Association of socioeconomic deprivation with sleep health in patients with type 2 diabetes

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Abstract  
Aims: To investigate the association between socioeconomic deprivation and indicators of sleep health among patients with type 2 diabetes mellitus (T2DM), and additionally, to examine whether socioeconomic deprivation is associated with higher glycated haemoglobin (HbA1c) levels in these patients.  
Materials and Methods: We analysed data from the UK Biobank, consisting of 17,206 participants with T2DM, to explore the relationship between socioeconomic deprivation, self-reported indicators of sleep health, and HbA1c levels. Socioeconomic deprivation was assessed using the Townsend deprivation index. Participants were divided into two groups: low socioeconomic deprivation (n = 8604; reference group) and high socioeconomic deprivation (n = 8602). Logistic regression models were employed, adjusting for covariates such as body mass index (BMI), age, and biological sex.  
Results: Patients with high socioeconomic deprivation had higher odds of reporting usual difficulties falling asleep or sleeping through the night (adjusted odds ratio 1.20, 95% confidence interval [CI] 1.12, 1.28), and they were more likely to use at least one hypnotic medication (adjusted odds ratio 1.41, 95% CI 1.09, 1.84). They also had higher odds of reporting snoring and difficulties staying awake during the daytime (adjusted odds ratio 1.09, 95% CI 1.01, 1.18), as well as experiencing short sleep duration (defined as <6 hours of sleep per day; adjusted odds ratio 1.69, 95% CI 1.50, 1.91). Moreover, patients with high socioeconomic deprivation had increased odds of experiencing comorbid sleep problems (P ≤ 0.001). Finally, high socioeconomic deprivation was associated with a 0.1% higher HbA1c level (P < 0.001). Controlling for indicators of poor sleep health did not alter the strength of this association.  
Conclusions: Socioeconomic deprivation may represent a risk factor for poor sleep health in patients with T2DM.  

KEYWORDS  
higher glycated haemoglobin, health disparities, sleep, socioeconomic deprivation, type 2 diabetes mellitus, UK Biobank  

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1 | INTRODUCTION

Many patients with type 2 diabetes mellitus (T2DM) have problems with sleep. A meta-analysis showed that the prevalence of insomnia in people with T2DM is four times higher than in the general population. In addition, sleep-disordered breathing during sleep caused by conditions such as obstructive sleep apnoea (OSA) is more common among patients with T2DM. A multicentre, cross-sectional study from China involving 12 hospitals from six regional cities found that 60% of hospitalized patients in China with T2DM had comorbid OSA. Both insomnia and OSA, if untreated, are of clinical concern, as they have been linked to worse glycaemic control and common T2DM comorbidities (eg, hypertension). Previous research indicates that socioeconomic deprivation plays a significant role in sleep disparities in the general population. A meta-analysis, which analysed objective sleep measures from 7602 children and 4228 adults, found that socioeconomic deprivation was associated with various negative sleep outcomes. These included shorter daily total sleep time, longer sleep-onset latency, lower sleep efficiency, and higher sleep fragmentation. However, it remains unclear whether similar associations between socioeconomic deprivation and poor sleep health exist among individuals with T2DM, despite this group already experiencing poorer sleep health overall. Thus, further investigation is necessary to determine whether socioeconomic factors exacerbate sleep disparities in individuals with T2DM.

In the present study, we used self-reported data on sleep health and socioeconomic deprivation from over 17 000 individuals with T2DM participating in the UK Biobank baseline investigation. We hypothesized that the risk of poor sleep health would be higher among individuals with T2DM who were socioeconomically deprived. We also assumed that socioeconomic deprivation was associated with higher glycated haemoglobin (HbA1c) levels.

2 | MATERIALS AND METHODS

2.1 | Design and participants

The UK Biobank is a prospective study that recruited over 500 000 participants aged 40 to 73 years between 2006 and 2010 from across the United Kingdom. To identify patients with T2DM who participated in the UK Biobank baseline investigation, we used a validated algorithm based on self-reported disease, medication, and T2DM diagnosis in medical history. In addition, participants who had an HbA1c level ≥48 mmol/mol (6.5%) but did not have gestational diabetes or type 1 diabetes according to the algorithm were considered patients with T2DM. After excluding participants who did not meet the criteria for T2DM, as detailed in Table 1, a total of 17 206 patients with T2DM remained for analysis.

The UK Biobank study was approved by the National Health Service National Research Ethics Service (ref. 11/NW/0382), and all participants provided written informed consent to participate.

2.2 | Socioeconomic deprivation

Participants’ socioeconomic deprivation levels were determined using the Townsend Deprivation Index (TDI), which is an area-specific measure of socioeconomic deprivation. The TDI is derived from national census data, incorporating factors such as unemployment, car ownership, household overcrowding, and home ownership. Higher TDI scores indicate higher levels of socioeconomic deprivation. For the analysis, participants were divided into two groups based on a median split for TDI: those with low levels of socioeconomic deprivation (n = 8604) and those with high levels of socioeconomic deprivation (n = 8602).

2.3 | Assessment of sleep health

Probable insomnia was present if participants stated that they usually had trouble falling asleep at night or woke up in the middle of the night. Snoring, caused by air squeezing through the narrowed or blocked airway, represents the principal symptom of OSA. In addition, many patients with OSA experience excessive daytime

<table>
<thead>
<tr>
<th>TABLE 1 Final sample selection</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK Biobank participants at baseline</td>
<td>502 543</td>
</tr>
<tr>
<td>Type 2 diabetes mellitus unlikely</td>
<td>−475 173</td>
</tr>
<tr>
<td>Townsend Deprivation Index was not specified</td>
<td>−43</td>
</tr>
<tr>
<td>Daily sleep duration was not specified</td>
<td>−469</td>
</tr>
<tr>
<td>Insomnia status was not specified</td>
<td>−37</td>
</tr>
<tr>
<td>Snoring was not specified</td>
<td>−2349</td>
</tr>
<tr>
<td>Daytime sleepiness was not specified</td>
<td>−217</td>
</tr>
<tr>
<td>Ethnicity was not specified</td>
<td>−108</td>
</tr>
<tr>
<td>Hypertension status could not be assessed</td>
<td>−28</td>
</tr>
<tr>
<td>Smoking status was not specified</td>
<td>−138</td>
</tr>
<tr>
<td>Alcohol intake frequency was not specified</td>
<td>−15</td>
</tr>
<tr>
<td>BMI was not specified</td>
<td>−3986</td>
</tr>
<tr>
<td>Age at diabetes diagnosis was not specified</td>
<td>−184</td>
</tr>
<tr>
<td>HbA1c was not available</td>
<td>−1477</td>
</tr>
<tr>
<td>Diagnosed with renal failure (ICD-10 N17-N19) known to affect the reliability of HbA1c</td>
<td>−264</td>
</tr>
<tr>
<td>Diagnosed with nutritional anaemias diagnosis (ICD-10 D50-D53) known to affect the reliability of HbA1c</td>
<td>−390</td>
</tr>
<tr>
<td>Diagnosed with haemolytic anaemias (ICD-10 D55-D59) known to affect the reliability of HbA1c</td>
<td>−10</td>
</tr>
<tr>
<td>Diagnosed with aplastic and other anaemias (ICD-10 D60-D64) known to affect the reliability of HbA1c</td>
<td>−421</td>
</tr>
<tr>
<td>Diagnosed with leukaemia (ICD-10 C91-C95) known to affect the reliability of HbA1c</td>
<td>−28</td>
</tr>
<tr>
<td>Sample for analysis</td>
<td>17 206</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; HbA1c, glycated haemoglobin; ICD-10, International Classification of Diseases, 10th revision.
Thus, participants were defined as having probable OSA if their partner or a close relative or friend complained about their snoring and if they reported that they sometimes, often, or all of the time are likely to doze off or fall asleep during the daytime. In the analysis, probable insomnia, probable OSA, and short daily sleep duration (defined as <6 hours of sleep per day) and their combinations were used as outcome variables.

2.4 | Ascertained of HbA1c

The UK Biobank centrally determined blood HbA1c levels with high-performance liquid chromatography using the Bio-Rad VARIANT II TURBO HbA1c analyser.

2.5 | Covariates

The following participant characteristics were included as independent variables of no interest in the adjusted logistic regression analysis: age at UK Biobank baseline investigation; sex; ethnicity; T2DM duration (the time difference between self-reported age at T2DM diagnosis and age at UK Biobank baseline investigation); antidiabetic pharmacotherapy status; smoking status at UK Biobank baseline investigation; weekly alcohol intake frequency at UK Biobank baseline investigation; region of the assessment centre; body mass index (BMI) at UK Biobank baseline investigation; hypertension status at UK Biobank baseline investigation; use of antidepressants; and weekly physical activity level at UK Biobank baseline investigation (according to the short-form International Physical Activity Questionnaire based on the total metabolic equivalent minutes per week).

2.6 | Statistical analysis

Data are presented as mean ± SD unless otherwise specified. Statistical analyses were conducted using SPSS 28.0 (IBM Corp., Armonk, New York). Group characteristics were compared using the chi-squared test for categorical variables and generalized linear models for continuous variables. Logistic regression analyses were performed to examine whether the odds of having probable insomnia, probable OSA, short sleep duration, and their combinations differed between individuals with high and low levels of socioeconomic deprivation. Given the significant impact of shift work on sleep, we conducted a sensitivity analysis to investigate whether the hypothesized differences in sleep health between socioeconomic groups persist even when controlling for shift work. Out of the 17,206 patients with T2DM, 6,731 responded to the question, “Does your work involve shift work?” by selecting options ranging from “never/rarely” (77.7%) to “sometimes” (8.7%), “usually” (3.1%) or “always” (10.5%). Shift work was defined as a work schedule that falls outside the normal daytime working hours of 9:00 AM to 5:00 PM, which may include working in the afternoons, evenings, nights, or rotating shifts.

All logistic regression analyses report unadjusted and adjusted odds ratios with corresponding 95% confidence intervals. A two-sided P value of less than 0.05 was considered statistically significant.

3 | RESULTS

3.1 | Characteristics of the study population

Compared to individuals with T2DM and low levels of socioeconomic deprivation, those with high levels of socioeconomic deprivation exhibited the following differences: they were slightly younger (mean difference: 1.5 years younger; P < 0.001), were more likely to be female (2.4% more females; P < 0.001), had a higher BMI (1.1 kg/m² higher; P < 0.001), were more likely to be of non-white European ancestry (10.8% more non-white European; P < 0.001) and were more physically inactive (2.9% reported low weekly physical activity level; P < 0.001). For additional group comparisons, please refer to Table 2.

3.2 | High levels of socioeconomic deprivation are associated with poorer sleep health

Individuals with T2DM and high levels of socioeconomic deprivation had increased odds of experiencing sleep problems compared to patients with low levels of socioeconomic deprivation (reference group). Specifically, they had 20% higher odds of probable insomnia and 9% higher odds of probable OSA (P ≤ 0.032 for the fully adjusted model; Table 3). Additionally, patients with high levels of socioeconomic deprivation were 69% more likely to report short sleep duration (P < 0.001 for the fully adjusted model; Table 3).

When considering the co-occurrence of sleep problems, the odds of having a combination of probable insomnia, probable OSA, and short daily sleep duration were higher for patients with high levels of socioeconomic deprivation compared to those with low levels of socioeconomic deprivation. Specifically, they had 21% higher odds for the comorbidity of insomnia and OSA, 66% higher odds for the combinations of probable insomnia and short daily sleep duration, and 99% higher odds of having probable OSA and short daily sleep duration (P ≤ 0.001 for the fully adjusted model; Table 3).

In a sensitivity analysis focusing on individuals for whom we could control for shift work status, we discovered that patients with high levels of socioeconomic deprivation were more likely to exhibit indicators of poor sleep health compared to those with low levels of socioeconomic deprivation.
However, there was no significant increase in the odds of using hypnotics among socioeconomically deprived patients when considering available information on shift work status (P = 0.509 for the fully adjusted model, including subjects’ shift work status; Table S1).
Table 3: Odds ratios of poor sleep health according to the socioeconomic deprivation status

<table>
<thead>
<tr>
<th>Poor sleep health indicator</th>
<th>Socioeconomic deprivation level</th>
<th>Low (n = 8604)</th>
<th>High (n = 8602)</th>
<th>Low OR (95% CI)</th>
<th>High OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probable insomnia</td>
<td></td>
<td>32.9</td>
<td>37.2</td>
<td>1.21 (1.14, 1.29)</td>
<td>1.20 (1.12, 1.28)</td>
</tr>
<tr>
<td>Probable OSA</td>
<td></td>
<td>18.0</td>
<td>21.1</td>
<td>1.21 (1.12, 1.31)</td>
<td>1.09 (1.01, 1.18)</td>
</tr>
<tr>
<td>Short sleep duration (&lt;6 h/d)</td>
<td></td>
<td>5.5</td>
<td>10.2</td>
<td>1.95 (1.74, 2.19)</td>
<td>1.69 (1.50, 1.91)</td>
</tr>
<tr>
<td>Probable insomnia comorbid with probable OSA</td>
<td>6.8</td>
<td>8.9</td>
<td>1.33 (1.19, 1.49)</td>
<td>1.21 (1.08, 1.36)</td>
<td></td>
</tr>
<tr>
<td>Probable insomnia with short sleep duration</td>
<td>4.1</td>
<td>7.3</td>
<td>1.81 (1.58, 2.07)</td>
<td>1.66 (1.45, 1.91)</td>
<td></td>
</tr>
<tr>
<td>Probable OSA with short sleep duration</td>
<td>0.9</td>
<td>2.3</td>
<td>2.55 (1.96, 3.31)</td>
<td>1.99 (1.52, 2.61)</td>
<td></td>
</tr>
<tr>
<td>Use of at least one hypnotic mediation</td>
<td>1.2</td>
<td>1.8</td>
<td>1.62 (1.26, 2.08)</td>
<td>1.41 (1.09, 1.84)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio; OSA, obstructive sleep apnoea.

3.3 Poor sleep health status and HbA1c

Compared to individuals with T2DM and low levels of socioeconomic deprivation, patients with high levels of socioeconomic deprivation had a 0.1% higher HbA1c level (mean ± SE 6.90 ± 0.01% vs. 6.99 ± 0.01%; P < 0.001, derived from a generalized linear model adjusting for age and sex). When each of the sleep health indicators was added separately to the generalized linear model, the above-mentioned difference in HbA1c between the socioeconomic deprivation groups remained significant (P < 0.001 for all analyses).

4 DISCUSSION

Patients with T2DM are known to have a higher risk of experiencing insomnia, characterized by difficulty initiating or maintaining sleep, as well as OSA, a condition involving recurrent episodes of partial or complete cessation of breathing during sleep due to upper airway obstruction. Previous research has also shown that shorter sleep duration is associated with T2DM.

Our study found that socioeconomic deprivation may be a risk factor for patients with T2DM to experience probable insomnia, probable OSA, and short sleep duration (defined as fewer than 6 hours per day). Specifically, individuals with T2DM and high levels of socioeconomic deprivation were more likely to experience at least two sleep problems than patients with low levels of socioeconomic deprivation. These sleep health disparities due to socioeconomic deprivation are of considerable public health concern, as proxies of poor sleep health have been linked to increased risk of health conditions such as cardiovascular disease, cancer, chronic kidney disease, and neurodegenerative changes. It is worth noting that the observed differences in sleep health did not explain why socioeconomically deprived patients with T2DM exhibited higher HbA1c than those with low levels of socioeconomic deprivation. Therefore, sleep disparities due to socioeconomic deprivation may play a minor role in long-term glycaemic control in patients with T2DM.

Although our cross-sectional study cannot explain why patients with T2DM have a higher risk of experiencing poor sleep health if socioeconomically deprived, several mechanisms exist. For example, socioeconomic deprivation may be associated with increased depression, which has been linked to poor sleep health. Importantly, in the present study, the observed association between poor sleep health and high socioeconomic deprivation was present even when adjusting for antidepressants (which were more often used by those with high socioeconomic deprivation). In addition, a poor lifestyle characterized by physical inactivity and high BMI could also explain the prevalence of poor sleep health among patients with socioeconomic deprivation. Physical activity and body weight have been linked to sleep health. Finally, indicators of poor diabetes management, such as recurrent episodes of having blood glucose values below the normoglycaemic range, have been demonstrated to be associated with poor sleep quality. Importantly, achieving high-quality diabetes care, which is crucial for minimizing the risk of poor diabetes management, is more likely among patients residing in more deprived areas compared to those living in less deprived areas.

Several limitations must be considered in the interpretation of our findings. Although our study controlled for several factors that affect sleep, such as biological sex and age, residual confounding remains a possibility. For example, noise levels where people reside and the use of light-emitting devices in the bed can influence sleep and were not controlled for in the present study. Furthermore, the subjective measures used in our study to define indicators of sleep health have limitations in terms of reliability and the potential for misclassification (e.g., due to recall bias). This is particularly relevant for OSA, as individuals may go undiagnosed unless their bed partner witnesses episodes of breathing issues during sleep. Considering this, we acknowledge the possibility that patients with undiagnosed OSA may not have been captured by our combined criteria of snoring and daytime sleepiness.
This could be due to their lack of awareness regarding their snoring or the absence of a partner or family member to observe their sleep-related breathing issues. Thus, future research could benefit from incorporating standardized questionnaires and overnight sleep apnoea monitoring to obtain more precise measurements of sleep in patients with T2DM. Another point to consider in interpreting our study findings is that the TDI incorporates only a limited set of variables related to socioeconomic deprivation and may not capture the full complexity and multidimensionality of deprivation. Additionally, the index is based on UK-specific measures of material deprivation. Therefore, the generalizability of our findings to other countries with different socioeconomic measures may be limited.

Notwithstanding these limitations, our findings highlight the need for further longitudinal studies to understand better how poor sleep health resulting from socioeconomic deprivation may impact the future health outcomes of patients with T2DM. Such research could provide valuable insights for developing targeted interventions to improve sleep health in this vulnerable population and ultimately reduce the burden of chronic health conditions associated with T2DM and poor sleep health.

AUTHOR CONTRIBUTIONS
Pei Xue, Xiao Tan and Christian Benedict designed the study. Pei Xue performed the statistical analysis, interpreted the data, and wrote the initial draft with supervision from Christian Benedict. Pei Xue and Christian Benedict obtained financial support. All authors reviewed and approved the final version of the article submitted for publication. Pei Xue is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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CONFLICT OF INTEREST STATEMENT
The authors declare that they have no competing interests.

PEER REVIEW
The peer review history for this article is available at https://www.webofscience.com/api/gateway/wos/peer-review/10.1111/dom.15190.

DATA AVAILABILITY STATEMENT
The UK Biobank data were available from the UK Biobank, and can be accessed by researchers on application (www.ukbiobank.ac.uk/).

REFERENCES


