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SLEEP AND HYPERTENSION (S JUSTIN THOMAS, SECTION EDITOR)

Associations Between Sleep Disorders and Hypertensive Disorders of Pregnancy and Materno-fetal Consequences

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Abstract

Purpose of the Review To review the data supporting the associations between sleep disorders and hypertensive disorders of pregnancy, their diagnosis, consequences, treatment, and potential mechanisms.

Recent Findings The prevalence of sleep-disordered breathing, insomnia, and restless legs syndrome increases as pregnancy progresses secondary to physiologic changes associated with pregnancy. Sleep-disordered breathing is strongly associated with the development of gestational hypertension and preeclampsia, both of which are associated with increased risk of perinatal complications. Diagnosing sleep disorders in pregnant presents added challenges, but polysomnography remains the gold standard for diagnosing sleep-disordered breathing in this group.

Summary Sleep disorders, and especially sleep-disordered breathing, are highly prevalent among pregnant women and associated with hypertensive disorders of pregnancy. Clinicians should be mindful of this association and endeavor to identify at-risk women for further evaluation.

Keywords Sleep-disordered breathing · Obstructive sleep apnea · Hypertension · Pregnancy · Hypertensive disorders of pregnancy

Introduction

Sleep is a vital component of optimal health [1]. When sleep is disturbed whether in the form of shortened duration, or increased fragmentation and awakenings, it can have negative health consequences. Sleep disorders, including obstructive sleep apnea (OSA) and insomnia (Table 1), have been associated with an increased risk of cardiovascular morbidity and mortality [2, 3], in part through their associations with hypertension. In the case of OSA, intermittent hypoxia, oxidative stress, and sympathetic overstimulation are considered key stressors that drive the development of hypertension [4]; the other sleep disorders follow similar pathophysiology [5]. There is also emerging data implicating an association between disordered sleep and hypertension during pregnancy. It is not uncommon for women to experience reduced quality of sleep while pregnant [6]. Additionally, hypertension is the most common medical problem encountered during pregnancy, affecting up to 10% of all pregnancies [7]. The question of whether alterations in sleep—and which ones and at what level of severity—contribute to hypertensive syndromes in pregnant women requires further exploration. This review will give a focused overview of the associations between sleep disorders and hypertensive disorders of pregnancy (HDP). It will also briefly discuss the approach to diagnosing sleep disorders in pregnant women as well as the data regarding the effect of treating sleep disorders on hypertensive disorders of pregnancy.

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Normal Sleep and Associated Changes in Blood Pressure

Normal sleep architecture transitions in a structured but dynamic, temporal alteration from light to very deep sleep, and

Table 1 Types of sleep disorders in pregnancy

Sleep disorder	Definition
Insomnia	Having problems getting to sleep or staying asleep at least three times per week for at least 3 months.
Restless legs syndrome (RLS)	Sensorimotor syndrome characterized by an urge to move, associate, or not with discomfort, occurring with inactivity and relieved by active movement. Occurs at night.
Sleep disordered breathing (SDB): Obstructive sleep apnea (OSA) and snoring (as a surrogate for OSA or as "primary snoring"), central sleep apnea (CSA), sleep related hypoventilation	Intermittent pauses in breath (secondary to airway collapse in the case of OSA or to failure to central respiratory drive in case of CSA) accompanied by oxygen desaturation, followed by microarousals that restore normal respiration [39].

can also be divided into two major sub-types: REM (rapid eye movement) and non-REM. REM, which constitutes about 25% of total sleep time, is characterized by vivid dreams and promotes memory consolidation. During REM sleep, sympathetic nervous system activity is relatively high, and there is a marked variability in heart rate, blood pressure (BP), and respiratory rate [8]. In contrast, the majority of sleep time is non-REM, which is characterized by high parasympathetic tone. It is divided into three different phases with different levels of sleep depth (from lighter to deeper): N1-the transitional phase from awake to sleep, N2-an intermediate phase which encompasses the majority of adult sleep, and N3-the deepest and most restorative phase of sleep [8].

In most individuals, BP during non-REM sleep decreases by 10% or more [9] compared to while awake [1]. This "dipping" pattern is concomitantly associated with decreases in vascular tone, heart and respiratory rates, and body temperature. Additional nocturnal patterns of BP change include "non-dipping," a reduced or absent decline in BP from the awake to asleep state, and "reverse dipping," a paradoxical increase in BP from the awake to the asleep state. All of these patterns are typically assessed using ambulatory BP monitoring (ABPM), and compared to the "dipping" phenotype, non-dipping and reverse dipping are associated with increased CVD risk and mortality independent of clinic BP [10, 11].

Nocturnal BP in Normal and Hypertensive Pregnancies

During pregnancy, the typical pattern of circadian BP dipping is unchanged in normotensive women, but frequently altered in women with increased BP [12–14]. However, women with elevated BP and overt HDP have been shown to have altered BP dipping patterns. Pregnant women with elevated BP that does not meet the criteria for hypertension (HTN) had a higher prevalence of blunted BP dipping compared to normotensive pregnant women [15]. Pregnant women with chronic HTN (CH) have high rates of non-dipping [16], while in preeclampsia (PE) nocturnal dipping is blunted in mild PE and reverse dipping has been described in severe PE [9, 12]. In a study examining 86 pregnant women with several forms of HDP with ABPM [(17% CH, 43% gestational HTN (GH), and 40% PE], nocturnal HTN was highly prevalent and found to be even more frequent among PE patients (59%) than GH or CH (45%). The presence of nocturnal HTN was also more frequently associated with PE complications such as renal insufficiency, liver dysfunction, thrombocytopenia, and retarded fetal growth [17]. Alterations in nocturnal BP dipping have also been shown to predict the development of HDP. In a prospective study of 251 Iranian women who had ABPM performed during each trimester, a blunted fall in nocturnal BP in the second trimester predicted the future development of GH and PE [18•].

Sleep Assessment and Quantification

To assess for alterations in sleep quality and quantity, as well as symptoms associated with sleep abnormalities, complimentary instruments and serial testing strategies are employed. Medical and demographic characteristics can be used as an initial screening tool. In a study of 3705 pregnant women who underwent a home sleep apnea test and questionnaire assessment, a predictive model for sleep-disordered breathing (SDB) was derived and cross validated. The most parsimonious prediction model included age, BMI, and snoring ($\geq$ 3 times per week) and has a high specificity (90%) and good sensitivity (67%) [19•]. Multiple other factors were examined, including self-report of excessive sleepiness, but they did not appreciably improve the prediction of SDB. Several validated questionnaires have been developed to examine specific aspects of sleep disturbances. The Pittsburgh sleep quality index (PSQI) can be administered to assess sleep quality; the Epworth sleepiness scale (ESS) assesses daytime sleepiness, a symptom associated with SDB in men more than women; the Berlin's and Stop-Bang assess for SDB; and the insomnia severity index (ISI) assesses for insomnia.

It is important to note that the sensitivity of screening questionnaires has been shown to be reduced in pregnancy when

compared to polysomnography (PSG), the gold-standard used to diagnose abnormalities of sleep [20–22]. In a study of 293 women in their third trimester, none of 6 most commonly used sleep screening questionnaires demonstrated greater than a modest correlation with PSG [23]. In light of the low diagnostic accuracy of screening questionnaires in pregnancy, women at high risk for SDB should be referred for objective diagnostic testing to confirm the diagnosis, assess the severity of the disorder, and treatment options [24]. PSG allows assessment of not only breathing disturbances but also of sleep architecture and leg movements. PSG includes the use of electroencephalography, electrooculography, electromyography, and a nasal detector of flow to capture apneas and hypopneas, a chest derived plethysmography for respiratory effort, a pulse oximeter, and movement or EMG sensors on the legs to detect periodic leg movements (which frequently accompany restless legs syndrome). Therefore, PSG is often needed when there is a clinical suspicion of SDB, periodic limb movement disorder/RLS, or both conditions [25]. Generally, PSG is performed in a laboratory setting, although tools are available for in-home collection of multiple channels of information.

To improve the accessibility and reduce the burden of testing, more limited, in-home tests, frequently referred to as home sleep apnea tests (HSATs), can be used. These examinations vary in their design and sensors, but often include sensors for measuring airflow nasal pressures, chest effort, and blood oxygen saturation, thus allowing detection of apneas and hypopneas and differentiation between central and obstructive origins. Some devices estimate total sleep duration, and with use of complex algorithms that account for changes in heart rate and peripheral tonometry, in different sleep stages, provide estimates of time in REM and NREM sleep [26, 27]. These estimates are considered less reliable estimates of sleep duration than multiple day assessments using wrist actigraphy, and provide less precision in measuring sleep state than PSG [8].

Actigraphy, which makes assumptions about sleep-wake epochs by recording changes in movement can be used to characterize sleep-wake patterns over multiple days, assessing overall sleep duration (identifying individuals with short sleep), identifying individuals with prolonged sleep latency (a marker of insomnia), and those with increase sleep fragmentation (a marker of a number of sleep disorders) [8]. In pregnant women, actigraphy supplemented by a sleep log has been used successfully to quantify sleep duration, quality, and fragmentation [28•].

Sleep Disorders During Pregnancy

Insomnia and Poor Sleep Quality

Insomnia, the most common sleep disorder, is defined as having problems getting to sleep or staying asleep at least three times per week for at least 3 months, with significant impact on normal daytime functioning that is not secondary to a known sleep disorder or other etiology such as SDB, depression, or medication side effects. In a prospective study including 2427 pregnant women who underwent serial sleep questionnaires throughout their pregnancies, it was found that there is a progressive reduction in overall sleep duration due to both delayed time to fall asleep, and to increased nighttime awakenings; by the end of the pregnancy, 37.9% women reported short sleep duration (≤ 6 h of sleep) [6]. Not only quantity but also quality of sleep worsened with progressive increase in gestational age (72% of pregnant women reported poor quality sleep at month four vs 83.5% by the end of pregnancy) [6]. Of note, these represent much higher prevalences of short sleep duration and poor sleep quality compared to non-pregnant women where the prevalences are 52.8% and 27.8% respectively [29]. In another study of 370 women, 73.5% reported insomnia symptoms in the third trimester and presence of insomnia was associated with abnormalities of maternal body composition (increased weight and arm circumference) [30]. Similarly, in a meta-analysis that comprised 24 studies and more than 11,000 women using the PSQI, 45% of pregnant women reported poor sleep with an average PSQI = 6.01 (95% CI 5.30–6.85 indexes above 5 are considered poor sleep]; there was also a worsening of sleep quality from the second to third trimesters with an increase of 1.68 points (95% CI: 0.42–2.94) [31••].

Both insomnia and poor-quality sleep have been associated with HDP as well as other complications such as gestational diabetes (GD). In a prospective study that included 89 pregnant women, women whose PSQI questionnaire was consistent with poor sleep quality in first trimester developed higher BPs in the third trimester of pregnancy compared to women without poor first-trimester sleep quality [32•]. In another group of 439 pregnant women who were screened for insomnia and snoring, isolated insomnia as well as insomnia associated with habitual snoring were independently associated with GH as well as with adverse maternal outcomes [33]. However, the influence of poor sleep and HDP might be bidirectional. In a cross-sectional study of 56 women with GH and GD, higher PSQI scores were reported compared to healthy pregnant women. The PSQI scores continued to worsen as their pregnancies advanced and the authors hypothesized that HDP might affect sleep by increasing maternal stress; however, due to the cross-sectional design of the study, causality cannot be determined [34]. However, conflicting results have also been published. In a prospective cohort of 782 women, short sleep duration and later sleep midpoint (midpoint between sleep onset and sleep offset) were associated with GD but not with HDP [28]. Importantly, sleep patterns in the latter cohort were assessed with actigraphy, while the former two studies assessed sleep time with the completion of a self-reported questionnaire [32, 33, 34].

Restless Legs Syndrome

RLS is a sensorimotor syndrome characterized by an urge to move, which may or may not be associated with discomfort that occurs with inactivity and is relieved by active movement. It follows a circadian pattern with a rise in symptoms at night. A recent meta-analysis showed that the frequency of RLS increases as pregnancy progresses, from 8% in the first trimester to 16% in the second and 22% in the third trimester, before declining dramatically after delivery to 4% [35•]. In addition to discomfort, RLS is associated with alterations in sleep. In a group of 1563 pregnant women in their third trimester, 36% reported significant symptoms of RLS that were also associated with a detriment in sleep quality and an increase in daytime sleepiness [36•].

RLS has also been associated with GH and other maternal and fetal complications, however, again the evidence is conflicting. In a group of 3874 Chinese women, 12.3% had at least one episode of RLS per week. RLS was found to be more common as maternal age increased as well as in women with other medical comorbidities. RLS was also found to be independently associated with GH (OR (95% CI): 2.96 (1.01–8.92)); PE (2.48 (2.01–3.06)) and cardiovascular disease (1.98 (1.15–3.40)) after adjustment for potential confounders [37]. However, work by Dunietz et al. did not find an association between RLS and maternal complications despite finding strong associations between RLS and important disturbances in the sleep-wake cycle and excessive daytime sleepiness in pregnant women [36•]. Many other studies have failed to show any association between RLS and maternal or fetal outcomes after adjusting for age, BMI and other maternal comorbidities that are known to be highly associated with RLS [38]. Study differences may reflect the heterogeneity in how RLS is identified, and differences in the severity of the disorder across samples.

Sleep-Disordered Breathing

SDB includes obstructive sleep apnea (OSA characterized by repetitive partial or complete obstruction of the upper airway), snoring (which may be a symptom of OSA or represent a condition referred to as "primary snoring"), and central sleep apnea (CSA, characterized by intermittent pauses in respiration due to inadequate central respiratory drive), and sleep-related or obesity-related hypoventilation syndromes (inadequate gas exchange during sleep related to inadequate ventilation). The most common SDB conditions in pregnancy are snoring and OSA. Snoring even without frank apneas and hypopnea may increase work of breathing and cause elevations in sympathetic nervous system activation. OSA, additionally exposes the woman to repetitive periods of oxygen desaturation, and microarousals also adversely influence blood pressure and elevate sympathetic tone [39, 40]. OSA is quantified by PSG or home sleep apnea tests, by the number of respiratory events per hour: apnea hypopnea index (AHI). Mild OSA is diagnosed with an AHI ≥ 5, moderate OSA with an AHI ≥ 15, and severe OSA is considered when AHI ≥ 30. Other information, including the degree of underlying oxygen desaturation and sleep fragmentation, are also used to asses OSA severity.

It has been estimated that SDB may affect between 4 and 11% of premenopausal women although the majority are undiagnosed [41]. OSA prevalence is associated with maternal obesity and older maternal age and is more common in women with chronic hypertension and those with complicated pregnancies. In the first large scale, prospective study using home sleep apnea tests to assess OSA, the nulliparous pregnancy outcomes study monitoring mothers-to-be (NuMoM2b) study, early- and mid-pregnancy sleep studies were obtained in 2472 women and the prevalence of at least moderate OSA (AHI ≥ 15) was 3.6% during early pregnancy and 8.3% during mid pregnancy. In nuMoM2b, women were generally healthy and not overweight (body mass index < 25) [42]. However, other studies have shown that rates of OSA are higher in the presence of comorbidities. In a group of 128 obese pregnant women (BMI ≥ 30) and at least one additional risk factor (HTN, pregestational diabetes mellitus, prior history of PE, or twins pregnancy), mild OSA (AHI ≥ 5) was present in 30% during early pregnancy (6 to 20 weeks) and up to 47% in late pregnancy (after 28 weeks). The prevalence of moderate-severe OSA was 9% and 12% respectively at those timepoints [43]. There are limited data regarding the resolution of gestational OSA, which is a topic under investigation in the ongoing nuMoM2b study. One study of only 10 patients found that OSA persisted but in a less severe form following delivery [44].

While there is current consensus that SDB is associated with the presence of HDP [22, 45–49], it is unclear if this relationship is driven by the strong association of SDB with maternal comorbidities such as maternal age, chronic HTN and, more importantly, obesity [20, 50, 51]. Many studies have shown that SDB during pregnancy appears more frequently among women who were heavier prior to pregnancy and who gained more weight during pregnancy [52]. Table 2 summarizes some of the most recent studies examining the association between SDB and HDP and maternal and fetal complications [20, 25, 53, 54•, 55•, 56••, 57•]. In the largest of these studies performed to date, Facco et al. examined more than 3000 women from the nuMoM2b cohort and found an independent association between SDB in early and mid pregnancy with preeclampsia adjusted ORs for preeclampsia when sleep-disordered breathing was present were 1.94 (95% CI 1.07–3.51) and 1.95 (95% CI 1.18–3.23), respectively, and for HDP 1.46 (95% CI 0.91–2.32) and 1.73 (95% CI 1.19–2.52) [28•]. Other evidence that points to an independent contribution of SDB to HDP and adverse maternal outcomes

Table 2 Select recent studies looking at the association between sleep-disordered breathing (SDB) and hypertensive disorders of pregnancy (HDP)

Author	Population	Measurements of OSA and BP (if any)	OSA frequency/prevalence	Hypertensive disorders of pregnancy and other outcomes
Sharma et al [38]	209 Indian pregn enrolled in 1st Tr	Snoring by: Epworth and Berlin QN	Not reported	Reporting snoring at least once during pregnancy was associated with GH: OR: 4.0 [1.3–11.9] & C-sect: 5.3 [1.7–16.3] Positive Berlin QN associated with GH: OR: 30 [3.6–253]
Karaduman et al. [49]	97 with chronic disease pregn 160 healthy pregn	Epworth and Berlin QN	Overall: 20–23% Healthy: 10–12% Chronic disease: 34–45%	Significantly higher risk of being at high risk for SDB among chronically ill pregn than among healthy pregn
Bin et al [53]	636,227 pregn Australia	OSA during pregnancy or before (by ICD10 codes)	0.08% (519 women) had OSA	OSA associated with: Adj RR [95%]: -GH: 1.43 [1.18–1.73] -Preterm: 1.50 [1.21–1.84] -APGAR <7: 1.60 [1.07–2.38] -NICU: 1.26 [1.11–1.44] -Large baby: 1.27 [1.04–1.55]
Facco et al [28•]	3132 pregn	In-home PSG twice: Early (E):6–15 WOP late (L): 22–31 WOP	OSA: Early: 3.6% Late: 8.3%	Risk of developing (OR [CI]) PE: E = 1.94 [1.07–3.51]; L = 1.95 [1.18–3.23] HDP: E: 1.46 [0.91–2.32]; L:1.73 [1.19–2.52]
Bourjelly et al [54•]	−1,577,632 pregn -National Perinatal Inf Center in USA	Based on ICD9 codes (no evidence of diagnostic method)	OSA: 0.12%	OSA associated with risk (OR [95% CI]) -PE: 2.19 [1.94–2.54]) -Eclampsia: 2.95 [1.08–8.02] OSA also associated with ICU stay and in-hospital stay
Spence et al [55•]	266 OSA + pregn 3:1 matched OSA-pregn	OSA identified by ICD9 codes		OSA associated with: -GH: 2.46 [1.3–4.68] -PE: 2.42 [1.43–4.09] -C-Sect: 1.6 [1.06–2.4] -Pre-term: 1.90 [1.09–3.30]
Okun et al [33]	439 pregn in 3rd Tr	Insomnia Qn self-reporting snoring		Comorbid insomnia and snoring is associated with GH (OR: 3.6 [1.0–10.6] Insomnia and snoring were associated with obesity
Liu et al [56••]	4556 pregn in	Snoring	OSA: 15% overall 5% Europe 15% Americas	OSA is associated with risk of (OR [95%]) -GH (1.97 [1.51–2.56]) -PE (2.35 [2.15–2.58]) -C-section (1.42 [1.12–1.79]) -Pulmonary edema (6.35 [4.2–9.50]) -Preterm birth (1.62 [1.29–2.02])
Li et al [79••]	56,751,632 pregn	SDB (combination snoring or OSA)		SDB is associated with risk of (OR [95%]) -GH: 1.84 [1.53–2.22] -PE: 2.19 [1.7–2.82] -Pre-term birth: 1.75 [1.21–2.5]
Jaimchariyatam et al. [57•]	1345 pregn Thai women 2nd Tr	Berlin QN	10.1% women high risk for OSA	PE and Eclampsia: OR [95% CI]: 2.72 [1.33–5.57]

Abbreviations: *Pregn* pregnant women; *Tr* trimester; *QN* questionnaire; *OR* Odds ratio; *GH* gestational hypertension; *C-sect* C-section; *SDB* sleep disordered breathing; *NICU* neonatal intensive care unit; *OSA* obstructive sleep apnea; *Adj* adjusted; *RR* relative ratio, *PSG* polysomnographie; *WOP* weeks of pregnancy; *PE* pre-eclampsia; *HDP* hypertensive disorders pf pregnancy

include a gradient of heightened risk of maternal complications among pregnant women that correlates with severity of SDB [58]. Furthermore, in a BMI-matched group of 40 women with PE and 40 healthy pregnant women, women with PE had a higher frequency of severe SDB (35% vs 15%; $p = 0.04$) despite a similar overall prevalence of SDB in obese and non-obese women [59].

Proposed Mechanisms of Association Between Abnormal Sleep and HTN in Pregnancy

Human physiologic life is characterized by alternating cycles of sleep and wakefulness in an approximately 24-h circadian rhythm. Due to slight differences between an individual's internal clock and the fixed external one, there is a daily need for minute adjustments to harmonize the two. Melatonin is the most important internal synchronization factor that keeps humans on an appropriately timed cycle, though cortisol and other hormones also play a role [1]. During pregnancy, maternal melatonin regulates both the maternal and fetal circadian cycles, as well as influencing fetal neurodevelopment, uterine contractions, and the timing of delivery [60]. Melatonin also affects other physiologic processes in pregnant and non-pregnant individuals, including nocturnal blood pressure (BP) dipping. The exogenous administration of melatonin results in a modest reduction of nocturnal blood pressure and individuals with nocturnal hypertension have been shown to have a blunted nighttime surge in endogenous melatonin [61, 62]. A study examining pregnant women with preeclampsia (PE) found they have lower melatonin levels compared to healthy pregnant women [63].

Several other physiological changes associated with pregnancy may influence changes in sleep and breathing while asleep [64]. The female sex hormones progesterone and estrogens are associated with significant changes both in the sleep cycle and sleep architecture [65, 66]. On one hand, some physiological changes that accompany pregnancy are potentially protective in relation to sleep disorders: (1) progesterone induces airway dilator muscles and has a positive effect in respiratory drive [66], (2) estrogen reduces AHI [67], (3) the avoidance of the supine position, a known risk factor for OSA [68, 69], and (4) a decrease of REM sleep, the stage of sleep that seems to worsen OSA in women [70]. On the other hand, some changes increase the risk for OSA: (1) estrogens stimulate mucosal edema and hyperemia thereby promoting nasopharyngeal narrowing and increasing airway resistance [71]; (2) weight gain is correlated in non-pregnant women with worsening of OSA [72], and (3) the increase in abdominal girth reduces functional residual capacity and reduced oxygen reserve, as well as reduces airway stiffness [73]. Many additional factors that progressively change during pregnancy have also been related to changes in sleep. Some of these factors include gastroesophageal reflux (a condition reported to be affecting up to 75% of pregnant women in some populations), nocturnal micturition, musculoskeletal stress due to changes secondary to uterus growth, nocturn uterine contractions and preparation for delivery, rhinitis and nasal congestion, metabolic and hormonal changes, and fetal movements. Given the complex physiologic changes associated with pregnancy that influence sleep, clinicians should be attentive to potential sleep disturbances in their pregnant patients.

Treatment of Sleep Disorders and Effects on Pregnancy Complications

There is a paucity of data regarding the real impact of treating SDB on pregnancy complications. In a group of 24 pregnant women who underwent PSG and were treated with either continuous positive airway pressure (CPAP) or a combination of mandibular device and nasal strips, it was found that, among women with concomitant GH and OSA, treatment with CPAP improved SDB severity but did not improve BP, despite an average CPAP use of 6.5 h/night which constituted 78% of total sleep time [74]. Though it is a limitation of the study design that the authors were not able to assess compliance with the mandibular device/nasal strip therapy. In another study, Guilleminault et al. found in a group of 12 pregnant women with OSA that receiving early treatment with CPAP during pregnancy alleviates symptoms related to SDB but does not prevent pregnancy complications [75]. However, in pregnant women with HDP and snoring, early treatment using CPAP combined with standard prenatal care (with antihypertension medication) achieved better BP control and improved pregnancy outcomes [76]. Furthermore, Blyton and colleagues demonstrated that treatment with CPAP in 10 women with PE and SDB improved decreased fetal movement associated with the combination of these pathologies [77].

Importantly, the effectiveness of CPAP may vary with OSA's severity. In a group of 117 pregnant women with OSA, there was no difference in pregnancy outcomes when CPAP was used in mild to moderate OSA, but women with severe OSA had significantly fewer adverse pregnancy outcomes when treated with CPAP [78]. The National Institutes of Health has recently embarked on a large randomized controlled study comparing CPAP to usual care in pregnant women with SDB, aiming to reduce HDP (https://clinicaltrials.gov/ct2/show/NCT03487185). The results of this study and other controlled studies are needed to elucidate the potential benefit of treating SDB to reduce HDP and improve pregnancy outcomes for both mother and baby.

Conclusions

Sleep disorders, and especially SDB are associated with development of HDP and subsequent maternal and fetal

complications. Sleep disorders are frequently underdiagnosed in this population due to non-specific symptoms, modest accuracy of screening tools during pregnancy, dynamic changes of SDB along pregnancy progression, and limited use objective sleep monitoring. Given the existing data linking SDB, it appears prudent to identify women at high risk for SDB- those who are older, heavier, report frequent snoring, or have a history of chronic hypertension. Both in-lab and home-based sleep apnea studies are acceptable approaches for pursuing diagnosis. In addition to SDB, clinicians should assess for other sleep problems, including short sleep duration, insomnia and RLS, and consider providing healthy sleep education and referral for sleep disorder management, as appropriate.

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Compliance with Ethical Standards

Conflict of Interest Dr. Bello reports grants from NIH/NHLBI, grants from Lewis Katz Foundation, outside the submitted work. The remaining authors report no relevant financial conflicts.

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- • Of importance
- •• Of major importance

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