Effects of Ethnicity on the Prevalence of Obstructive Sleep Apnea in Patients with Acute Coronary Syndrome: A Pooled Analysis of the ISAACC Trial and Sleep and Stent Study

(*Running title: Koo CY et al, OSA in ACS*)

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ABSTRACT

Objective: Obstructive sleep apnea (OSA) is an increasing yet under-recognized risk factor for acute coronary syndrome (ACS). We sought to determine the effects of ethnicity on the prevalence of OSA in patients presenting with ACS who participated in an overnight sleep study.

Methods: A pooled analysis using patient-level data from the ISAACC Trial and Sleep and Stent Study was performed. Using the same portable diagnostic device and scoring criteria, OSA was defined as an apnea-hypopnea index of $\geq$15.

Results: A total of 1961 patients were analyzed, including Spanish (53.6%, n=1050), Chinese (25.5%, n=500), Indian (12.0%, n=235), Malay (6.1%, n=119), Brazilian (1.7%, n=34) and Burmese (1.2%, n=23) populations. Significant differences in body mass index (BMI) were found among the various ethnic groups, averaging from 25.3 kg/m^2 for Indians and 25.4 kg/m^2 for Chinese to 28.6 kg/m^2 for Spaniards. The prevalence of OSA was highest in the Spanish (63.1%), followed by the Chinese (50.2%), Malay (47.9%), Burmese (43.5%), Brazilian (41.2%), and Indian patients. The estimated odds ratio of BMI on OSA was highest in the Chinese population (1.17; 95% confidence interval: 1.10–1.24), but was not significant in the Spanish, Burmese or Brazilian populations. The area under the curve (AUC) for the Asian patients (ranging from 0.6365 to 0.6692) was higher than that for the Spanish patients (0.5161).

Conclusion: There was significant ethnic variation in the prevalence of OSA in patients with ACS, and the magnitude of the effect of BMI on OSA was greater in the Chinese population than in the Spanish patients.

INTRODUCTION

Cardiovascular disease is the leading cause of mortality, accounting for over 17 million deaths per year worldwide (1). Acute coronary syndrome (ACS) is the most common initial presentation of end organ damage due to atherosclerotic cardiovascular disease. More than one million patients suffer from ACS every year in the USA (2). Despite state-of-the-art treatment with dual antiplatelet therapy, intensive lipid lowering, and early revascularization, subsequent fatal and non-fatal cardiovascular events occur in over 20% of the patients who survive the initial ACS (3,4). The residual risk of cardiovascular events underscores the need for the identification and treatment of non-traditional risk factors.

Obstructive sleep apnea (OSA) is a prevalent but under-recognized form of sleep-disordered breathing (5), and has been increasingly recognized as a risk factor and prognostic marker for ACS (6–8). Studies have shown that 46–66% of the patients presenting with ACS have OSA (8,9), and untreated OSA is associated with subsequent adverse cardiac events and repeated revascularization (6-8). However, a comparison of the prevalence of OSA across different ethnic groups has been precluded by small sample sizes and the single-center nature of the studies conducted. It is generally believed that the effects of OSA on the cardiovascular system are similar in both Western and Asian countries. However, the prevalence of OSA in the general population may differ not only between Western and Asian countries, but also within Asia itself (10,11). In this regard, Asian patients have a different prevalence of obesity as well as different craniofacial profiles compared with Caucasians (12,13).

To date, the effects of ethnicity on the prevalence of OSA in patients presenting with ACS have been unknown. We conducted a pooled analysis of two large-scale, multi-center studies that

conducted overnight sleep examinations on patients presenting with ACS: the "impact of continuous positive airway pressure on patients with ACS and nonsleepy OSA" (ISAACC) Trial (14) and the "Sleep and Stent Study" (15). This was a multi-national collaborative effort aimed at determining the effects of ethnicity on the prevalence of OSA in patients with ACS, and was in response to the recognition that OSA is a prevalent, novel and treatable cardiovascular risk factor by the American College of Cardiology/American Heart Association and European Society of Cardiology (16,17). We hypothesized that differences in the prevalence of OSA and its interaction with obesity would be found among the various ethnic groups.

METHODS

Study design and patient population

This study was a combined analysis of two datasets – the ISAACC Trial and the Sleep and Stent Study. The details of the protocols of these two studies have been published previously (14,15). The ISAACC was a multi-center Spanish study designed to investigate the benefit of continuous airway positive pressure (CPAP) on patients with ACS and OSA. The Sleep and Stent Study is a multi-national study that evaluates the clinical outcomes of patients and the prevalence of OSA after percutaneous coronary interventions, including patients presenting with ACS. Approval for both studies was obtained by local ethics or institutional review boards, and informed consent was obtained from all patients.

A combined total of 2930 patients was available from the datasets for the Sleep and Stent Study (1794 patients) and the ISAAC Trial (1136). Among the patients available for primary analysis, 29 were excluded because they were over 80 years old, 518 were excluded because of elective percutaneous coronary interventions, 255 were excluded because of poor quality or failed sleep

studies, 124 were excluded because of predominantly central sleep apnea, 7 were excluded because of renal impairment, and 36 were excluded because of a significant amount of missing data. Thus, 1961 patients were eligible for the final analysis.

For the analysis of the combined dataset, we included adult patients aged between 18 and 80 years who presented with ACS. The ethnicity of each individual patient was recorded during enlistment into the trials. The combined exclusion criteria were all patients with known OSA and/or on CPAP therapy, patients with heart failure or chronic obstructive pulmonary disease who were on oxygen therapy, renal insufficiency (defined as estimated glomerular filtration rate <15 mL/min/1.73m^2), hemodynamic instability requiring the insertion of an intra-aortic balloon pump or mechanical ventilation, pregnancy, a history of malignancy, sedated patients, or patients who were unable to provide consent.

The primary objective of the study was to compare the prevalence of OSA among the various ethnic groups. We also evaluated the demographic and clinical risk factors for OSA, and investigated the impact of body mass index (BMI) on the prevalence of OSA in different ethnic groups.

Overnight sleep study

The sleep studies were performed using a portable diagnostic device (Embletta Gold, Natus Medical Inc., Canada) that has been validated against in-laboratory polysomnography (18). The parameters measured included airflow (nasal cannula and thermistor), respiratory movements (respiratory inductance plethysmography), percutaneous oxygen saturation via digital pulse oximetry, snoring episodes, echocardiography, and body position.

The apnea-hypopnea index (AHI), quantified as the total number of apneas and hypopneas per hour of sleep, was measured for each sleep study. Apnea was defined as a ≥90% decrease in airflow from baseline for ≥10 s. Apneas were further classified as obstructive or central, depending on the presence of respiratory-related chest wall movement. Hypopnea was defined as a 30–90% reduction in airflow from baseline for ≥10 s. Desaturations were defined as a decrease in percutaneous oxygen saturation of ≥3% in the Sleep and Stent Study and of >4% in the ISAACC Trial. The studies were scored according to the American Academy of Sleep Medicine 2007 (alternative) guidelines (19). Poor quality studies were excluded from the final analysis. Patients with predominantly central sleep apnea were also excluded from the analysis.

Statistical analyses

Categorical variables were presented as frequencies and percentages, and continuous variables were described as means with standard deviations or medians with ranges/interquartile ranges. Differences in the characteristics between the OSA and non-OSA groups were analyzed using the independent sample t-test for continuous data or the χ^2 test for categorical data.

A bivariate analysis of the factors affecting AHI and an age-adjusted analysis of the effect of BMI on sleep apnea according to ethnicity were conducted using the χ^2 test and logistic regression, respectively, the latter was carried out using effect estimates quantified on the basis of the odds ratio (OR) and its associated 95% confidence interval (CI). A receiver operating characteristic curve (ROC) analysis was performed and the area under curve (AUC) was estimated and compared between the ethnic groups. Further, a forest plot was generated to obtain a pooled estimate of the prevalence of OSA for all ethnic groups combined, assuming a random

effects model. All statistical analyses were carried out using STATA v. 13 (StataCorp LP, College Station, TX, USA), assuming a two-sided test with a 5% level of significance.

RESULTS

Baseline characteristics

The baseline demographic and clinical characteristics of the patients are shown in Table 1. The study population was predominantly male (85.1%) with a mean age of 57.7 ± 10.3 years. A total of six ethnicities were studied during the analysis, including Spanish (53.6%, n=1050), Chinese (25.5%, n=500), Indian (12.0%, n=235), Malay (6.1%, n=119), Brazilian (1.7%, n=34), and Burmese (1.2%, n=23) populations.

Significant differences in BMI were found among the various ethnic groups, averaging from 25.3 kg/m^2 for the Indian and 25.4 kg/m^2 for the Chinese to 28.6 kg/m^2 for the Spanish patients. Among the six ethnic groups, Malays appeared to have the highest prevalence of risk factors for coronary artery disease, predominantly smoking, hyperlipidemia, and diabetes mellitus. Malays and Indians also showed a general trend towards presenting with ST elevation myocardial infarctions (58.0% and 64.8%, respectively).

The baseline angiographic and procedural characteristics are presented in Table 2. No such data were available for analysis from the ISAACC Trial. The left anterior descending artery was the culprit vessel in 52.3% of the patients, and most of the patients (85.5% of the study population) presented with single vessel coronary artery disease. In line with current evidence-based guidelines, drug eluting stents were the preferred modality of percutaneous coronary intervention in 77.6% of the patients.

The echocardiography and laboratory characteristics across the various ethnicities are presented in Table 3. The median left ventricular ejection fraction ranged from 50% to 57%. The Brazilians appeared to have the highest serum creatinine levels among the six ethnic groups, and the Malays and Indians had the highest serum low-density lipoprotein levels compared with the other ethnicities.

Overnight sleep study

The results of the sleep study are detailed in Table 4. The median overall AHI across the various ethnicities was 17 (interquartile range: 7–32), and was highest in the Spanish population (median AHI, 20; range: 8–36) and lowest amongst the Indian population (median AHI, 9; range: 4–20). Using AHI ≥ 15 as the cut-off, OSA was present in 55.1% of the study population. The prevalence of OSA was highest in the Spanish population (63.1%), and lowest amongst the Indian population (36.1%). Figure 1 shows the forest plot of the prevalence of OSA among the various ethnicities. A bivariate analysis was further conducted to investigate the predictors of OSA (Table 5). In addition to ethnicity, age, BMI, and hypertension were found to be predictors of OSA.

Effect of BMI and ethnicity on OSA

A further multivariable analysis of these significant predictors found that the effect of BMI on OSA differed according to ethnicity (Table 6). A significant interaction between BMI and ethnicity to predict OSA was observed. The age-adjusted effect of BMI on OSA was highest in the Chinese population with an OR of 1.17 (95% CI: 1.10–1.24), followed by 1.16 (95% CI:

1.05–1.28) in the Malay population, and 1.11 (95% CI: 1.02–1.20) in the Indian population. The effect of BMI on OSA was not as significant in the Spanish, Burmese, and Brazilian populations.

An ROC analysis was performed to assess the effect of BMI on OSA according to ethnic group. The AUC for the Asian ethnicities was generally higher (range: 0.6365–0.6692) than that for the Spanish population (0.5161) (Table 7).

DISCUSSION

This is the largest study to report the effects of ethnicity on the prevalence of OSA in patients presenting with ACS. The main findings of this pooled analysis confirmed that OSA was prevalent in patients presenting with ACS, at an overall rate of 55.1%. Significant differences in the prevalence of OSA were found among the various ethnic groups, being highest in the Spanish (63.1%), followed by the Chinese (50.2%), Malay (47.9%), Burmese (43.5%), Brazilian (41.2%), and Indian (36.1%) patients. Other clinical predictors of OSA were old age, BMI, and hypertension. We also found that the effect of BMI on OSA differed between the various ethnic groups. The per unit increase in BMI was associated with a higher increase in the prevalence of OSA in the Asian than in the Spanish patients. These observational findings were particularly relevant because of the lack of data on the interaction between ethnicity and OSA in patients presenting with ACS.

Epidemiological studies have reported differences in demographic profiles, clinical presentations, and long-term outcomes after ACS among patients from various ethnic groups (20–22). In a Canadian registry that included more than 62,000 patients who presented with ACS, patients of South Asian origin were found to be younger, more likely to be male, and more likely to have

diabetes mellitus and hypertension than those of European origin (21). Similarly, in a large-scale registry in Singapore that included over 15,000 patients who presented with ACS, patients of Indian origin had the highest prevalence of diabetes mellitus, hyperlipidemia, prior myocardial infarction, prior percutaneous coronary intervention, and prior coronary artery bypass grafting compared with those of Chinese and Malay origin (22). It should be noted that, while OSA has been increasingly recognized as a risk factor for ACS, none of the early studies on the prevalence of OSA in patients presenting with ACS had reported a comparison across different ethnic groups.

Our findings have several important clinical and research implications. We found that the prevalence of OSA was higher in the Spanish than in the Asian patients, even though the proportion of male patients was smaller in the Spanish than in the Asian cohorts. This could probably be explained by the higher BMI and older age of the Spanish compared with the Asian patients. It should be highlighted that, in the aggregate and despite the variations observed, OSA was highly prevalent in all of the ethnic groups. Thus, the recommendation to screen for and treat OSA as a potential strategy to improve cardiovascular outcomes should be a global strategy rather than be focused on certain ethnic groups (17).

Although the BMI of the Asian cohorts appeared to be lower than that of the Spanish cohort, the impact of BMI on OSA in Asians should not be underestimated. Indeed, the results of the present study indicated that the age-adjusted effect of BMI on OSA in the Chinese, Malay, and Indian populations was more notable than that in the Spanish cohort. The OR of the per unit increase in BMI on OSA was highest in the Chinese population (1.17), implying that, for every unit increment in BMI, the Asian population has a greater risk of developing OSA than Spanish

patients, in contrast with studies on non-ACS populations, in which the magnitude of the effect of BMI on OSA was similar among both African Americans and Caucasians (10,23). The mechanism linking the larger effect of BMI on OSA in Asian ethnicities is unknown, but could be due to body fat distribution patterns, with a predisposition for central or abdominal fat distribution among Asians. Increased fat deposition around the neck results in a narrower, more collapsible upper airway, while central obesity is associated with reduced lung volume from fat deposition around the chest, reducing caudal traction on the pharynx. In view of the increasing epidemic of obesity affecting Asian countries (24), our findings underscore the importance of an efficient weight management program for the prevention of OSA.

The globally high prevalence of OSA reported here also highlights the impracticability of using in-laboratory polysomnography as a screening method for patients with ACS. It has been estimated that the demand exceeds the actual capacity by a factor of 10 in most countries and by a factor of 50 in the United Kingdom (25). A sleep study conducted in a hospital setting using a portable device is an inexpensive and convenient way to circumvent this problem. Such studies have been shown to provide diagnostic and treatment results equivalent to those of in-laboratory sleep studies, and they are currently covered by insurance in the USA when used for the diagnosis of OSA (26). According to the American Academy of Sleep Medicine, a portable diagnostic device is an acceptable alternative to in-laboratory polysomnography where there are safety concerns about housing patients who present with ACS in a sleep laboratory (27).

ACS remains a vexing problem in clinical practice and presents tremendous challenges to public health globally. In the past two decades, much research on OSA has focused on its association with cardiovascular disease. As a result, the vasculopathic effects of OSA have been increasingly

revealed and recognized (28). Our collaborative effort to combine large databases from different countries has provided an insight into the potential impact of OSA in ACS patients across different ethnic groups. With the high risk of recurrent cardiovascular events from OSA and the encouraging results of CPAP treatment in attenuating cardiovascular consequences in subjects with OSA, the prompt recognition and management of OSA among patients should form an integral part of the management of ACS.

Limitations

There are several limitations to our study. This pooled analysis combined data from two separate databases with prospectively enrolled patients, and amalgamation of the groups introduced a risk of bias. Although six ethnicities were investigated, fewer patients were Burmese and Brazilian. This small sample size within these ethnicities might have affected analyses within these subgroups. The sleep studies were analyzed independently by the two study teams. Although the same portable device and scoring criteria were used, inter-observer variability may have occurred. In addition, the Chinese patients were recruited from Mainland China, Hong Kong, and Singapore, and the Indian patients were from India and Singapore; therefore, differences in environmental effects on OSA may have influenced the results of this study. The only measurements of obesity available for our analysis were BMI, weight, and neck and abdominal circumference. More sophisticated parameters, including body fat distribution, were not available. Specific craniofacial measurements were not available for analysis, and this could potentially be one aspect for further research in the future, because most of the data on craniofacial variability in ethnic groups and its impact on OSA have been obtained from observational studies. As the ISAACC Trial and Sleep and Stent Study are ongoing, data on the clinical outcomes of the patients are not reported in the present study.

Conclusions

The prevalence of OSA varied significantly between Spanish and Asian patients presenting with ACS, and also differed among the various ethnic groups within Asia. The higher prevalence of OSA in the Spanish patients was probably due to the higher prevalence of obesity. It should be noted that the effect of a per unit increase in BMI on the OR for OSA was greater in the Asian patients, especially the Chinese, than in the Spanish patients. The overall high prevalence of OSA in patients with ACS and the feasibility of using a portable diagnostic device suggest that the systemic screening and treatment of OSA may be a plausible way to attenuate the risk of subsequent adverse events after ACS.

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Table 1. Patient demographics and clinical characteristics

Characteristics	Overall (n = 1961)	Chinese (n = 500)	Malay (n = 119)	Indian (n = 235)	Burmese (n = 23)	Spanish (n = 1050)	Brazilian (n = 34)	*p*-value
Age in years, mean (SD)	57.7 (10.3)	58.8 (10.0)	53.0 (8.8)	54.5 (10.0)	52.1 (11.2)	58.2 (10.3)	65.8 (9.2)	< 0.001
Gender (n, %)								0.003
Male	1667 (85.1)	426 (85.2)	108 (90.8)	216 (91.9)	21 (91.3)	872 (83.1)	26 (76.5)	
Female	292 (14.9)	74 (14.8)	11 (9.2)	19 (8.1)	2 (8.7)	178 (17.0)	8 (23.5)	
Height (m)	1.68 (0.08)	1.67 (0.07)	1.65 (0.07)	1.68 (0.08)	1.67 (0.08)	1.69 (0.08)	1.65 (0.09)	< 0.001
Weight (kg)	76.9 (14.3)	70.7 (11.9)	74.2 (12.8)	71.9 (10.7)	76.1 (15.5)	81.4 (14.7)	74.7 (13.6)	< 0.001
Body Mass Index in kg/m^2, mean (SD)	27.3 (4.4)	25.4 (3.3)	27.1 (4.2)	25.3 (3.5)	27.2 (4.7)	28.6 (4.6)	26.9 (3.2)	< 0.001
Cardiovascular risk factors (n, %)								
Smoking	891 (45.9)	203 (40.6)	67 (56.3)	99 (42.5)	12 (52.2)	504 (48.9)	6 (17.7)	< 0.001
Hyperlipidemia	1063 (55.1)	313 (62.6)	109 (91.6)	69 (31.9)	21 (91.3)	529 (51.1)	22 (64.7)	< 0.001
Hypertension	1001 (51.3)	303 (60.6)	57 (47.9)	108 (46.4)	11 (45.8)	492 (47.5)	30 (88.2)	< 0.001
Diabetes mellitus	616 (31.7)	182 (36.4)	70 (58.8)	95 (40.8)	12 (52.2)	241 (23.3)	16 (47.1)	< 0.001
Insulin dependent diabetes mellitus	110 (7.9)	19 (10.4)	7 (10.0)	10 (10.5)	1 (8.3)	68 (6.7)	5 (31.3)	0.005
Concomitant conditions (n, %)								
Previous myocardial infarction	305 (16.1)	81 (16.2)	17 (14.3)	26 (11.2)	1 (4.4)	169 (17.2)	11 (32.4)	0.013
Previous cerebrovascular accident	75 (3.9)	26 (5.2)	8 (6.7)	9 (3.9)	1 (4.4)	29 (2.8)	2 (5.9)	0.143
Chronic renal failure	33 (3.6)	18 (3.6)	6 (5.0)	3 (1.3)	0 (0.0)	-	6 (17.7)	< 0.001
Clinical presentations (n, %)								< 0.001
ST-elevation myocardial infarction	809 (45.6)	179 (35.9)	69 (58.0)	151 (64.8)	11 (47.8)	377 (43.5)	22 (64.7)	
Non-ST-elevation myocardial infarction	650 (36.6)	140 (28.1)	37 (31.1)	68 (29.2)	8 (34.8)	394 (45.4)	3 (8.8)	
Unstable angina	316 (17.8)	180 (36.1)	13 (10.9)	14 (6.0)	4 (17.4)	96 (11.1)	9 (26.5)	

Table 2. Echocardiography and laboratory values

Characteristics	Overall	Chinese	Malay	Indian	Burmese	Spanish	Brazilian	P value
Median left ventricular ejection fraction, % (IQR)	55 (47 – 61)	55 (48.5 – 63)	55 (45 – 60)	50 (44 – 58)	57 (50 – 60)	55 (50 – 61)	-	< 0.001
Median creatine kinase, U/L (IQR)	306 (111 – 1062)	181 (74 – 1016)	657 (214 – 2044)	583 (221 – 1554)	700 (233 – 1497)	327 (125 – 972)	110 (90 – 166)	< 0.001
Median creatinine, µmol/L (IQR)	78 (67 – 92)	77 (67 – 92)	86 (73 – 101)	86 (71 – 98)	78 (58 – 88)	76 (65 – 88)	104 (83 – 104)	< 0.001
Mean white blood cell, $x10^9$/L (SD)	9.33 (3.15)	8.83 (3.36)	10.97 (3.47)	8.24 (2.87)	10.24 (3.09)	9.68 (2.93)	7.57 (1.90)	< 0.001
Mean haemoglobin, g/dL (SD)	14.21 (1.77)	14.3 (1.82)	14.46 (2.23)	13.90 (2.04)	14.13 (1.78)	14.29 (1.60)	13.13 (1.42)	< 0.001
Mean platelet, $x10^9$/L (SD)	223.2 (66.4)	226.3 (64.4)	248.1 (56.9)	219.5 (67.3)	224.9 (46.5)	217.4 (62.9)	281.4 (146.5)	< 0.001
Mean total cholesterol, mmol/L (SD)	4.70 (1.21)	4.63 (1.21)	5.50 (1.39)	5.08 (1.18)	4.56 (1.14)	4.63 (1.13)	3.92 (1.39)	< 0.001
Median TG, mmol/L (IQR)	1.5 (1.1 – 2.1)	1.6 (1.2 – 2.1)	1.7 (1.4 – 2.4)	1.6 (1.1 – 2.4)	1.7 (1.4 – 2.1)	1.4 (1.1 – 1.9)	1.1 (0.9 – 2.1)	< 0.001
Mean LDL, mmol/L (SD)	2.92 (1.01)	2.83 (1.00)	3.52 (1.14)	3.27 (0.86)	3.13 (0.88)	2.9 (1.0)	2.1 (1.1)	< 0.001
Mean HDL, mmol/L (SD)	1.08 (0.63)	1.05 (0.27)	1.01 (0.25)	0.97 (0.23)	0.92 (0.18)	1.12 (0.81)	1.17 (0.39)	< 0.001

TG = triglyceride; LDL = low density lipoprotein cholesterol; HDL = High density lipoprotein cholesterol; IQR = inter-quartile range, SD = standard deviation

Table 3. Sleep study results

Characteristics	Overall	Chinese	Malay	Indian	Burmese	Spanish	Brazilian	P value
Median Overall AHI	17 (7 – 32)	15 (7 – 29)	14 (4 – 34)	9 (4 – 20)	12 (5 – 39)	20 (8 – 36)	12.7 (4.7 – 19.3)	< 0.001
Median ODI	10 (3 – 24)	5.9 (1.7 – 16.4)	6.1 (1.4 – 19)	5.0 (1.7 – 13.1)	5.8 (1.4 – 15.6)	16.6 (5.3 – 32.2)	8.9 (2.6 – 13.2)	< 0.001
Lowest SpO2, % (SD)	83.7 (8.7)	85.1 (5.8)	85.3 (5.9)	84.9 (6.8)	83.9 (7.7)	82.5 (10.3)	80.7 (9.5)	< 0.001
Median Total time SpO2<90%, minute	6 (0.7 – 28)	4.6 (0.6– 18.2)	3.5 (0.4 – 16.0)	2.6 (0.6 – 17.6)	3.2 (0.8 – 28.1)	8.4 (1 – 36.9)	9.2 (2.5 – 53)	< 0.001
Median Total % time SpO2 <90%, %	1.5 (0.2 – 7.4)	1 (0.1 – 4.3)	0.9 (0.1 – 4.3)	0.6 (0.1 – 4.4)	0.8 (0.2 – 5.6)	2.2 (0.2 – 9.5)	2.2 (0.7 – 14.5)	< 0.001
AHI ≥ 15	1080 (55.1)	251 (50.2)	57 (47.9)	85 (36.1)	10 (43.5)	663 (63.1)	14 (41.2)	< 0.001

AHI = Apnea-Hypopnea Index, ODI = Oxygen Desaturation Index

Table 4. Bivariate analysis of risk factors of AHI

Characteristics	**AHI ≥15 (n = 1080)**	**A < *15*HI < 15 (n = 881)**	***p*-value**
Age in years, mean (SD)	58.1 (10.2)	57.1 (10.4)	0.026
Gender (n, %)			0.319
Male	927 (85.8)	742 (84.2)	
Female	153 (14.2)	139 (15.8)	
Height (m)	1.68 (0.08)	1.67 (0.08)	0.001
Weight (kg)	79.1 (14.6)	74.2 (13.6)	< 0.001
Body Mass Index in kg/m^2, mean (SD)	27.9 (4.5)	26.5 (4.1)	< 0.001
Cardiovascular risk factors (n, %)			
Smoking	496 (46.5)	395 (45.2)	0.557
Hyperlipidemia	603 (56.6)	460 (53.3)	0.145
Hypertension	575 (53.6)	426 (48.8)	0.034
Diabetes mellitus	340 (31.8)	276 (31.6)	0.951
Insulin dependent diabetes mellitus	59 (7.2)	51 (9.0)	0.210
Concomitant conditions (n, %)			
Previous myocardial infarction	168 (16.2)	137 (16.0)	0.885
Previous stroke	41 (3.9)	34 (3.9)	0.949
Chronic renal failure	15 (3.6)	18 (3.7)	0.961
Clinical presentations (n, %)			0.728
ST-elevation myocardial infarction	435 (44.9)	374 (46.5)	
Non-ST-elevation myocardial infarction	363 (37.4)	287 (35.7)	
Unstable angina	172 (17.7)	144 (17.9)	

Table 5. Age-adjusted effect of BMI on sleep apnoea according to ethnic group

Characteristics	**OR**	**95% CI**	***p*-value**
Age (years)	1.01	1.004 to 1.02	0.004
Body Mass Index (kg/m^2)			
Chinese	1.17	1.10 to 1.24	< 0.001
Malay	1.16	1.05 to 1.28	0.005
Indian	1.11	1.02 to 1.20	0.013
Burmese	1.05	0.88 to 1.26	0.596
Spanish	1.01	0.99 to 1.04	0.350
Brazilian	1.27	0.97 to 1.66	0.084

Table 6. Area under curve (AUC) of effect of BMI on sleep apnoea (adjusted for age) according to ethnic group

Ethnicity	AUC	95% CI
Chinese	0.6365	0.5901 to 0.6809
Malay	0.6617	0.5647 to 0.7433
Indian	0.6403	0.5752 to 0.7026
Burmese	0.6692	0.4273 to 0.8362
Spanish	0.5161	0.4840 to 0.5477
Brazilian	0.6714	0.4947 to 0.8261

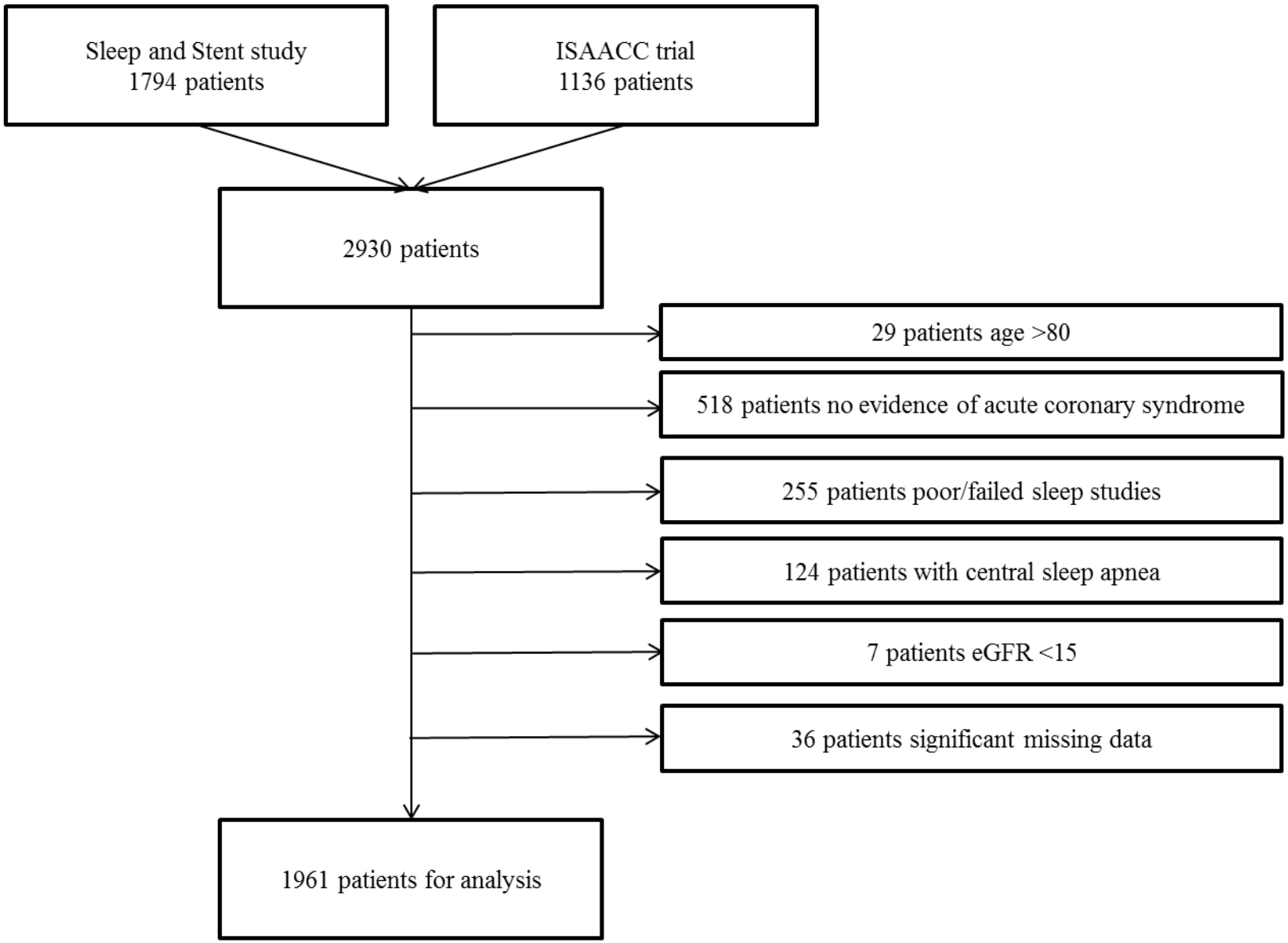

Figure 1: Patient flow chart showing excluded patients from analysis

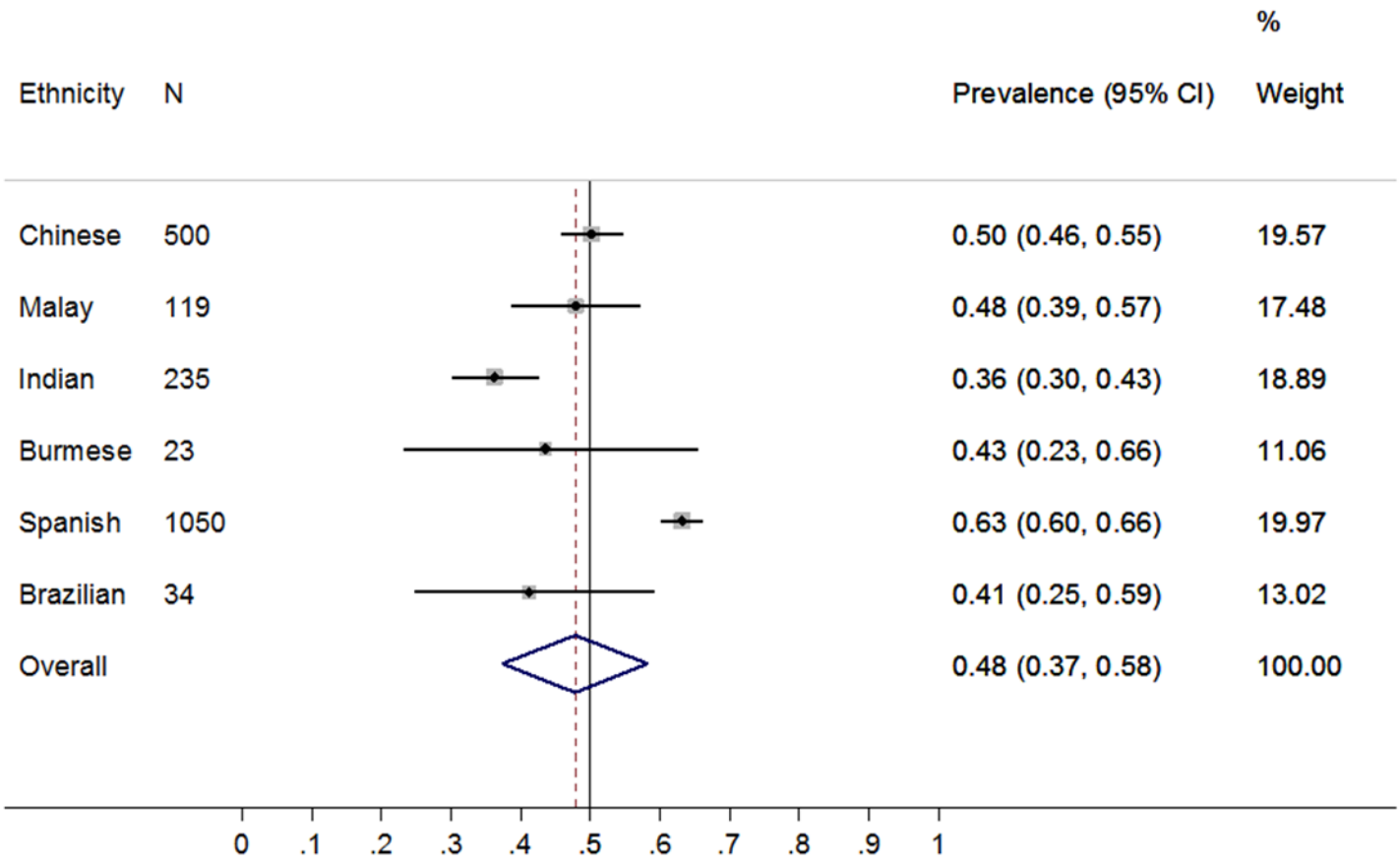

Figure 2: Forest plot of OSA prevalence and ethnicity