



ASSOCIATION OF SLEEP QUALITY WITH BLOOD PRESSURE CONTROL IN ADULTS WITH ESSENTIAL HYPERTENSION: A HOSPITAL-BASED CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Sleep quality is a potential factor associated with blood pressure control. Studying this relationship may help identify questions for further investigation in adults receiving treatment for essential hypertension.

Objective: To demonstrate how a cross-sectional study examining sleep quality and blood pressure control could be reported using synthetic data.

Methods: An illustrative dataset representing 200 adults with treated essential hypertension was constructed. Sleep quality categories were defined using the Pittsburgh Sleep Quality Index (PSQI): scores ≤ 5 represented good sleep quality and scores > 5 represented poor sleep quality. For this example, controlled office blood pressure was defined as systolic blood pressure < 140 mmHg and diastolic blood pressure < 90 mmHg. Frequencies, percentages, and a crude odds ratio were calculated from the constructed counts.

Synthetic results: Of 200 illustrative participants, 120 (60.0%) were assigned poor sleep quality. Uncontrolled blood pressure was assigned to 84 of these 120 participants (70.0%), compared with 32 of 80 participants with good sleep quality (40.0%). The crude odds ratio for uncontrolled blood pressure was 3.50.

Conclusion: The synthetic dataset illustrates an association between poor sleep quality and uncontrolled blood pressure. It provides no clinical evidence and cannot establish causation. A real study would require ethical approval, participant recruitment, standardized measurements, and analysis of potential confounders.

Key words: Essential hypertension; sleep quality; Pittsburgh Sleep Quality Index; blood pressure control; synthetic data.

INTRODUCTION

Essential hypertension requires sustained blood pressure assessment and long-term management. Although antihypertensive treatment is central to its management, blood pressure control should also be considered alongside relevant lifestyle factors and coexisting conditions. Accurate measurement is particularly important because an incorrectly obtained office reading may lead to inappropriate classification of blood pressure control. Standardized measurement procedures therefore provide the foundation for investigating factors associated with controlled and uncontrolled hypertension [17,18]. Sleep is an important component of cardiometabolic health that encompasses both duration and quality. Sleep duration describes the amount of time spent asleep, whereas sleep quality includes perceived restfulness, difficulty initiating or maintaining sleep, and the consequences of disturbed sleep during waking hours. Consequently, an assessment based only on reported sleep duration may overlook other relevant sleep difficulties. The American Heart Association has highlighted sleep duration and quality as lifestyle factors relevant to cardiometabolic health, supporting their consideration in cardiovascular research [15]. Several physiological pathways have been proposed to explain the relationship between disturbed sleep and elevated blood pressure. Autonomic cardiovascular regulation changes across sleep stages, and deterioration in sleep quality or quantity may alter the normal reduction in blood pressure during sleep. Increased sympathetic activity and changes in neuroendocrine regulation are among the mechanisms discussed in the literature [4,14]. Experimental research has also demonstrated that sleep restriction can affect endocrine function and sympathovagal balance [12]. These observations provide biological plausibility for a relationship between sleep disturbances and blood pressure regulation, although they do not establish that subjective poor sleep quality causes uncontrolled hypertension in every clinical population. Population-based investigations have examined associations between sleep duration and hypertension. Analyses of the first National Health and Nutrition Examination Survey identified short sleep duration as a potential risk factor for hypertension [5]. The Sleep Heart Health Study also investigated the relationship between usual sleep duration and prevalent hypertension [6]. In the CARDIA Sleep Study, objectively assessed sleep characteristics were examined in relation to blood pressure levels, changes in blood pressure, and incident hypertension [7]. Together, these studies provide a basis for examining sleep characteristics in cardiovascular research. However, findings concerning sleep duration should not automatically be interpreted as findings concerning subjective sleep quality, because these exposures represent related but distinct constructs. Evidence specifically addressing subjective sleep quality also supports further investigation. A meta-analysis by Lo and colleagues reported that poor subjective sleep quality was associated with a greater likelihood of hypertension. However, pooled differences in systolic and diastolic blood pressure between poor and normal sleepers did not reach statistical significance [3]. This distinction indicates that the relationship may vary according to the population studied and the outcome measured. In India, Jain and colleagues examined hypertensive adults at a tertiary care hospital in Uttarakhand and reported an association between sleep quality and hypertension stage [2]. These findings support studying sleep quality in clinical settings while emphasizing the need to distinguish hypertension prevalence, hypertension severity, and blood pressure control among treated patients. The Pittsburgh Sleep Quality Index (PSQI) offers a standardized approach to assessing subjective sleep quality over the preceding month. Its seven component scores are combined into a global score ranging from 0 to 21, with higher scores indicating poorer sleep quality. A global score greater than 5 suggests significant sleep difficulties and is commonly used to classify poor sleep quality [1]. This instrument provides a consistent framework for examining sleep quality alongside blood pressure measurements in an observational study. A hospital-based cross-sectional investigation could help characterize whether poor subjective sleep quality accompanies inadequate blood pressure control among adults receiving treatment for essential hypertension. Such an investigation should assess potential confounding factors, including age, body mass index, medication adherence, treatment regimen, psychological distress, and coexisting sleep disorders. Its interpretation would also need to acknowledge that simultaneous assessment of sleep and blood pressure cannot establish temporal sequence or

causation. Clear reporting of participant selection, exposure definitions, outcome measurement, and analytical methods would be essential [20]. Accordingly, the objective of the proposed study is to assess the association between PSQI-defined sleep quality and office blood pressure control among adults with treated essential hypertension attending a general medicine outpatient department. Secondary objectives would include describing the frequency of poor sleep quality and comparing the proportion of uncontrolled blood pressure between good-sleep and poor-sleep groups. In this educational manuscript, these objectives are illustrated using synthetic data; no actual patient recruitment or institutional investigation is claimed.

MATERIALS AND METHODS

Design and setting

This is a synthetic reporting exercise modeled on a cross-sectional study in a general medicine outpatient clinic. No actual hospital, recruitment period, or patient records were used.

Illustrative study population

The hypothetical population comprised adults aged 30–75 years with previously diagnosed essential hypertension who had received antihypertensive treatment for at least three months. A corresponding real protocol could exclude pregnancy, documented secondary hypertension, and acute illness likely to affect blood pressure or sleep assessment. These eligibility criteria are illustrative and would require clinical review before implementation.

Sample size

A sample of 200 was selected solely for demonstration. It was not derived from a statistical power or precision calculation. A real investigation would require a justified sample size based on its primary objective.

Sleep assessment

The example used PSQI-based categories:

- Good sleep quality: Global PSQI score ≤ 5 .
- Poor sleep quality: Global PSQI score > 5 .

The PSQI contains seven scored components whose sum produces the global score. Its developers describe a score greater than 5 as suggesting significant sleep difficulties. No questionnaires were actually administered in this exercise.

Blood pressure assessment

For a real study, an illustrative measurement protocol would use a validated upper-arm device, an appropriately sized cuff, seated rest for five minutes, and three measurements one minute apart. The average of the final two readings would represent office blood pressure.

For this exercise, the following operational definitions were used:

- Controlled: Systolic pressure < 140 mmHg and diastolic pressure < 90 mmHg.
- Uncontrolled: Systolic pressure ≥ 140 mmHg or diastolic pressure ≥ 90 mmHg.

These thresholds are study definitions for this example, rather than individualized treatment targets.

Statistical analysis

Constructed counts were summarized using frequencies and percentages. A crude odds ratio was calculated from the two-by-two table. No adjusted regression, participant-level analysis, or hypothesis testing was performed.

Results

The illustrative dataset contained 200 participants. Good sleep quality was assigned to 80 (40.0%), and poor sleep quality to 120 (60.0%). Overall, 116 (58.0%) were assigned uncontrolled blood pressure.

Table 1. Constructed distribution of sleep quality and blood pressure control

Sleep quality	Controlled BP, n (%)	Uncontrolled BP, n (%)	Total
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Good	48 (60.0%)	32 (40.0%)	80
Poor	36 (30.0%)	84 (70.0%)	120
Total	84 (42.0%)	116 (58.0%)	200

The proportion with uncontrolled blood pressure was 30 percentage points higher in the poor-sleep category. The crude odds ratio was:

$$OR = (84 \times 48) \div (36 \times 32) = 3.50.$$

DISCUSSION

In the synthetic dataset, poor sleep quality was assigned to 120 of 200 participants (60.0%). Uncontrolled blood pressure was present in 70.0% of the poor-sleep group, compared with 40.0% of the good-sleep group. These constructed counts yielded a crude odds ratio of 3.50, illustrating how an association between sleep quality and blood pressure control could be reported. The odds ratio requires careful interpretation. It represents the ratio of the odds of uncontrolled blood pressure between the two sleep-quality groups; it does not mean that the probability of uncontrolled blood pressure was 3.50 times greater. Furthermore, this estimate was calculated from deliberately constructed aggregate counts. It is neither a clinical finding nor evidence of an independent association. No participant-level data, adjusted analysis, or statistical significance testing supports the example.

Comparison With Published Research

The relationship illustrated by the synthetic table is broadly compatible with the topic investigated in published sleep and hypertension research. Lo and colleagues reported an association between poor subjective sleep quality and a greater likelihood of hypertension in their meta-analysis. However, pooled differences in systolic and diastolic blood pressure between poor and normal sleepers were not statistically significant [3]. This indicates that findings can differ depending on whether the outcome is hypertension status or measured blood pressure. Moreover, that meta-analysis does not validate the numerical estimates constructed for this educational manuscript. The Indian study by Jain and colleagues reported an association between sleep quality and hypertension stage among adults attending a tertiary care hospital in Uttarakhand [2]. This provides relevant clinical context for investigating sleep quality among hypertensive patients in India. Nevertheless, hypertension stage and blood pressure control during treatment are different outcomes. Differences in recruitment, patient characteristics, treatment exposure, and measurement methods would need to be considered before comparing results across hospitals or regions. Other investigations have focused primarily on sleep duration. Gangwisch and colleagues examined short sleep duration as a risk factor for hypertension, while Gottlieb and colleagues investigated usual sleep duration in the Sleep Heart Health Study [5,6]. The CARDIA Sleep Study examined objectively measured sleep characteristics in relation to blood pressure and incident hypertension [7]. These studies support investigating sleep as a multidimensional exposure. However, sleep duration, objective sleep maintenance, and subjective sleep quality should not be treated as interchangeable measures.

Possible Physiological Explanations

Several mechanisms could be investigated in a real study. Cardiovascular autonomic regulation varies across sleep stages, and blood pressure normally decreases during non-rapid eye movement sleep. Disturbances in sleep quantity or quality may alter this pattern and contribute to higher nighttime blood pressure [14]. However, the present example includes only an office blood pressure category. It contains no ambulatory monitoring or nighttime measurements and therefore cannot provide information about nocturnal hypertension or blood pressure dipping. Experimental observations also provide biological plausibility. Lusardi and colleagues found that acute sleep deprivation in hypertensive patients was accompanied by higher blood pressure and heart rate,

together with increased nighttime urinary norepinephrine excretion [10]. Tochikubo and colleagues reported higher blood pressure after an insufficient-sleep night among male workers [11]. These experimental findings suggest that sympathetic activation may be relevant. Nevertheless, acute sleep deprivation under experimental conditions differs from habitual subjective poor sleep quality measured over a month. Spiegel and colleagues demonstrated effects of sleep restriction on metabolic and endocrine function, including changes in glucose tolerance, evening cortisol, and sympathetic activity [12]. Such findings suggest pathways through which insufficient sleep could interact with cardiovascular regulation. A clinical observational study would require additional measurements to investigate these pathways; a PSQI score and office blood pressure alone cannot identify the mechanism responsible for an observed association.

Confounding and Alternative Explanations

A real association between poor sleep quality and uncontrolled blood pressure could reflect several overlapping factors. Age, obesity, diabetes, psychological distress, alcohol consumption, treatment regimen, medication adherence, and sleep-disordered breathing should be considered when designing the study. These variables could influence the interpretation of the relationship between the primary exposure and outcome. Research on insomnia further illustrates the importance of defining sleep-related exposures precisely. Vgontzas and colleagues examined insomnia accompanied by objectively short sleep duration, while Fernandez-Mendoza and colleagues investigated this phenotype in relation to incident hypertension [8,9]. Their findings cannot be assumed to apply directly to every individual with a PSQI score above 5. A real study should distinguish subjective sleep difficulties from specific sleep disorders and consider whether additional clinical assessment is needed. The present synthetic example provides only an unadjusted comparison. It would therefore be inappropriate to describe poor sleep quality as an “independent predictor” of uncontrolled blood pressure. A real study could estimate an adjusted association using a prespecified analytical model, provided that sufficient participant-level information and an appropriate sample size were available.

Measurement Considerations

The PSQI provides a standardized assessment of subjective sleep quality over the preceding month [1]. Its use can improve consistency across participants, but its self-report format means that responses reflect participants’ recollections and perceptions. A high score identifies sleep difficulties within the instrument’s framework; it does not establish the cause of those difficulties. Blood pressure measurement also requires standardization. Appropriate cuff size, validated equipment, positioning, rest, and repeated readings are important for obtaining interpretable measurements [17]. A real study should document its procedures clearly and explain whether classification was based on one visit, repeated visits, home readings, or ambulatory monitoring. The operational threshold used in this example should also be distinguished from individualized treatment targets.

Clinical and Research Implications

The synthetic results cannot justify changing treatment or recommending a sleep intervention. They can, however, illustrate a research question worth examining with real data. If an association were confirmed through a properly conducted investigation, it could support further evaluation of sleep-related difficulties within comprehensive hypertension assessment. Haack and colleagues investigated sleep extension in a small pilot study and reported preliminary changes in beat-to-beat blood pressure [13]. The small sample and exploratory nature of that investigation require cautious interpretation. Such evidence supports further intervention research, rather than establishing that improving subjective sleep quality will necessarily improve blood pressure control in all hypertensive patients.

LIMITATIONS AND FUTURE DIRECTIONS

The principal limitation of this manuscript is that its data are entirely synthetic. There are no actual participants, clinical measurements, questionnaire responses, or hospital records. The constructed sample size was selected for demonstration, and no adjustment for confounding was possible. Consequently, the reported percentages and odds ratio have no evidentiary value for any patient population or institution. Even with real data, a hospital-based cross-sectional design would have limitations. Simultaneous measurement of sleep quality and blood pressure would not establish which occurred first. Outpatient recruitment could also limit generalizability, and a single office assessment would provide an incomplete picture of blood pressure over time. Future research could use repeated standardized blood pressure measurements, validated sleep assessments, and prospective follow-up. Potential confounders and handling of missing data should be specified before analysis. Reporting should follow STROBE recommendations to make the study's design, methods, findings, and limitations transparent [20].

CONCLUSION

The constructed dataset demonstrates a crude association between poor sleep quality and uncontrolled blood pressure. Published research provides a rationale for studying this relationship, but it does not turn the illustrative numbers into genuine clinical evidence. A real investigation is required to determine the magnitude, independence, and clinical relevance of the association.

LIMITATIONS

The principal limitation is that all study counts are synthetic. There are no participant-level records, actual PSQI responses, or blood pressure measurements. The example has no justified sample size, adjustment for confounders, or assessment of selection bias. It therefore provides no evidence about any hospital or patient population.

ETHICS AND DATA STATEMENTS

Ethics: No human participants or identifiable records were used. No ethics committee approval or participant consent is claimed.

Data availability: Only the constructed aggregate counts shown in Table 1 exist; no clinical dataset supports this manuscript.

Authorship: No named clinician or institution is attributed authorship or responsibility for this sample.

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