and cardiovascular contributions<sup>29</sup>. Roman et al. found also evidence for a desensitization of the (5-HT)<sub>1A</sub> receptor system after chronic sleep restriction in rats, providing implications for altered brain serotonergic neurotransmission and subsequent mood disorders<sup>30</sup>. Short term effects of sleep deprivation on cognition have been extensively studied and both a global effect on attention, vigilance, and behavioural variability, associated with impaired function of the prefrontal cortex, and also specific effects on affective processing and emotional control beyond the general impact on alertness have been identified<sup>31</sup>. Inadequate sleep in young adolescents has been related to a wide range of negative functional outcomes, including somatic and psychosocial health, school performance and risk taking behavior<sup>32</sup>.

Meta-analyses of observational cohort studies on cardiovascular outcomes in short sleep duration and insomnia have provided consistent results for a higher incidence of hypertension<sup>33,34</sup>, coronary heart disease<sup>35</sup>, and stroke<sup>35,36</sup> and also higher overall cardiovascular morbidity and mortality<sup>37,38</sup>.

Pathophysiological mechanisms responsible for these associations are thought to be the autonomic and HPA axis dysregulation and the subsequent stimulation of pro-inflammatory pathways, as indicated by the increased levels of inflammatory cytokines after sleep restriction<sup>39</sup>. Furthermore, Sauvet et al. discovered early effects of acute sleep deprivation on endothelial function before the increase in sympathetic activity<sup>40</sup> and their results were confirmed in a randomized trial by Calvin et al.<sup>41</sup>. Taken also into consideration the metabolic consequences of sleep disturbance, an increased risk of atherogenesis is the final outcome. Short sleep duration has been associated with objectively assessed indexes of atherosclerosis, such as coronary artery calcification<sup>42</sup> and carotid intima-media thickness<sup>43</sup>.

Similarly, meta-analyses of prospective studies on metabolic outcomes have found higher incidence of type 2 diabetes<sup>44</sup> and obesity<sup>45</sup> associated with short sleep duration and/or insomnia symptoms. Putative mechanisms may include increased insulin resistance<sup>46,47</sup>, altered hormonal appetite signalling (elevated ghrelin and lowered leptin, peptide YY, and glucagon-like peptide-1 levels)<sup>48,49</sup>, and increased caloric intake<sup>50,51</sup> leading to impaired glucose metabolism and weight gain<sup>52</sup>.

Circadian disruption caused by light exposure at night and desynchronised feeding schedules, as in shift workers, can alter the homeostasis of cellular metabolism, induce inflammation and contribute to tumorigenesis and cancer development<sup>53</sup>. Experimental animal studies have shown that chronodisruption, either by environmental cues<sup>54</sup> or by physical<sup>55</sup> and genetic<sup>56</sup> manipulation of the suprachiasmatic nucleus, promotes cancer growth in tumor models. However, prospective studies in humans are inconclusive and a recent meta-analysis found significantly increased relative risk only for incident colorectal cancer and not for breast, lung, or prostate cancer<sup>57</sup>.

Finally, the detrimental effects of sleep debt are reflected in the consistent evidence for higher all-cause mortality associated with short sleep duration<sup>58-61</sup>.

### **3- Mediation of the socioeconomic status-health gradient by sleep disturbances**

Like many other concepts, SES and its impact on health outcomes have different expression and different timeline from one individual to another, even if they are members of the same community or part of the same social class (Lallukka et al., 2012, Li et al., 2008, Mezick et al., 2008, Nomura et al., 2010, Paine and Gander, 2016, Paine et al., 2016, Phelan et al., 2010)<sup>67</sup>. In some cases, personal and cultural behaviour induces a lifestyle affecting trajectory and conditions of a good health (McLaughlin Crabtree et al., 2005, Patel et al., 2015, Pena et al., 2016)<sup>70</sup>. In previous researches, Etindele et al. presented brain disorders as a complex combination resulting from a diversity of psychosocial, physiological and environmental risk factors modifying neuronal networks, and leading to cognitive impairment, suicidality and associated outcomes such as mood disorders and sleep disorders (Etindele Sosso, 2017, Etindele Sosso et al., 2017, Etindele Sosso and Raouafi, 2016, Sosso, 2017)<sup>71,72</sup>. According to previous reports, these factors reveal systematic trends in the distribution of health facilities each person is exposed from birth to death; leading to chronic conditions during aging or financial burden increasing comorbidities from middle-age and elderly (Phelan et al., 2010, Sekine et al., 2006, Sivertsen et al., 2017)<sup>73,74</sup>. Tomfohr et al explored this theory by measuring the association between SES in childhood and adult sleep and analyzing adult sleep according to race<sup>75</sup>. They also evaluated if associations between SES, race and sleep are influenced by factors such as health practices and current social status. The experimental design was mixed with a combination of interviews and polysomnography; allowing researchers to obtain perceived or self-reported measures and

quantitative measures during the same project. They found that participants with lower childhood SES spent more time in Stage 2 sleep and less time in slow-wave sleep than those with higher childhood SES. Their findings showed that women from low childhood SES had more difficulties to fall asleep compared with women with high SES. Their sample was representative with women from different social class or ethnicity, and black participants spent less time in slow-wave sleep than white participants. An interaction Age X Race was identified in the prediction of subjective sleep quality, confirming the influence of age in the relation between SES and SD.

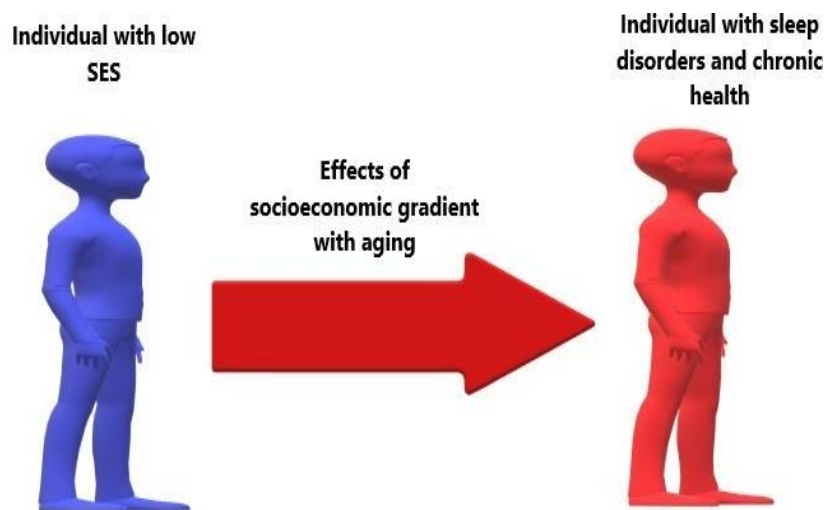
Since SES influences sleep outcomes and poor sleep has direct effects on health, as we described previously, research has further focused on the hypothesis that SD partly mediates the negative SES-health gradient. In an early report, Mulatu and Schooler identified significant longitudinal and reciprocal connections between SES and self-reported general health with sleep duration serving as significant mediator variable. However, they found an inverse association between SES and sleep duration, despite the fact that low SES predicted poorer overall health<sup>76</sup>. On the other hand, Moore et al. found a significant mediating role for poor sleep quality instead of quantity in explaining poor perceived physical and mental health of low-income subjects<sup>77</sup>. Contoyannis and Jones explained controversies and non-significant effects of lifestyle choices on the SES-health relation found in previous research by the theory of unobserved heterogeneity, according to which individuals that feel healthier are more likely to engage in unhealthy behaviors. Employing complex statistical methods, they concluded that over 75% of the total effect of lifestyle factors on the SES-health gradient is masked when they are only considered exogenous variables; accounting for endogeneity, sleeping the recommended amount of hours has a much larger positive impact on general health<sup>78</sup>. Sekine et al. tested the hypothesis that sleep quality mediates the relationship between SES and health related quality of life and identified significant gender differences, concluding that the influence of SES is more evident on the physical and particularly mental health of men rather than women<sup>79</sup>. In a more recent research on children,



insomnia complaints were proven as mediator of the association between low perceived family economy and self-reported mental health problems<sup>80</sup>.

Studies have also been conducted focusing on the effect of SES and sleep on more objective health outcomes. Cohen et al. showed that sleep duration and efficiency mediates the negative relation between perceived social ranking and susceptibility to common cold<sup>81</sup>. Inadequate sleep was found to mediate the link between SES and obesity in US<sup>82</sup> and Spanish<sup>83</sup> populations. Kumari et al. and Hawkey et al., investigated more deeply the direct association between SES and clinical outcomes such as HPA axis and sleep disorders. Kumari et al. studied if dysregulation of the HPA axis associated with disadvantaged social position in working populations also occurs in retired old people; and they found that poorer health, sleep behaviors and unstable income mediate the effect of occupational status and wealth on cortisol secretion<sup>84</sup>. Hawkey et al. investigated implications of SES over physiological dysregulation. Their conclusion stated that the effects of SES are specific to certain systems in a middle to early old-age population, creating and worsening the association between allostatic load and sleep disturbances<sup>85</sup>. Martinez et al. discovered that insomnia symptoms are in the middle of a significant path starting from low SES, passing through financial strain and leading to psychological distress and smoking prevalence<sup>86</sup>, whereas Finy and Christian concluded that low SES influences inflammation and immunity indirectly through sleep quality in pregnant women<sup>87</sup>. All these findings mixed together reveal implication and mediation influence that social conditions and their determinants exerts on global health in the life course in general, and specifically on sleep disorders (Green et al., 2012, Gu et al., 2010, Gureje et al., 2011, Hsu et al., 2013, Lallukka et al., 2012, Li et al., 2008)<sup>90</sup>. This is true for every society, developing country or low- and middle-income countries. Epidemiology of populational health demonstrated that influence of SES is present for children, adolescents and old people; whether someone lives in developed country like USA or low-income region like Sub-Saharan Africa (Green et al., 2012, Gu et al., 2010, Gureje et al., 2011, Hsu et al., 2013, Lallukka et al., 2012, Li et al.,

2008)<sup>90</sup>. The main confounding factor in this relation is age, which increase for every human and create conditions for chronic diseases, regardless of SES<sup>89,91</sup>. Lo and Lee explored SD among seniors by investigating the prevalence of poor sleep quality, the relationship between sleep quality and health-related quality of life, and associated factors of good sleepers in different age group. They conclude on a negative association between poor quality and short-term sleep with a healthy quality of life and stated that such association worsens with aging<sup>92</sup>. Similar conclusions for Green et al. who studied patterns of insomnia symptoms as people age and examines how they vary according to gender and profession, using data of three cohorts followed for 20 years. They found that chronic symptoms of insomnia -expressed by difficulties in maintaining and initiating sleep- are influenced by social factors (Green et al., 2012). Sleep disturbances appear, regardless of context, associated to SES. Sleep disorders is the result of allostatic load and in the same time the predicting sign that an individual reach his social resilience limit, as depicted in the following model (Figure 1).



**Theoretical model:** Relation between low socioeconomic status (SES) and development of sleep disorders (SD)

#### **4 Conclusions and future research**

SD mechanisms remain unknown and external stimuli originating from our environment complicate our general understanding. The existence of a socioeconomic gradient was newly recognized as a determinant of health, but sleep medicine did not link, until now, SES with clinical outcomes related to sleep impairment. More than the other stressors, the relation between SES and SD should be investigated. Living conditions and social class influences the development of health outcomes like SD by inducing allostatic load from the childhood until aging. Mood disorders, as well as metabolic diseases may be associated to this progressive decrease of global health of people, and sleep seems to be a good indicator of this degradation. Until now SES is a concept indirectly observable, but with a clear definition and use of quantitative measures like polysomnography and hormonal controls, future investigations will improve our comprehension of this socioeconomic gradient; and will clearly link the clinical outcomes observed with a direct or indirect effect of SES.

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