Association of Snoring With Chronic Bronchitis

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Background: Snoring is more prevalent in patients with chronic bronchitis than in persons without it. Few studies have examined the effect of snoring on chronic bronchitis. We prospectively investigated the association between snoring and the incidence of chronic bronchitis.

Methods: The baseline study was conducted from June 25, 2001, to January 29, 2003. Members of the study cohort consisted of 5015 male and female Korean citizens aged 40 to 69 years at baseline who participated in a comprehensive health examination and on-site interviews at Korea University Ansan Hospital. Of these, 4270 participants (52% men and 48% women) entered the analysis for the first 2-year follow-up from April 17, 2003, to February 20, 2005, and those who met the same inclusion criteria remained in the analysis for a second 2-year follow-up period from February 21, 2005, to November 17, 2006. We collected information on snoring at baseline and identified incident cases of chronic bronchitis during a 4-year follow-up period. On the baseline questionnaire, we excluded participants who reported the presence of cough and sputum production on most days for at least 3 months a year.

Results: During 4 years of follow-up, we documented 314 cases of new-onset chronic bronchitis (27.1 cases per 1000 person-years). After taking into account age, smoking, and other risk factors for chronic bronchitis, the multivariate relative risks of chronic bronchitis were 1.25 (95% confidence interval [CI], 0.95-1.64) for persons snoring 5 times per week or less and 1.68 (95% CI, 1.17-2.42) for those snoring 6 to 7 times per week compared with never snorers (P for trend=.049). The analyses stratified by risk factors, including smoking, occupation, and body mass index, showed a stronger association among never smokers, house workers, and overweight persons. In analysis for the joint effect of smoking and snoring, the relative risks of chronic bronchitis were 1.39 (95% CI, 1.01-1.90) for nonsmoking and snoring, 2.31 (95% CI, 1.38-3.87) for smoking and never snoring, and 2.86 (95% CI, 1.91-4.27) for smoking and snoring compared with nonsmoking and never snoring.

Conclusions: This prospective study observed that snoring is associated with chronic bronchitis. Our findings provide support for the hypothesis that snoring influences the development of chronic bronchitis.


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nome Epidemiology Study, which in the past has been called the Korean Health and Genome Study. The baseline study was conducted from June 23, 2001, to January 29, 2003. Members of the study cohort consisted of 5015 male and female Korean citizens aged 40 to 69 years in 2001 who participated in a comprehensive health examination and on-site interviews at Korea University Ansan Hospital. Members of the study cohort completed an interviewer-administered questionnaire, which included questions on demographic information, medical history and health conditions, family disease history, and lifestyle. On the basis of a standardized protocol, all interviewers are trained every 2 years. Cohort members have been followed up biennially with a scheduled site visit.

Participants for the study were identified from residents of Ansan, which is located 25 miles (40 km) southwest of Seoul. According to the 2000 census, Ansan is an urban community with a population of 555,000. To enroll participants, we used a list of telephone numbers obtained from local telephone companies because the community has a high penetration rate of telephone subscribership. We conducted a 2-stage cluster sampling based on information from the governing district (tested dong) from the telephone directory and information on age and sex distribution from the 2000 census. We identified 10,957 eligible study participants through telephone contact and received an oral agreement for participation from 5792 individuals. Among 5020 participants visiting for the baseline health examination, those who did not specify a birth date or who reported a biological age of 39 years (n=5) on the questionnaire were excluded. Thus, 5015 participants (2521 men and 2494 women) were included as eligible cohort members. The distribution of age and sex, percentage of alcohol drinking, and prevalence of hypertension, diabetes mellitus, and cerebrovascular disease were similar between participants and non-participants, but smokers were more likely to refuse participation in the study. Each participant signed a Human Subjects Committee–approved informed consent form before the baseline health examination.

For the analysis, we excluded participants who did not complete questions related to snoring (n=53), whose anthropometric measurements were not completed on the health examination (n=8), whose smoking status was not reported (n=14), or who reported pregnancy during the follow-up (n=1). Since the outcome measure for this study was new cases of chronic bronchitis, we excluded participants who reported physician-diagnosed chronic obstructive pulmonary disease before 2001 or who reported on the questionnaire the presence of cough and sputum production on most days for at least 3 months a year. In addition, we further excluded from the analysis participants who reported physician-diagnosed cancer, cardiovascular disease, tuberculosis, or asthma. Thus, 4270 participants (52% men and 48% women) entered the analysis for comparisons. For categorical data, linear trends in proportions were evaluated using a Tukey adjustment for multiple comparisons. For continuous data, statistical differences of the means were evaluated using an F test for trend. We calculated descriptive statistics for the baseline characteristics of study participants by the categories of snoring frequency. For continuous data, statistical differences of the means were evaluated using a Tukey adjustment for multiple comparisons. For categorical data, linear trends in proportions were assessed using a χ² test for trend.

We calculated person-years from the date of the baseline health examination until diagnosis of chronic bronchitis on follow-up, death, or the date of the last health examination and interview during the 4-year period, whichever came first. Participants completed an interviewer-administered questionnaire. On the 2001 questionnaire, we collected information on snoring; demographic characteristics, including age, sex, income, occupation, history of occupational exposure to dust or chemicals, marital status, and educational level; and lifestyle factors, including smoking status, alcohol consumption, and physical activity. On the 2003 questionnaire, we collected data on rhinitis diagnosed in 2001 or before by physicians.

In detail, participants were asked if they snored. If so, they were further asked how frequently they snored (infrequently, 1 to 3 times per week, 4 to 5 times per week, or 6 to 7 times per week). A test-retest reliability study found a substantial agreement for the question on snoring. Habitual snoring has been described as snoring every night or almost every night in some studies but has been defined differently in others. Self-reported snoring status is prone to misclassification, resulting in a reduction in the strength of association; in particular, the categorization of intermediate levels between extreme groups of snoring frequency has been complicated. Moreover, repeated mechanical vibrations that simulate snoring, which induced inflammatory processes in experimental studies, may be comparable to snoring every night in humans. Thus, we created 3 categories: never, snoring 3 times per week or less (snoring infrequently, 1 to 3 times per week, or 4 to 5 times per week), and snoring every night or almost every night (6 to 7 times per week).

Daily alcohol consumption (grams per day) was calculated based on the questionnaire information on alcohol consumption in the past 30 days, average frequency of drinking occasion, amount of alcoholic beverages consumed for a typical occasion, and the volume of 1 standard drink for a specific beverage. To obtain information on physical activity, participants were asked to report hours spent during a typical day in sleep and 5 categories of activity intensity (sedentary, very light, light, moderate, or vigorous) after interviewers gave examples of activities corresponding to each category. A total metabolic equivalent score was calculated by multiplying hours spent by metabolic equivalent values (1.0 for sleep or sedentary, 1.5 for very light, 2.4 for light, 3.0 for moderate, and 7.5 for vigorous activity), which have been determined based on the activities given for each category.

A comprehensive health examination was conducted by health care professionals, who were trained with a standardized protocol. Height and body weight were measured to the nearest 0.1 cm or 0.1 kg without shoes, and body mass index (calculated as weight in kilograms divided by height in meters squared) was determined.
first. We conducted pooled logistic regression analysis to estimate an odds ratio of chronic bronchitis with its 95% confidence interval (CI) and considered odds ratios estimates of relative risks (RRs).17 We presented RRs associated with potential confounding variables for snoring 5 times per week or less and snoring 6 to 7 times per week using never snorers as a comparison group (reference). We also conducted tests for a linear trend in the log odds of chronic bronchitis with increasing snoring frequency, for which snoring frequency was coded as 0 for never, 1 for infrequent, 2 for 1 to 3 times per week, 3 for 4 to 5 times per week, and 4 for 6 to 7 times per week. Potential confounding variables included in multivariate models were age, sex, income, occupation, history of occupational exposure to dust or chemicals, marital status, educational level, smoking status, passive smoking among never smokers, physician-diagnosed rhinitis, body mass index, alcohol consumption, physical activity, and average daily sleep. In the models, age and body mass index were fit as continuous variables, and other variables were entered as categorical variables. We also examined the association stratified by smoking status (never, former, or current smokers), occupation (white collar, housework, or blue collar), and body mass index (<25 or ≥25). In further analyses, we focused on nonsmokers (never smokers or former smokers) vs current smokers, white-collar job or housework vs blue-collar job, and body mass index less than 25 vs 25 or greater and examined the joint effects of these risk factors with snoring on chronic bronchitis. To reduce the number of subgroups created for the analyses of the joint effects, we combined 2 snoring groups, such as snoring 5 times per week or less and snoring 6 to 7 times per week, and compared snorers with never snorers. We used SAS procedures (SAS 9.1; SAS Institute Inc, Cary, North Carolina) to conduct the analyses.

During 4 years of follow-up, we documented 314 cases of new-onset chronic bronchitis (27.1 cases per 1000 person-years). The characteristics of the study participants are presented in Table 1. Persons snoring frequently were more likely to be older, men, working, ever exposed to chemicals, smokers, and heavier and to have consumed alcohol (P < .001).

Table 2 gives the relationship between snoring and chronic bronchitis. Snoring frequency has a positive linear association with the risk of chronic bronchitis (P for trend = .049). The multivariate RRs of chronic bronchitis were 1.25 (95% CI, 0.95-1.64) for snoring 5 times per week or less and 1.68 (95% CI, 1.17-2.42) for snoring 6 to 7 times per week compared with never snorers (Table 2).

Analyses stratified by smoking, occupation, or body mass index were conducted for the association between snoring and chronic bronchitis. In the analysis for smoking, a strong association between snoring and chronic bronchitis was observed for never smokers (P for trend = .006), whereas no significant association was found for former or current smokers (Table 3). In the analysis for occupation, a significant association between snoring and chronic bronchitis was observed among house workers (P for trend = .002). A linear trend was found for white-collar (P = .49) or blue-collar workers (P = .67), but the association was statistically insignificant (Table 3). In the analysis for body mass index, a stronger association

### Table 1. Baseline Characteristics Across Categories of Snoring Among 4270 Study Participants

<table>
<thead>
<tr>
<th>Variable</th>
<th>Never</th>
<th>0-4 Times per Week</th>
<th>5-6 Times per Week</th>
<th>6-7 Times per Week</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. (%) of participants</td>
<td>1506 (35.3)</td>
<td>2196 (51.4)</td>
<td>568 (13.3)</td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Age, mean, y</td>
<td>48.0</td>
<td>48.8</td>
<td>51.0</td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Male, %</td>
<td>626 (41.6)</td>
<td>1200 (54.6)</td>
<td>377 (66.4)</td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Monthly wage of &lt;10^4 won (US $1090), %</td>
<td>217 (14.4)</td>
<td>286 (13.0)</td>
<td>101 (17.8)</td>
<td></td>
<td>.27</td>
</tr>
<tr>
<td>Occupation, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White-collar job</td>
<td>161 (10.7)</td>
<td>302 (13.8)</td>
<td>95 (16.7)</td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Blue-collar job</td>
<td>768 (50.9)</td>
<td>1198 (54.6)</td>
<td>339 (59.7)</td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Housework</td>
<td>575 (38.2)</td>
<td>691 (31.5)</td>
<td>132 (23.2)</td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>History of occupational exposure, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To dust</td>
<td>270 (18.0)</td>
<td>458 (20.9)</td>
<td>116 (20.5)</td>
<td></td>
<td>.07</td>
</tr>
<tr>
<td>To chemicals</td>
<td>111 (7.4)</td>
<td>218 (10.0)</td>
<td>67 (11.8)</td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Married, %</td>
<td>1388 (92.2)</td>
<td>2027 (92.3)</td>
<td>505 (88.9)</td>
<td></td>
<td>.07</td>
</tr>
<tr>
<td>Educational level of &gt;9 years, %</td>
<td>930 (61.8)</td>
<td>1399 (63.7)</td>
<td>363 (63.9)</td>
<td></td>
<td>.26</td>
</tr>
<tr>
<td>Smoking status, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current smokers</td>
<td>260 (17.3)</td>
<td>488 (22.2)</td>
<td>157 (27.6)</td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Former smokers</td>
<td>225 (14.9)</td>
<td>426 (19.5)</td>
<td>126 (22.2)</td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Passive smoking among never smokers</td>
<td>369 (37.4)</td>
<td>500 (41.8)</td>
<td>104 (40.6)</td>
<td></td>
<td>.09</td>
</tr>
<tr>
<td>Self-reported physician-diagnosed rhinitis, %</td>
<td>49 (3.3)</td>
<td>72 (3.3)</td>
<td>19 (3.3)</td>
<td></td>
<td>.85</td>
</tr>
<tr>
<td>Body mass index, mean</td>
<td>23.9</td>
<td>25.0</td>
<td>26.1</td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Alcohol consumption, mean g/d</td>
<td>8.8</td>
<td>12.8</td>
<td>19.4</td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Physical activity, mean</td>
<td>24.3</td>
<td>24.3</td>
<td>23.4</td>
<td></td>
<td>.51</td>
</tr>
<tr>
<td>Average daily sleep, mean, h/d</td>
<td>6.6</td>
<td>6.6</td>
<td>6.6</td>
<td></td>
<td>.58</td>
</tr>
<tr>
<td>Value</td>
<td>Never</td>
<td>0-4 Times per Week</td>
<td>5-6 Times per Week</td>
<td>6-7 Times per Week</td>
<td></td>
</tr>
</tbody>
</table>
| Age categories (40-44, 45-49, 50-54, 55-59, 60-64, and ≥65 years) are used to standardize means for continuous variables.
| Monthly wage of <10^4 won (US $1090), %b | 217 (14.4) | 286 (13.0) | 101 (17.8) | | .27 |
| a The wage corresponds approximately to the government-set minimum wage for a family of 3 persons.
| Calculated as weight in kilograms divided by height in meters squared.
| Average daily metabolic equivalents per hour.
### Table 2. Relative Risks of Chronic Bronchitis in Relation to Snoring

<table>
<thead>
<tr>
<th>Snoring Frequency</th>
<th>No. of Person-years</th>
<th>No. of Cases</th>
<th>Age-Adjusted RR (95% CI)</th>
<th>Multivariate RR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>3956</td>
<td>86</td>
<td>1.0 [Reference]</td>
<td>1.0 [Reference]</td>
</tr>
<tr>
<td>≤5 Times per week</td>
<td>6083</td>
<td>168</td>
<td>1.27 (0.97-1.65)</td>
<td>1.25 (0.95-1.64)</td>
</tr>
<tr>
<td>6-7 Times per week</td>
<td>1547</td>
<td>60</td>
<td>1.75 (1.24-2.47)</td>
<td>1.68 (1.17-2.42)</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; NA, not applicable; RR, relative risk.

#### Notes:

Data are adjusted for age, sex, income (monthly wage of <10⁶ or ≥10⁶ won [US $1090]), occupation (white-collar job, blue-collar job, or housework), occupational dust exposure (yes or no), occupational chemical exposure (yes or no), marital status (married or other status), educational level (<9 or ≥9 years), smoking status (never smoker, former smoker, or current smoker of =10, 10-20, or ≥20 cigarettes daily), passive smoking among never smokers (yes or no), self-reported physician-diagnosed rhinitis, body mass index (calculated as weight in kilograms divided by height in meters squared), alcohol consumption (lifetime abstainers, current abstainers, or current alcohol consumption of <5.1, 5.1-15, 15.1-30, or >30 g/d), quartiles of physical activity (metabolic equivalents per hour daily), and average daily sleep (<5, 5-6, 7-8, or ≥9 h/d).

### Table 3. Multivariate Analysis Stratified by Smoking, Occupation, and Body Mass Index for the Association Between Snoring and Chronic Bronchitis

<table>
<thead>
<tr>
<th>Stratified Analyses by Risk Factor</th>
<th>Snoring Frequency</th>
<th>P Value for Trenda</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Never</td>
<td>≤5 Times per Week</td>
</tr>
<tr>
<td>Smoking status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never smokers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of person-years</td>
<td>2625</td>
<td>3332</td>
</tr>
<tr>
<td>No. of cases</td>
<td>48</td>
<td>75</td>
</tr>
<tr>
<td>Multivariate RR (95% CI)b</td>
<td>1.0 [Reference]</td>
<td>1.18 (0.80-1.72)</td>
</tr>
<tr>
<td>Former smokers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of person-years</td>
<td>633</td>
<td>1277</td>
</tr>
<tr>
<td>No. of cases</td>
<td>12</td>
<td>30</td>
</tr>
<tr>
<td>Multivariate RR (95% CI)b</td>
<td>1.0 [Reference]</td>
<td>1.40 (0.68-2.89)</td>
</tr>
<tr>
<td>Current smokers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of person-years</td>
<td>698</td>
<td>1474</td>
</tr>
<tr>
<td>No. of cases</td>
<td>26</td>
<td>63</td>
</tr>
<tr>
<td>Multivariate RR (95% CI)b</td>
<td>1.0 [Reference]</td>
<td>1.22 (0.75-2.00)</td>
</tr>
<tr>
<td>Occupation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White-collar job</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of person-years</td>
<td>452</td>
<td>881</td>
</tr>
<tr>
<td>No. of cases</td>
<td>9</td>
<td>20</td>
</tr>
<tr>
<td>Multivariate RR (95% CI)b</td>
<td>1.0 [Reference]</td>
<td>1.52 (0.63-3.70)</td>
</tr>
<tr>
<td>Housework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of person-years</td>
<td>1460</td>
<td>1863</td>
</tr>
<tr>
<td>No. of cases</td>
<td>30</td>
<td>46</td>
</tr>
<tr>
<td>Multivariate RR (95% CI)b</td>
<td>1.0 [Reference]</td>
<td>1.18 (0.72-1.93)</td>
</tr>
<tr>
<td>Blue-collar job</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of person-years</td>
<td>2045</td>
<td>3339</td>
</tr>
<tr>
<td>No. of cases</td>
<td>47</td>
<td>102</td>
</tr>
<tr>
<td>Multivariate RR (95% CI)b</td>
<td>1.0 [Reference]</td>
<td>1.28 (0.89-1.84)</td>
</tr>
<tr>
<td>Body mass index</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of person-years</td>
<td>2660</td>
<td>3145</td>
</tr>
<tr>
<td>No. of cases</td>
<td>64</td>
<td>87</td>
</tr>
<tr>
<td>Multivariate RR (95% CI)b</td>
<td>1.0 [Reference]</td>
<td>1.11 (0.79-1.56)</td>
</tr>
<tr>
<td>≥25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of person-years</td>
<td>1296</td>
<td>2938</td>
</tr>
<tr>
<td>No. of cases</td>
<td>22</td>
<td>81</td>
</tr>
<tr>
<td>Multivariate RR (95% CI)b</td>
<td>1.0 [Reference]</td>
<td>1.65 (1.01-2.70)</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; RR, relative risk.

#### Notes:

a P value test for trend when snoring frequency (never, infrequent, 1-3 times per week, 4-5 times per week, or 6-7 times per week) was fit into the model as an ordinal variable.

b Data are adjusted for age, sex, income (monthly wage of <10⁶ or ≥10⁶ won [US $1090]), occupation (white-collar job, blue-collar job, or housework), occupational dust exposure (yes or no), occupational chemical exposure (yes or no), marital status (married or other status), educational level (<9 or ≥9 years), smoking status (never smoker, former smoker, or current smoker of =10, 10-20, or ≥20 cigarettes daily), passive smoking among never smokers (yes or no), self-reported physician-diagnosed rhinitis, body mass index (calculated as weight in kilograms divided by height in meters squared), alcohol consumption (lifetime abstainers, current abstainers, or current alcohol consumption of <5.1, 5.1-15, 15.1-30, or >30 g/d), quartiles of physical activity (metabolic equivalents per hour daily), and average daily sleep (<5, 5-6, 7-8, or ≥9 h/d).
was observed among overweight persons compared with persons of healthy weight (Table 3).

Table 4 presents the joint effects of snoring and other risk factors, including smoking, occupation, and body mass index, on chronic bronchitis. In the analysis for smoking and snoring, the multivariate RRs of chronic bronchitis were 1.39 (95% CI, 1.01-1.90) for nonsmoking and snoring, 2.31 (95% CI, 1.38-3.87) for smoking and never snoring, and 2.86 (95% CI, 1.91-4.27) for smoking and snoring compared with nonsmoking and never snoring. However, no significant association was observed in the analysis for the joint effect of occupation and snoring and for body mass index and snoring (Table 4).

This prospective cohort study found that snoring is associated with risk of chronic bronchitis. After taking into account age, smoking, occupation, and other potential risk factors for chronic bronchitis, persons who snore every night or almost every night had a 68% (95% CI, 17%-142%) higher risk of developing chronic bronchitis compared with never snorers.

The worldwide prevalence of chronic bronchitis ranges from 1% to 18% based on data reported in the last 30 years. Several factors are suggested to be associated with this disease. Epidemiologic findings consistently support the relationship between cigarette smoking and chronic bronchitis or chronic obstructive pulmonary disease. Symptoms of chronic bronchitis are more prevalent among smokers, and the risk of physician-diagnosed chronic bronchitis increases about 3-fold among smokers compared with never smokers. It has also been reported that individuals exposed to dust, fumes, or gas are more likely to have symptoms of chronic bronchitis, and thus the population attributable risk of chronic bronchitis is estimated to range from 4% to 29%. Other potential risk factors for chronic bronchitis, such as outdoor air pollution, obesity, and respiratory infection, have been explored, but more data are needed.

To our knowledge, the present investigation is the sole prospective cohort study to evaluate the association between snoring and chronic bronchitis. Previous epidemiologic studies for chronic bronchitis and snoring used a cross-sectional design, and thus the causality of the association has remained ambiguous. Most studies have provided only descriptive information that snoring is a potential risk factor for chronic bronchitis, such as outdoor air pollution, obesity, and respiratory infection, but more data are needed.

The stratified analysis also showed that house workers had a stronger association between snoring and chronic bronchitis than white-collar or blue-collar workers. The elevated risk among house workers might reflect the association among never smokers who have never smoked. The association between snoring and chronic bronchitis was stronger among overweight persons compared with persons of healthy weight, but a synergistic effect of overweight and snoring on chronic bronchitis was unclear. Obesity is associated with elevated levels of C-reactive protein, which is a marker of systemic inflammation, and with habitual snoring. However, because a U-shaped curve was observed in our data for the association between body mass index and chronic bronchitis (data available from authors on request) and because obesity is less prevalent in Korea compared with Western countries, greater body mass index might have shown minor effects on chronic bronchitis in this study.

The mechanisms underlying the association between snoring and chronic bronchitis are largely unknown. Recent experimental studies have evaluated the hypothesis that repeated snoring vibrations may trigger airway

<table>
<thead>
<tr>
<th>Joint Effects of Risk Factor and Snoring</th>
<th>No. of Person-Years</th>
<th>No. of Cases</th>
<th>Multivariate RR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking and snoring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonsmoking and never snoring</td>
<td>3258</td>
<td>60</td>
<td>1.0 [Reference]</td>
</tr>
<tr>
<td>Nonsmoking and snoring</td>
<td>5658</td>
<td>144</td>
<td>1.39 (1.01-1.90)</td>
</tr>
<tr>
<td>Smoking and never snoring</td>
<td>698</td>
<td>26</td>
<td>2.31 (1.38-3.87)</td>
</tr>
<tr>
<td>Smoking and snoring</td>
<td>1972</td>
<td>84</td>
<td>2.86 (1.91-4.27)</td>
</tr>
<tr>
<td>Occupation and snoring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White-collar job and never snoring</td>
<td>1912</td>
<td>39</td>
<td>1.0 [Reference]</td>
</tr>
<tr>
<td>White-collar job and snoring</td>
<td>3374</td>
<td>95</td>
<td>1.31 (0.88-1.94)</td>
</tr>
<tr>
<td>Blue-collar job and never snoring</td>
<td>2045</td>
<td>47</td>
<td>1.03 (0.65-1.64)</td>
</tr>
<tr>
<td>Blue-collar job and snoring</td>
<td>4256</td>
<td>133</td>
<td>1.37 (0.91-2.07)</td>
</tr>
<tr>
<td>Body mass index and snoring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;25 and never snoring</td>
<td>2660</td>
<td>64</td>
<td>1.0 [Reference]</td>
</tr>
<tr>
<td>&lt;25 and snoring</td>
<td>3742</td>
<td>108</td>
<td>1.14 (0.82-1.57)</td>
</tr>
<tr>
<td>≥25 and never snoring</td>
<td>1296</td>
<td>22</td>
<td>0.67 (0.41-1.11)</td>
</tr>
<tr>
<td>≥25 and snoring</td>
<td>3888</td>
<td>120</td>
<td>1.20 (0.88-1.66)</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; RR, relative risk.

Data are adjusted for age, sex, income (monthly wage of <10 or ≥10 won [US $1090]), occupation (white-collar job, blue-collar job, or housework), occupational dust exposure (yes or no), occupational chemical exposure (yes or no), marital status (married or other status), educational level (<9 or ≥9 years), smoking status (never smoker, former smoker, or current smoker of ≤10, 10-20, or ≥20 cigarettes daily), passive smoking among never smokers (yes or no), self-reported physician-diagnosed rhinitis, body mass index (calculated as weight in kilograms divided by height in meters squared), alcohol consumption (lifetime abstainers, current abstainers, or current alcohol consumption of <5.1, 5.1-15, 15.1-30, or >30 g/d), quartiles of physical activity (metabolic equivalents per hour daily), and average daily sleep (<5, 5-6, 7-8, or ≥9 h/d).

The category includes never smokers and former smokers.

The category includes white-collar workers and house workers.
inflammation. An in vitro study\(^6\) cultured human bronchial epithelial cells on a platform under which a loudspeaker system generated sound pressure vibrations that simulated snoring. During the 24-hour culture, similar proliferation was observed in cells subjected to vibration stimuli compared with control cells, but interleukin 8 levels were significantly elevated in the supernatant of cell cultures subjected to 12 hours and 24 hours of vibration.\(^6\) Interleukin 8 is known as a proinflammatory biomarker and has reportedly been involved in the association between smoking and chronic bronchitis.\(^29\)

A subsequent study\(^7\) evaluated the hypothesis with an in vivo rat model and found that snoringlike vibrations applied to the soft-palate tissue of the airway induced messenger RNA overexpression in inflammatory proteins. Thus, biological mechanisms underlying the association between snoring and chronic bronchitis may be postulated given the association between snoring and upper airway inflammation\(^6,7\) and between upper airway inflammation and lower airway inflammation.\(^8\) In addition, systemic inflammation related to OSAS needs to be considered as another potential cause.\(^30\) Elevated measures of systemic inflammation observed in patients with obstructive sleep apnea may be due not only to obesity but also to airway inflammation.\(^8\) Using the induced sputum technique, Salerno et al\(^9\) observed bronchial inflammation among obese patients affected by OSAS. The investigators suggested that OSAS-related airway inflammation may be caused by obesity, hypoxia, and mechanical stress.\(^9\) During an obstructive apnea event, respiratory efforts against a closed airway occur and induce fluctuations of intrathoracic pressure, which may act as mechanical stresses and play a role in enhancing inflammation.\(^9\)

Strengths of our study include its population-based design, the interviewer administration of a questionnaire, and prospective follow-up of cases of chronic bronchitis. In the interpretation of our findings, however, the fact that the study used self-reported information for exposure and outcome data needs to be taken into account. Cases of chronic bronchitis were documented based on the questionnaire data, without confirmation from a physician diagnosis. Thus, the incidence of chronic bronchitis might be overestimated, although potential overreporting of this outcome is unlikely to be important. The information on snoring was not verified. Individuals without bed partners might be more likely to underreport snoring, but the differential classification of exposure is unlikely. The presence of unknown and uncontrolled confounding factors cannot be ruled out as a further limitation, whereas their effect on the study findings is likely minimal, and our analyses have taken into account a broad range of potential confounding factors.

This study included at baseline residents of Ansan, which is an urban community built in the middle of an industrialized region. The levels of overall air pollution in this city are as high as in Seoul or other urban cities of developed countries.\(^32\) The male smoking prevalence in Korea is among the highest in the world,\(^33\) whereas habitual snoring is less prevalent in our cohort compared with data on Western populations.\(^30,34\) Thus, our data on the incidence rate and the estimated risks of chronic bronchitis may not be generalizable to other populations, but our findings may provide novel information that snorers are at greater risk of developing chronic bronchitis than persons who do not snore during sleep.

In summary, our findings provide support for the hypothesis that snoring is associated with chronic bronchitis. Further investigations are needed to confirm the association between snoring and chronic bronchitis and to explore the mechanisms underlying the association.

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Author Contributions: Dr Shin had full access to all of 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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REFERENCES


