Introduction

Obstructive sleep apnea (OSA) is a common disease characterized by repetitive episodes of airflow cessation or airflow reduction that occur during sleep as a consequence of collapse of the upper airway.

1 It is an important medical condition that causes excessive daytime sleepiness, snoring, and nocturnal hypoxemia during sleep,2 and is strongly associated with hypertension, glucose intolerance, cardiovascular disorders, and cerebrovascular disorders.3-6 One epidemiologic study that used polysomnography (PSG) to establish the prevalence of sleep-disordered breathing (SDB) and OSA in Korea found that the prevalence of SDB was 27% in men and 16% in women,7 and was similar to that of other countries.8,9

PSG is generally considered a gold-standard diagnostic tool for the evaluation of OSA. However, it has been utilized in a very limited manner in population-based epidemiologic studies because it is an expensive and time-consuming method.

The Berlin Questionnaire (BQ) was first introduced in 1996 at the Conference on Sleep in Primary Care in Berlin, Germany. It was validated as a means of identifying patients with
a high risk of OSA,¹⁰,¹¹ and comprises three categories: snoring, wake-time sleepiness or tiredness, and the presence of obesity or hypertension.¹⁵ The BQ has been used in screening for OSA and in epidemiologic studies, and is known to be a convenient and inexpensive tool.¹²,¹³ The usefulness of the Korean version of the BQ (K-BQ) as a screening tool for OSA has been confirmed in one study; it enables the prioritization of subjects with a high risk of OSA in the Korea general population.¹⁴

To the best of our knowledge, no previous studies have used the BQ to estimate the prevalence of OSA in a Korean population. The purpose of this study was therefore to estimate the prevalence of OSA using the K-BQ and to determine the factors related to a high risk of OSA in a Korean population.

**Methods**

**Study sample**

Pooled data collected from Community Health Surveys conducted by the Korea Center for Disease Control and Prevention and the public health centers of ten counties in the Gyeongnam province of Korea in 2011 were analyzed in this study. The target area of this study was the west area of Gyeongnam province, consisting of two urban communities and seven rural communities. The community health survey was conducted by a randomized sampling method of adults aged 19 years or older living in each area. The participants were 8,140 community-dwelling adults age ≥19 years; of these, 185 participants who did not provide the complete information were excluded, thus ultimately 7955 participants were included. Informed consent to participate was obtained from all subjects. The study was approved by the Institutional Review Board of Kyungpook National University Hospital.

**Measures**

The participants were interviewed in their homes by trained interviewers using a closed-ended, structured questionnaire. The interviews typically lasted 45 minutes. If the participant was absent from home, the interviewer revisited on at least three other occasions at different times of the day. The questionnaires consisted of queries regarding sociodemographic characteristics, health behavior, presence of chronic diseases, and work, and the K-BQ.¹⁵

Demographic data (e.g., age, sex, and marital status) and socioeconomic measures (education and occupation) were analyzed. The participants were grouped according to age, as follows: 19–44, 45–64, 65–75, and >75 years. Marital status was divided into three groups: single, married, and divorced/separated/widowed. Education was classified into five groups: no education, elementary school, middle school, high school, and above high school. The interview collected detailed occupational information, including job title, duration of employment, and working schedules. Occupation was categorized to six subtypes according to the sixth version of the Korea Standard Classification of Occupation (KSCO).¹⁶ The KSCO is a tool for organizing jobs into a clearly defined set of groups according to the tasks and duties undertaken in the job to earn money (economic activities). Participants were divided into four self-reported occupational groups based on the KSCO: farmers, white-collar workers, blue-collar workers, and others. Blue-collar workers included craft and related-trades workers, plant/machine operators and assemblers, and elementary occupations, while white-collar workers included legislators, senior officials and managers, professionals, technicians and associated professionals, clerks, service workers, and sales staff. Shift work was defined to refer in general to a way of organizing daily working hours in which different persons or teams work in succession to cover more than the usual 8-hour working day, up to and including the entire 24 hours.

Smoking, alcohol, and exercise were surveyed as living habits and health behavior. Being a smoker was defined as smoking currently and having smoked at least 100 cigarettes. The Alcohol Use Disorders Identification Test (AUDIT) was used to identify persons with hazardous and harmful patterns of alcohol consumption.¹⁷ The AUDIT was developed by the World Health Organization (WHO) as a simple method of screening for excessive drinking and to assist in brief assessments, and it comprises ten questions about recent alcohol use, alcohol-dependence symptoms, and alcohol-related symptoms. Subjects score their responses to the ten questions on a scale from 0 to 4, and a total score of ≥8 is considered to indicate hazardous and harmful alcohol use, as well as possible alcohol dependence. Physical exercise was assessed by asking the participants how many days per week they did each of the following activities for at least 30 minutes at a time during the past year: walking, hiking, bicycling, aerobics or calisthenics, swimming, water aerobics, weight training or stretching, or other exercise. The frequency of exercise was calculated according to the number of times per week that participants engaged in any of these forms of exercise. The subjects were then divided into two groups: exercise and non-exercise. Participants who regularly engaged in physical exercise more than five times per week were placed into the exercise group; all others were assigned to the nonexercise group.

The presence of chronic diseases was ascertained using the lead-in statement: “We are interested in chronic diseases that have lasted or are expected to last 6 months or longer and that have been diagnosed by a health professional.” Individual chronic diseases were selected based on a priori interest in
the snorer’s health and by surveying a sufficient number of cases; these included hypertension, diabetes mellitus, and musculoskeletal diseases (osteoarthritis, rheumatoid arthritis, osteoporosis, fibromyalgia, and back pain).

The BQ contains three categories:
1. Category 1 addresses snoring and witnessed apnea. Subjects were asked to score their snoring.
2. Category 2 investigates daytime fatigue and sleepiness during daily activities.
3. Category 3 focuses on the history of high blood pressure or a high body mass index (BMI).

Categories 1 and 2 were assumed to be positive if the total score was ≥2. Category 3 was considered positive if the subject had hypertension or a BMI of ≥30 kg/m². Accordingly, subjects were stratified as “high risk” if they had two or more categories with positive scores. The validated K-BQ was used in this study. Each patient’s risk profile for OSA was calculated by following all of the original BQ instructions except for BMI, because the WHO Western Pacific Regional Office proposed modified BMI cutoff values of 23 kg/m² and 25 kg/m² to define being overweight and obese, respectively, in Asian populations; the latter modified cutoff point for BMI (≥25 kg/m²) was implemented in category 3.

**Statistical analyses**
All statistical analyses were conducted with SPSS for Windows (version 12, SPSS, 2005). Comparison between the groups was achieved using the t test for continuous variables and the chi-square test for discrete variables. Logistic regression models were applied to identify the overall and independent clinical determinants in relation to high risk of OSA. Multiple logistic and regression analyses were conducted to evaluate the factors influencing the probability of a high risk of OSA.

**Results**
Of the 8140 respondents from the target population, 7955

| Variable                  | Number | High risk of OSA | p*    |
|---------------------------|--------|------------------|-------|
| Gender                    |        |                  |       |
| Male                      | 3559   | 558              | 15.7  |
| Female                    | 4396   | 431              | 9.8   | <0.001 |
| Age (years)               |        |                  |       |
| 19–44                     | 2165   | 193              | 8.9   |
| 45–64                     | 3057   | 414              | 13.5  |
| 65–75                     | 1768   | 289              | 16.3  |
| >75                       | 965    | 92               | 9.5   | <0.001 |
| Marital status            |        |                  |       |
| Not married               | 650    | 43               | 6.6   |
| Married/living as married | 5468   | 718              | 13.1  |
| Divorced/separated/widowed| 1837   | 225              | 12.2  | <0.001 |
| Educational level         |        |                  |       |
| None                      | 1795   | 222              | 12.4  |
| Elementary school         | 1883   | 289              | 15.3  |
| Middle school             | 1093   | 140              | 12.8  |
| High school               | 2028   | 225              | 11.1  |
| Above high school         | 1156   | 113              | 9.8   | <0.001 |
| Occupation                |        |                  |       |
| White collar              | 955    | 102              | 10.7  |
| Blue collar               | 1059   | 142              | 13.4  |
| Farmer                    | 2243   | 311              | 13.9  |
| Others                    | 3698   | 434              | 11.7  | 0.023 |
| Shift work                |        |                  |       |
| Yes                       | 522    | 62               | 11.9  |
| No                        | 7433   | 927              | 12.5  | 0.691 |
| Total                     | 7955   | 989              | 12.4  |

*Analysis by chi-square test.
### Table 2. Distribution of responses by risk group (i.e., high and low risks of OSA)

| Question                                                                 | Low risk of OSA | High risk of OSA | p*    |
|-------------------------------------------------------------------------|-----------------|------------------|-------|
|                                                                          | Number (%)      | Number (%)       |       |
| **A) Category 1**                                                       |                 |                  |       |
| Has your weight changed in the last 5 years?                            |                 |                  |       |
| Increased                                                               | 88 (1.3)        | 52 (5.3)         | <0.001|
| Decreased                                                               | 301 (4.3)       | 166 (16.8)       |       |
| No                                                                      | 6571 (94.4)     | 771 (78.0)       |       |
| Do you snore?                                                           |                 |                  | <0.001|
| Yes                                                                     | 1603 (23.0)     | 929 (93.9)       |       |
| No                                                                      | 4793 (68.8)     | 54 (5.5)         |       |
| Do not know                                                             | 570 (8.2)       | 6 (0.6)          |       |
| Snoring loudness                                                        |                 |                  | <0.001|
| As loud as breathing                                                    | 448 (28.0)      | 125 (13.5)       |       |
| As loud as talking                                                      | 893 (55.7)      | 376 (40.5)       |       |
| Louder than talking                                                     | 189 (11.8)      | 295 (31.8)       |       |
| Very loud                                                               | 72 (4.5)        | 133 (14.3)       |       |
| How often do you snore?                                                 |                 |                  | <0.001|
| Almost every day                                                        | 199 (12.4)      | 380 (40.9)       |       |
| 3-4 times/week                                                          | 224 (14.0)      | 326 (35.1)       |       |
| 1-2 times/week                                                          | 604 (37.7)      | 140 (15.1)       |       |
| 1-2 times/month                                                         | 565 (35.3)      | 83 (9.9)         |       |
| Never or almost never                                                   | 10 (0.6)        | 0 (0.0)          |       |
| Has your snoring ever bothered other people?                            |                 |                  | <0.001|
| Yes                                                                     | 271 (16.9)      | 425 (45.7)       |       |
| No                                                                      | 1332 (83.1)     | 504 (54.3)       |       |
| Has anyone noticed that you stop breathing during your sleep?           |                 |                  | <0.001|
| Almost every day                                                        | 23 (1.4)        | 76 (8.2)         |       |
| 3-4 times/week                                                          | 23 (1.4)        | 97 (10.4)        |       |
| 1-2 times/week                                                          | 110 (6.9)       | 94 (10.1)        |       |
| 1-2 times/month                                                         | 825 (51.5)      | 402 (43.3)       |       |
| Never or almost never                                                   | 621 (38.8)      | 260 (28.0)       |       |
| **B) Category 2**                                                       |                 |                  |       |
| How often do you feel tired or fatigued after sleeping?                 |                 |                  | <0.001|
| Almost every day                                                        | 184 (2.6)       | 271 (27.4)       |       |
| 3-4 times/week                                                          | 143 (2.1)       | 262 (26.5)       |       |
| 1-2 times/week                                                          | 474 (6.8)       | 144 (14.6)       |       |
| 1-2 times/month                                                         | 1062 (15.3)     | 230 (23.3)       |       |
| Never or almost never                                                   | 5096 (73.2)     | 82 (8.3)         |       |
| During your waking time, do you feel tired, fatigue, or not up to par?  |                 |                  | <0.001|
| Almost every day                                                        | 137 (2.0)       | 251 (25.4)       |       |
| 3-4 times/week                                                          | 145 (2.1)       | 277 (28.0)       |       |
| 1-2 times/week                                                          | 555 (8.0)       | 173 (17.5)       |       |
| 1-2 times/month                                                         | 1014 (14.6)     | 207 (20.9)       |       |
| Never or almost never                                                   | 5108 (73.4)     | 81 (8.2)         |       |
| Have you ever nodded off or fallen asleep while driving a vehicle?       |                 |                  | <0.001|
| Yes                                                                     | 158 (2.3)       | 174 (17.6)       |       |
| No                                                                      | 6808 (97.7)     | 815 (82.4)       |       |
| If yes, how often has this occurred?                                    |                 |                  | <0.001|
| Almost every day                                                        | 3 (1.9)         | 35 (20.1)        |       |
| 3-4 times/week                                                          | 24 (15.2)       | 64 (36.8)        |       |
Prevalence and Related Factor of Obstructive Sleep Apnea

Table 2. Continued

| Question                     | Low risk of OSA | High risk of OSA | \( p^* \) |
|------------------------------|-----------------|------------------|-----------|
|                              | Number (%)      | Number (%)       |           |
| I–2 times/week               | 59 (37.3)       | 63 (34.2)        |           |
| I–2 times/month              | 72 (45.6)       | 12 (6.9)         |           |

C) Category 3

Do you have high blood pressure?

Yes                  1157 (16.6)  462 (46.7)  <0.001
No                  5809 (83.4)  527 (53.3)           

*Analysis by chi-square test.

Table 3. Living habits, health behavior, and chronic diseases of the participants \( n=7955 \) and comparison of these characteristics with the high-risk group for OSA

| Variable                        | Number | High risk of OSA (%) | \( p^* \) |
|---------------------------------|--------|----------------------|-----------|
| Living habits & health behavior |        |                      |           |
| Smoking                         |        |                      |           |
| Yes                             | 1774   | 267                  | 15.1      |
| No                              | 6181   | 722                  | 11.7      | 0.001† |
| Harmful alcohol use             |        |                      |           |
| Yes                             | 1454   | 265                  | 18.2      |
| No                              | 6501   | 724                  | 11.1      | <0.001‡ |
| Physical exercise               |        |                      |           |
| Nonexercise                     | 6403   | 777                  | 12.1      |
| Exercise                        | 1552   | 212                  | 13.7      | 0.102§ |
| Chronic diseases                |        |                      |           |
| Musculoskeletal diseases        |        |                      |           |
| Yes                             | 2025   | 316                  | 15.6      |
| No                              | 5930   | 673                  | 11.3      | <0.001¶ |
| Diabetes mellitus               |        |                      |           |
| Yes                             | 572    | 141                  | 24.7      |
| No                              | 7383   | 848                  | 11.5      | <0.001¶ |
| Hypertension                    |        |                      |           |
| Yes                             | 1619   | 462                  | 28.5      |
| No                              | 6336   | 527                  | 8.3       | <0.001¶ |

*Analysis by chi-square test, †Significantly different from nonsmokers, ‡Significantly different from those with normal alcohol use, §Not significantly different from those with exercise, ¶Significantly different from those with no chronic diseases.

OSA: obstructive sleep apnea.

(age 55±16 years, mean±SD) were ultimately included in this study. Of these, 3559 (44.7%) were men and 4396 (55.3%) were women, aged 55±16 years and 56±16 years, respectively. The demographic information (e.g., age, sex, and marital status) and socioeconomic measures (education and occupation) of the 7955 subjects are given in Table 1. The participants were classified according to the risk categorization yielded by the BQ. Of the entire study population, 989 (12.4%) were categorized as having a high risk of OSA. In addition, the demographic information and socioeconomic measures were compared among those with a high risk of OSA by BQ (Table 1). Significant differences were found between members of the high-OSA-risk group when they were further stratified according to gender, age, marital status, educational level, and occupation. However, the type of work schedule (i.e., shift vs. nonshift) was not a significant factor for a high risk of OSA.

The distribution of responses according to OSA risk group (i.e., high vs. low) is given in Table 2. Snoring was present in 929 (93.9%) of those with a high risk of OSA. Among these 929 snoring participants, 428 (46.1%) reported that their snoring was louder than normal speech, 706 (76.0%) reported snoring at least 3 times per week, and 425 (45.7%) reported that their snoring bothered other people. In 173 (18.6%) respondents, breathing pauses during sleep were observed by others more than 3 times per week, 533 (53.9%) stated that
they did not feel rested after a night’s sleep at least 3 times per week, and 528 (53.4%) reported that they experienced wake-time tiredness or fatigue at least 3–4 times per week. Nodding off or falling asleep while driving was reported by 174 respondents (17.6%); of these, 99 (56.9%) reported that they nodded off at the wheel at least 3 times per week. Hypertension was present in 462 (46.7%) of the snoring participants. There were significant differences between the high- and low-OSA-risk groups for all questions.

Comparisons of living habits, health behavior, and the presence of chronic diseases among those with a high risk of OSA revealed significant differences for the presence of smoking, harmful alcohol use, and chronic diseases (Table 3). The amount of physical exercise did not differ significantly between the high- and low-risk groups. Multiple logistic regression analysis was performed to identify which factors were independently related to a high risk of OSA. Table 4 lists the odds ratios and 95% confidence intervals for a high risk of OSA in relation to sex, age, educational level, occupation, living habits, health behavior, and presence of chronic diseases. Adjusted analyses revealed that male sex, harmful alcohol use, and presence of chronic disease were associated with a high risk of OSA.

### Discussion

This is the first report on the prevalence of individuals with a high risk of OSA in a large Korean population using the K-BQ, which is a widely used, simple, and validated tool for the prediction of the risk of sleep apnea. In the present study the estimated prevalence of individuals with a high risk of OSA was 12.4%, which is lower than that found in a US-population-based study presented by The National Sleep Foundation poll, also using the BQ, but higher than that reported for a Persian population. The former was based on telephone interviews of a representative sample of US adults. Furthermore, the present study included many more participants than these two previous studies, and its dropout rate was quite low because the participants were interviewed using a door-to-door method and revisited on up to at least three more occasions if they were absent at the first visit. The population sample in this study should be representative of the entire

| Table 4. Factors related to a high risk of OSA |
|-----------------------------------------------|
| Factor                        | OR (Unadjusted) | 95% CI (Unadjusted) | OR (Adjusted) | 95% CI (Adjusted) |
|-----------------------------------------------|
| Sex (male/female)                  | 1.711†          | 1.496–1.957         | 1.810†         | 1.502–2.182       |
| Age (reference value, 19–44 years)      |                 |                     |               |                  |
| 45–64 years                        | 1.600†          | 1.336–1.917         | 0.991          | 0.791–1.243       |
| 65–74 years                        | 1.996†          | 1.643–2.424         | 0.947          | 0.713–1.257       |
| ≥75 years                          | 1.077           | 0.830–1.398         | 0.457†         | 0.320–0.651       |
| Educational level (reference value, none) |                |                     |               |                  |
| Elementary school                 | 1.283†          | 1.063–1.549         | 1.103          | 0.888–1.370       |
| Middle school                      | 1.040           | 0.829–1.304         | 0.945          | 0.717–1.246       |
| High school                        | 0.883           | 0.725–1.076         | 0.907          | 0.684–1.202       |
| Above high school                 | 0.767§          | 0.603–0.974         | 0.892          | 0.627–1.268       |
| Occupation (reference value, others) |                |                     |               |                  |
| White collar                       | 0.899           | 0.716–1.130         | 1.103          | 0.838–1.452       |
| Blue collar                        | 1.165           | 0.951–1.427         | 1.198          | 0.954–1.505       |
| Farmer                             | 1.211†          | 1.036–1.415         | 1.046          | 0.877–1.247       |
| Shift work (yes/no)                | 0.946           | 0.719–1.244         | 1.022          | 0.762–1.371       |
| Living habits & health behavior    |                |                     |               |                  |
| Smoking status (yes/no)            | 1.340†          | 1.151–1.559         | 1.081          | 0.901–1.297       |
| Harmful alcohol use (yes/no)       | 1.778†          | 1.525–2.074         | 1.566†         | 1.302–1.884       |
| Exercise (yes/no)                  | 1.146           | 0.973–1.349         | 1.130          | 0.947–1.348       |
| Chronic diseases                   |                |                     |               |                  |
| Musculoskeletal diseases (yes/no)   | 1.444†          | 1.250–1.669         | 1.411†         | 1.185–1.681       |
| Diabetes mellitus (yes/no)         | 2.521†          | 2.058–3.089         | 1.615†         | 1.292–2.017       |
| Hypertension (yes/no)              | 4.401†          | 3.827–5.063         | 4.941†         | 4.200–5.812       |

*Analysis by logistic regression model [adjusted for the other variables], †p<0.001, ‡p<0.05.

OR: odds ratio, CI: confidence interval.
Korean total population because of the randomized selection design.

A well-designed and extensive prevalence study of SDB in Korea investigated a random sample of 457 men and women among a total of 5,020 adults aged 40–69 years via full overnight PSG in order to determine the prevalence of SDB [defined as an apnea-hypopnea index (AHI) of ≥5]; this was found to be 27% in men and 16% in women. The survey in the present study was conducted using a standardized and random sampling method of adults aged ≥19 years. The prevalence of a high risk of OSA was 15.7% for the men and 9.8% for the women. A previous study revealed that high-risk grouping based on the K-BQ predicted on AHI ≥5 had a sensitivity of 0.69 and a specificity of 0.83. Given the sensitivity of the K-BQ, the prevalence of a high risk of OSA found in the present study is similar to that obtained previously in Korea. These results demonstrate the usefulness of the K-BQ for studying the prevalence of OSA in the general population.

The overall and independent clinical determinants in relation to a high risk of OSA were also examined in this study. It is well known that the prevalence of OSA varies with gender. As in a previous study, the frequency of a high risk of OSA in the present study was significantly higher in men. In the present study the K-BQ-based frequency of subjects with a high risk of OSA tended to increase with age in those younger than 75 years; this finding has also been reported elsewhere. Age-related differences in the prevalence of a high risk of OSA may be attributable to the prevalence of snoring, which is age-dependent. Interestingly, the risk of OSA appeared to decline in those older than 75 years. Some previous work has indicated that the risk of sleep apnea increases linearly with aging, but other studies have demonstrated a decline after midlife. The inclusion of fewer subjects aged >75 years in the present study could have been responsible for the bell-shaped relationship between age and a high risk of sleep apnea. Although there were significant differences in educational level and occupation among the subjects for high risk of OSA (according to the chi-square test), that significance disappeared after adjusting for confounding factors. There was a tendency for highly educated people and white-collar workers in the community to have lower frequency of OSA. A similar association between educational level and OSA was also found in a previous study. Furthermore, another study found no association between occupational factors and SDB. It has also been reported that nighttime work or night-shift work may worsen the OSA index. This could be expected, but no such relationship was found in the present study; however, this finding may be attributable to the small number of subjects in shift work.

Population-based cross-sectional epidemiologic studies have not consistently demonstrated significant associations between self-reported typical alcohol consumption and OSA, with some finding significant associations with OSA but others failing to demonstrate any associations. Some studies demonstrated an independent association between sleep apnea and hypertension. Moreover, it was reported that the presence of diabetes was associated with a high risk of OSA. Several studies have shown an association between OSA and musculoskeletal diseases such as arthritis, fibromyalgia, and back pain. The correlation between OSA and musculoskeletal diseases may be due to disruption in slow-wave sleep, resulting in unremitting sleep, diffuse musculoskeletal pain, and fatigue. There is also a relationship between osteoporosis and OSA. Hypoxia, inflammation, and oxidative stress, which are well-known pathophysiological features of OSA, are known to affect bone metabolism and may be considered risk factors for osteoporosis. The results of the present study also suggest that harmful alcohol use and chronic diseases such as musculoskeletal diseases, diabetes mellitus, and hypertension are associated with a high risk of OSA.

To the best of our knowledge, no previous general-population-based studies have used the K-BQ to investigate the prevalence of a high risk of OSA in Koreans. Key strengths of this study include its use of a large population-based sample, and the relatively high participation rate. However, two limitations of the study are the method used to estimate the prevalence of OSA and its questionnaire-based design. The data were collected from a large number of participants to overcome this limitation. Another limitation is that the sampling areas were not nationwide. However, the target area of this study comprised two urban communities and seven rural communities, and the survey was conducted by applying a standardized and random sampling method to adults aged ≥19 years. Thus, the prevalence found in this study should be representative of the general population in Korea. However, further study with nationwide sampling is also needed.

In general, the BQ is a useful screening tool for identifying those with a high risk of OSA. The findings of our study demonstrate that this questionnaire can be useful for prevalence studies of OSA in the general population. Furthermore, it was found that harmful alcohol use and chronic diseases such as musculoskeletal diseases, diabetes mellitus, and hypertension are very common among those with a high risk of OSA, and might thus be factors associated with a high risk of OSA. Efforts to diagnose and treat effectively both the OSA itself and its related factors may thus be very important in public healthcare management.
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Conflicts of Interest

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