Elevated healthcare utilisation in young adult males with obstructive sleep apnoea

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ABSTRACT: The aim of the present study was to explore morbidity and healthcare utilisation among young adult males with obstructive sleep apnoea (OSA) compared with middle-aged OSA patients over the 5-yr period preceding diagnosis.

A prospective case–control study was performed; 117 young (22–39-yr-old) males with OSA were matched with 117 middle-aged (40–64-yr-old) OSA males for body mass index, apnoea/hypopnoea index, arterial oxygen saturation, arousal and awakening index, and Epworth Sleepiness Scale score. Each OSA patient was matched with controls by age, geographic area and physician.

Young adult males with OSA showed no increase in specific comorbidity compared with controls. Middle-aged OSA patients exhibited increased risk of cardiovascular disease. Healthcare utilisation for the 5-yr period was ⩾1.9 times higher among young and middle-aged male OSA patients than among controls. Multiple logistic regression analysis revealed that hyperlipidaemia in young adults and a body mass index of >37 kg·m^{-2} and cardiovascular disease in middle-aged adults are the only independent determinants of the upper third, most costly, OSA patients.

Compared with middle-aged males with obstructive sleep apnoea, in whom increased expenditure was related to cardiovascular disease and body mass index, utilisation was not related to any specific disease in younger cases.

KEYWORDS: Age, heathcare utilisation, morbidity, obstructive sleep apnoea

Obstructive sleep apnoea (OSA) is a common disorder, affecting 4% of the middle-aged male population. Untreated OSA may be a burden on the healthcare system as it is a risk factor for chronic conditions, such as cardiovascular disease (CVD). Elevated costs and CVD have been documented for years prior to the diagnosis of OSA [1, 2].

Most information about OSA comorbid conditions has been described using cross-sectional population-based studies starting from the age of 40 yrs [3–6]. Data regarding healthcare utilisation [1, 2, 7–12] have been obtained from laboratory-based OSA patients, mostly aged >40 yrs. The risk of CVD among OSA patients increases with age [1, 2, 4]. Clinicians and decision-makers are following the results of the Sleep Heart Health Study [4–6], which is providing data on OSA patients from the age of 40 yrs. Little is known about whether young adult (age <40 yrs) males with OSA show different morbidity and healthcare utilisation compared with controls and middle-aged (age 40–64 yrs) male OSA patients.

The present study was motivated following a recent call emphasising the need for early OSA diagnosis and treatment among young adults [13]. Decision-makers are currently less aware of the potential dividends from investment in preventive or early intervention among young adult OSA patients. The purpose of the present study was to explore morbidity and healthcare utilisation among young adult males with OSA over the 5-yr period preceding diagnosis.

METHODS

Setting

The present case–control study was conducted in two sleep disorder centres (the Sleep–Wake Disorders Unit of Soroka University Medical Center (Faculty of Health Sciences, Ben-Gurion University of the Negev, Beer-Sheva, Israel) and the Sleep Disorders Unit of Loewenstein Hospital Rehabilitation Center (Ra'anana, Israel)) in two districts (Southern and Central) where >95 and >70% of patients, respectively, are enrollees of Clalit Health Services (CHS), the largest health maintenance organisation in Israel.

Informed consent was obtained from all subjects with OSA.

Study population

Between January 2001 and April 2003, male patients (aged 22–64 yrs) with polysomnographically proven OSA were recruited consecutively. Young adult (age 22–39 yrs) male OSA patients (n=117) were matched with middle-aged (age 40–64 yrs) male OSA patients (n=117) by body mass index (BMI), apnoea/hypopnoea index (AHI), sleep time with an arterial oxygen saturation (Sa,O_2) of <90% (t90), arousal and awakening index, and Epworth Sleepiness Scale (ESS) score [14]. Each OSA patient was matched 1:1 by age, sex, geographical area and family physician in order to control subjects selected randomly from the CHS database [2, 11].

Patients and controls with chronic obstructive pulmonary disease, genetic disorders, cancer and autoimmune disorders, and those hospitalised for >50 days during the 5 yrs of data collection, were excluded [1, 2, 11]. Patients were not matched to controls for BMI since that information is not included in the CHS database. Ethical considerations meant that it was not possible to contact the control subjects; it is possible that ~5% of the controls might have had undiagnosed OSA.

Data resources

Data resources included polysomnography (PSG) results [15, 16]. OSA was defined as an episode of complete cessation of breathing of ⩾10 s with continuing inspiratory effort. Airflow was measured using a thermistor. A hypopnoea was scored when continuing inspiratory effort was accompanied by a reduction of ⩾50% in airflow, resulting in either an arousal or oxygen desaturation of ⩾4%. AHI was calculated per hour of sleep. Oxygen desaturation index was calculated as the number of desaturation events (Sa,O_2 decrease of >4%) per hour of sleep. t90 was calculated as a percentage. Sleeping habits, clinical history, ESS score and Functional Outcomes of Sleep Questionnaire (FOSQ) score [17] were collected as previously described elsewhere [2]. Language was not a barrier to completing the questionnaires, since the questionnaire had been validated in Hebrew [2]. The accumulated diagnoses of CVD were reviewed along with their respective International Classification of Diseases (ninth revision; ICD-9) codes, including: hypertension (401–405); ischaemic heart disease (410–414); cardiac arrhythmia; congestive heart failure; valvular cardiac disease and cerebrovascular accident (426–438); and peripheral vascular disease (443). A definition of CVD diagnosis [2] includes at least one of the following ICD-9 codes: 410–414, 426–438 and 443. In addition, medical conditions that increase the risk of CVD were included, *i.e.* hyperlipidaemia (272) and diabetes mellitus (250). Participants' mailing addresses were used as a proxy for socioeconomic status [18].

Healthcare utilisation

Healthcare utilisation information was obtained from CHS databases [2, 11, 19–21]. All costs were combined for the 5 yrs prior to PSG diagnosis and similar time periods were used for the control subjects. Healthcare utilisation included: hospitalisation (duration and costs); emergency department visits (number and costs); visits to specialists (type of specialty, number of visits and cost; OSA consultations did not include the last otolaryngology surgeon or pulmonologist visits prior to the PSG study); and prescriptions supplied (number, category [22] and cost). All costs were calculated according to the price list published by the Israeli Ministry of Health (Jerusalem, Israel) in 2005 (4.5 Israeli New Shekels=US$1). The cost of the PSG study was not included.

Statistical analysis

Healthcare utilisation was analysed according to previous recommendations [23]. The following design was applied: young adult (22–39 yrs) males with OSA, young paired adult males and middle-aged (40–64 yrs) males with OSA [4–6]. In order to confirm that the middle-aged male OSA group was typical, an additional group of middle-aged male pair-matched controls was included. Costs are not normally distributed among OSA patients [11]. Therefore, the OSA group was arbitrarily divided by cost into the most (upper 33.3%) and the least (remaining 66.7%) costly male OSA patients. The multiple logistic regression model was fitted to establish the determinants of the most costly OSA patients (dependent variable). Independent variables included age, BMI, partner complaints, ICD-9 codes, drugs supplied, smoking history, PSG findings, ESS score and FOSQ score. Significance was accepted at a p-value of ⩽0.05, with Bonferroni correction for multiple comparisons.

RESULTS

In total, 1,508 males underwent PSG studies during the study period. Of these, 112 were enrollees of other health maintenance organisations and/or were severely sick. Of the remainder, 93 (6.7%) patients refused to participate in the study and 243 (18.6%) were aged ⩾65 yrs and did not meet the inclusion criteria. Following PSG, 138 subjects did not meet the inclusion criteria of OSA diagnosis (AHI of <5 events·h^{-1}). Ultimately, 922 male OSA patients (AHI of ⩾5 events·h^{-1}) were eligible for the present study. Of these, all 117 (12.7%) young adult males with OSA were population-matched with middle-aged OSA patients randomly selected from 805 eligible middle-aged patients.

Subjects

The characteristics of the male OSA patients are shown in table 1. The mean age difference between the two groups was 20 yrs (p<0.0001). No significant differences were found in arousal and awakening index, AHI, t90, ESS score, BMI and FOSQ score of young and middle-aged adults. The ESS score inversely correlated with the FOSQ score in both young adult (r= -0.29; p=0.013) and middle-aged (r= -0.46; p<0.0001) OSA patients. The proportion of married middle-aged OSA patients was 27% greater (p<0.0001) and this group had received fewer years of education (p<0.05). Both young and middle-aged adult males with OSA reported a similar (p=0.6) weight gain of ~5 kg in the 12 months prior to the PSG study and a similar prevalence of habitual snoring of 95%. More young adult males with OSA are current smokers (48%; p<0.024). Of the bed partners of both male OSA groups, 60% reported significant sleep disturbance due to the patient's habitual loud snoring. Approximately half of the partners who complained about snoring slept in separate bedrooms.

Comorbidity

Compared with their controls, a similar risk was found among young adults with OSA regarding diagnosis of CVD, hyperlipidaemia, diabetes, asthma and depression. Only a few

TABLE 1	Demographics and characteristics of male obstructive sleep apnoea patients	
	Young adults[#]	Middle-aged adults[¶]
Patients n	117	117
Age yrs	33.8±4	53.1±6.4[+]
Married %	61.5	89.0[+]
Education yrs	13.4±2.7	12.4±3.1*
Sleep efficiency %	86±10.0	83±16.1
Arousal and wakening index events·h^{-1}	31.7±23.4	32.0±22.8
AHI events·h^{-1}	30.5±25.0	32.0±25.5
$t90$ %	13.1±23.9	12.7±22.2
ESS score	9.0±5.7	8.8±5.4
BMI kg·m^{-2}	30.2±6.2	30.7±5.1
CVD n	1	24[+]
HPL n	12	45[+]
Diabetes n	3	12*

Data are presented as mean±SD, unless otherwise stated. AHI: apnoea/hypopnoea index; $t90$: sleep time with an arterial oxygen saturation of <90%; ESS: Epworth Sleepiness Scale; BMI: body mass index; CVD: cardiovascular disease; HPL: hyperlipidaemia. *: p<0.05; [#]: <40 yrs; [¶]: 40–64 yrs; [+]: p<0.0001.

subjects (range 0–12) in both young adult groups were found to have these illnesses. However, middle-aged OSA subjects (range 7–45) had more hyperlipidaemia, diabetes, asthma and CVD compared with their controls (odds ratio (OR) 2.1; 95% confidence interval (CI) 1.7–3.8).

Healthcare utilisation

Compared with controls, the 5-yr total costs (table 2) were 1.98 and 1.90 times as high in young and middle-aged OSA patients, respectively (p<0.002). Only one young adult and one middle-aged adult received zero healthcare expenditure during the 5-yr observation period. Costs for visits to the emergency department, consultations and supplied drugs, but not hospitalisation costs, were all significantly higher in both OSA groups compared with controls (table 2).

Consultations

Compared with controls, the total number of visits made to specialists during the 5 yrs prior to PSG diagnosis revealed that young adult males with OSA had more consultations with otolaryngology surgeons (1.3±0.1 versus 0.3±0.07; p<0.0001) and pulmonologists (0.09±0.03 versus 0.02±0.01; p<0.05). There were 32% repeated (≥2) otolaryngology consultations among young adult males with OSA compared with 5.2% in their controls (p<0.0001). Relative to controls, middle-aged male adults with OSA had more consultations with otolaryngologists (0.4±0.1 versus 1.4±0.1; p<0.0001), pulmonologists (0.02±0.01 versus 0.4±0.1; p<0.0001) and other specialists (e.g. dermatologists, cardiologists, orthopaedist, neurologists and gastroenterologists; p<0.01). Significantly more repeated (≥2) consultations were found among all consultants, except for orthopaedics, urology and general surgery.

Drugs supplied

Compared with controls, the total 5-yr costs for drugs among young and middle-aged male OSA patients were 2.9 (p=0.056) and 3.3 times (p<0.001) as high, respectively (table 2). The mean total numbers of drug supplied during the 5 yrs prior to PSG diagnosis is summarised in table 3. The pharmacological categories in which significant differences were found in one of the studied groups are included. The main drug categories supplied to young and middle-aged male adults with OSA were for the respiratory system and CVD, respectively. No differences were found in the number (table 3) and/or costs of CVD drugs supplied to young male OSA patients relative to their controls (US$8.8±3.5 versus 1.7±0.8; p=0.1). The cost for the cholesterol and triglyceride reducer subcategory was US$0.60 and 2.70 in controls and young adult males with OSA, respectively, and US$6.70 and 36.00 in controls and middle-aged adults with OSA, respectively. Drugs for the obstructive airway disease subcategory comprised <30% of the respiratory system category in all four groups. Hypnotic and sedative drugs were supplied similarly (<14%), and anti-psychotic subcategory drugs were supplied from the psycholeptics and psychoanaleptics category, 68 and 33% (p<0.01) among young adult male OSA patients and controls, respectively. The psycholeptic and psychoanaleptic category drugs were supplied significantly more to middle-aged adult males with OSA (table 3).

Characteristics of the upper third, most costly, male OSA patients

When dividing the young adult OSA group by cost, the upper 33.3% (n=39) of patients, who were the most costly, consumed 82% of all costs and showed a mean consumption during the 5 yrs prior to PSG diagnosis of US$1,876±349, as compared with US$206±17.7 for the least costly (lower 66.6%) patients (p<0.0001). The most costly subjects consumed 9.1 times more healthcare resources than the least costly patients. The most costly young adult male OSA subjects were diagnosed more frequently with hyperlipidaemia (p<0.002), but had similar $t90$, ESS score, BMI, FOSQ score, AHI and arousal and awakening index compared with the least costly subjects. For example, the AHI was 33.9±4.5 versus 28.8±2.7 events·h^{-1} (p=0.6) and the arousal and awakening index was 37.5±6.2 versus 26.9±4.2 events·h^{-1} (p=0.3) in the most costly versus the least costly patients, respectively.

The most costly middle-aged male OSA subjects consumed 78% of all costs and showed a mean consumption during the 5 yrs prior to PSG diagnosis of US$4,296±677, as compared with US$398±32.6 for the least costly patients (p<0.0001). The most costly male OSA patients consumed 10.8 times more healthcare resources than the least costly patients. The most costly subjects had more comorbid conditions, i.e. 2.0 times more CVD (p=0.006), 1.9 times more hyperlipidaemia (p=0.005) and 4.0 times more diabetes (p=0.019); the univariate ORs are exhibited in table 4. The FOSQ score was 77.4±2.8 versus 65.2±4.0 units among the most versus least costly patients, respectively (p=0.03). The most costly middle-aged OSA patients showed a significantly greater arousal and awakening index of 44.8±5.8 versus 22.7±4.7 events·h^{-1} (p=0.003), and a $t90$ of 19.3±4.4 versus 8.9±2.4% (p=0.014) relative to the least costly patients, respectively. However, the

TABLE 2 Cost elements for male obstructive sleep apnoea (OSA) patients *versus* matched controls in the 5 yrs prior to diagnosis

	Young adults			Middle-aged adults		
	Control	OSA	p-value[#]	Control	OSA	p-value[#]
Hospitalisation						
Costs US$	144.7±44.6 (0; 0–2832)	299.5±115.8 (0; 0–12036)	0.7	575.0±197.1 (0; 0–18408)	886.5±221.3 (0; 0–19116)	0.161
Time days	0.4±0.1 (0; 0–8)	0.8±0.3 (0; 0–34)	0.7	1.6±0.6 (0; 0–52)	2.5±0.6 (0; 0–54)	0.161
Emergency department						
Costs US$	88.7±12.2 (0; 0–665.3)	132.7±16.8 (111.0; 0–887.1)	0.020	86.2±19.1 (0; 0–1996)	126.1±22.6 (0; 0–1996)	0.049
Visits n	0.8±0.1 (0; 0–6)	1.2±0.2 (1; 0–8)	0.024	0.8±0.2 (0; 0–18)	1.1±0.2 (0; 0–18)	0.046
Consultation						
Costs US$	95.1±10.5 (39.3; 0–472)	165.4±14.0 (118; 0–787)[¶]	<0.0001	114.0±14.2 (79; 0–904)	285.4±25.3 (197; 0–1967)	<0.0001
Visits n	2.4±0.3 (1; 0–12)	4.2±0.4 (3; 0–20)[¶]	<0.0001	2.9±0.4 (2; 0–23)	7.3±0.6 (5; 0–50)	<0.0001
Drugs						
Costs US$	57.1±10.1 (17; 0–815)	165.1±45.4 (37; 0–3322)[¶]	0.056	120.3±24.6 (38; 0–2347)	400±68 (158; 0–5126)	<0.001
Total costs US$	386±55 (162; 0–3030)	763±137 (303; 3–12825)[¶]	0.004	895.3±218.2 (236; 0–19305)	1698±282.2 (559; 0–24196)	0.002

Data are presented as mean±SEM (median; range) total costs and healthcare utilisation per patient during the 5 yrs prior to OSA diagnosis. [#]: Wilcoxon test; [¶]: p<0.0001 *versus* middle-aged OSA patients (Mann–Whitney U-test).

AHI was similar (p=0.77) for the most *versus* the least costly patients, 31.1±3.5 *versus* 32.4±3.0 events·h^{-1}, respectively.

The univariate and multivariate ORs of the determinants of the most costly male OSA patients are presented in table 4. After adjusting for age, AHI and BMI, multiple logistic regression analysis revealed that hyperlipidaemia (OR (95% CI) 7.0 (1.8–29.2)) is the only independent determinant of the most costly young adult males with OSA.

After adjusting for age and AHI, multiple logistic regression analysis revealed that BMI (OR (95% CI) 5.6 (1.6–20.1)) and CVD diagnosis (2.7 (1.15–6.3)) are the independent determinants of the most costly middle-aged adults with OSA.

TABLE 3 Number of drugs supplied to male obstructive sleep apnoea (OSA) patients in the 5 yrs prior to diagnosis

	Young adults			Middle-aged adults		
	Drugs	Difference	p-value[#]	Drugs	Difference	p-value[#]
Respiratory system (R)	6.5±1.1 (3; 0–85)	3.0±1.3 (0.4–5.6)	0.002	7.8±1.2 (4; 0–110)	4.8±1.2 (2.3–7.2)	<0.0001
Antibacterials for systemic use (J01)	3.4±0.7 (2; 0–73)	1.0±0.7 (-0.5–2.5)*	0.06	4.4±0.5 (3; 0–31)	2.1±0.5 (1.1–3.2)	<0.0001
Cardiovascular system (C)	3.4±1.4 (0; 0–140)	3.0±1.5 (0.1–6.0)[¶]	0.2	19±3.5 (1; 0–209)	12.9±4.0 (5.1–21)	<0.0001
Psycholeptics and psychoanaleptics (N05, N06)	3.0±1.1 (0; 0–70)	2.8±1.1 (0.7–5.0)[¶]	0.04	3.9±1.1 (0; 0–85)	2.9±1.1 (0.7–5.1)	0.001
Analgesics (N02)	2.5±0.8 (1; 0–92)	1.4±0.9 (-0.3–3.1)[¶]	0.12	5.2±0.9 (2; 0–51)	2.7±0.9 (0.9–4.5)	0.002
Anti-inflammatory and antirheumatic products (M01)	0.8±0.1 (0; 0–6)	0.22±0.10 (-0.05–0.5)[¶]	0.2	2.6±0.4 (2; 0–25)	1±0.5 (0.06–1.9)	0.008
Peptic ulcer and gastro-oesophageal reflux disease (A02B)	0.4±0.14 (0; 0–14)	-0.5±0.5 (-1.5–0.5)[¶]	0.83	4.1±1.0 (0; 0–63)	3.2±0.9 (1.4–4.9)	<0.0001
Drugs used in diabetes (A10)	0.33±0.33 (0; 0–39)	0.34±0.34 (-0.33–1.01)*	0.6	3.7±1.5 (0; 0–115)	3.2±1.4 (0.4–5.9)	0.03

Data are presented as mean±SEM (median; range) number of drugs supplied per patient during the 5 yrs prior to OSA diagnosis and as mean±SEM (95% confidence interval) difference in prescription number over the 5 yrs. Differences between patients and controls were found in all pharmacological groups shown (a similar methodological approach was used to that in [10]). Cardiovascular categories include: cardiac therapy and selective calcium channel blockers with direct cardiac effect (C01 and C08D); centrally and peripherally acting antiadrenergic agents (C02A and C02C); agents acting on arteriolar smooth muscle (C02D); thiazides, other low-ceiling diuretics, potassium-sparing agents and diuretics, and potassium-sparing agents in combination (C03A, C03B, C03D and C03E); high-ceiling diuretics (C03C); peripheral vasodilators (C04); vasoprotectives (C05); β-blocking agents (C07); selective calcium channel blockers with mainly vascular effects (C08C); plain and combination angiotensin-converting enzyme inhibitors (C09A and C09B); plain and combination angiotensin II antagonists (C09C and C09D); and cholesterol and triglyceride reducers (C10A). *: p<0.05; [#]: Wilcoxon test; [¶]: p<0.0001 *versus* middle-aged OSA patients (Mann–Whitney U-test).

TABLE 4	Determinants of the upper third most costly male obstructive sleep apnoea (OSA) patients				
	Unit	Univariate analysis		Multivariate analysis	
		OR (95% CI)	p-value	OR (95% CI)	p-value
Young adults					
Age	+1 yr	1.04 (0.95–1.20)	0.390	1.02 (0.91–1.13)	0.773
AHI	+1 events·h^{-1}	1.01 (0.99–1.02)	0.298	1.003 (0.98–1.02)	0.778
BMI	+1 kg·m^{-2}	1.04 (0.98–1.10)	0.190	1.01 (0.93–1.10)	0.816
HPL	1=yes; 0=no	7.5 (1.9–29.6)	0.004	7.0 (1.8–29.2)	0.008
Middle-aged adults					
Age	+1 yr	1.05 (0.99–1.10)	0.137	1.03 (0.96–1.10)	0.361
AHI	+1 events·h^{-1}	0.998 (0.98–1.01)	0.798	0.993 (0.97–1.01)	0.433
BMI	1⩾38 kg·m^{-2}; 0<38 kg·m^{-2}	5.03 (1.6–16)	0.006	5.6 (1.6–20.1)	0.008
CVD	1=yes; 0=no	3.05 (1.36–6.80)	0.007	2.7 (1.15–6.3)	0.023
HPL	1=yes; 0=no	3.1 (1.4–6.9)	0.006	NI	
Diabetes	1=yes; 0=no	4.8 (1.3–17.02)	0.016	NI	
t90	1⩾10%; 0<10%	3.33 (1.3–8.7)	0.014	NI	

Univariate and multivariate logistic regression models were used to calculate odds ratios (ORs) with 95% confidence intervals (CI) and establish the primary determinants of the most costly OSA patients. AHI: apnoea/hypopnoea index; BMI: body mass index; HPL: hyperlipidaemia; CVD: cardiovascular disease; t_{90}: sleep time with an arterial oxygen saturation of <90%; NI: not included.

DISCUSSION

Young and middle-aged adults with OSA are high consumers of healthcare services. The most costly patients consumed >78% of all the OSA group costs. Young male adults with OSA show high healthcare utilisation due to nonspecific comorbidity.

Subjects studied

The present study is the first report comparing healthcare utilisation between young and middle-aged adult males with OSA, stratified by age, in which severity of OSA and BMI have been controlled. Only 15% of the subjects referred for PSG evaluation were young adults. Of these, 12.7% (n=117) were classified as having mild typical OSA or beyond. Similar rates of OSA have been reported in young adults [24–26]. It is well known that age per se is a continuous and cumulative risk factor for CVD and healthcare utilisation among male OSA patients [1, 2, 7–12]. However, most information has been reported for male OSA patients aged ⩾40 yrs. The age definition of young adults varies. Here, the stratification methodology of the Sleep Heart Health Study [4–6], which selected an age of 40 yrs as the lower boundary of their inclusion criteria, was adapted. However, there is no particular reason to suspect that there is a discontinuity or structural break in the relationship between age and healthcare expenditure at age 40 yrs. It is possible that this stratification deflected the attention of clinicians and decision-makers from early diagnosis of young adult males with OSA [13]. The present study fills the gap in the information needed to prioritise diagnosis in this age category.

Associated morbidity

OSA is already prevalent in the third decade of life, and these patients are generally referred to a sleep clinic for OSA diagnosis due to characteristic symptoms that start bothering the subject or their bed partner [13]. Patients who ultimately

present for evaluation of OSA have been treated for years for secondary manifestations [27, 28], e.g. minor mental disorders [29] and nonspecific respiratory system symptoms. The present information on drugs supplied, especially those from the respiratory system, antibacterials for systemic use and psycholeptics and psychoanaleptics categories, is an indirect supportive index of secondary and nonspecific manifestations of OSA. No indices were found for the presence of CVD among young adult males with OSA using healthcare utilisation parameters. It is reasonable that the changes in the cardiovascular system are subclinical and, as hypothesised [13], manifested later in life. In some of these individuals, the nonspecific manifestations and CVD may be ameliorated with continuous positive airway pressure treatment [30]. Therefore, the present authors support the need for early OSA diagnosis among young adults [13].

The only difference between the OSA subgroups was the presence of CVD in the middle-aged patients [1, 2, 27, 31]. In the present study, the risk of comorbid conditions (CVD, hyperlipidaemia and diabetes) among adults with OSA increases considerably with age [1–6, 30, 32–34]. Delaying diagnosis and treatment to the fifth and sixth decades may be too late, especially for young adults who may develop irreversible CVD [13].

Healthcare utilisation

Several factors may complicate attempts to obtain unbiased estimates of healthcare expenditures. For example, medical care expenditures may exhibit a large number of observations clustered at zero, with the rest of the observations being positive and highly skewed [35]. The usual solution to this problem is to estimate a two-part or Heckman sample selection model [36]. All of this is relevant to the present study; however, the current OSA subjects are dominated by people who require nonzero healthcare expenditures (only one middle-aged adult and one young adult required zero healthcare expenditure). Positive and

highly skewed utilisation were minimised using the exclusion criteria, *i.e.* patients hospitalised for >50 days during the 5 yrs of data collection [1, 2].

Since costs are not normally distributed among OSA patients, a small group [11] of OSA patients who were the most ill and most costly consumed >70% of all healthcare resources used by OSA patients. In the present study, the most costly male OSA patients, who consumed >78% of all costs during the 5 yrs, consumed at least nine times more healthcare resources than the least costly young and middle-aged male OSA patients. Is there any relationship between age and healthcare expenditure in the young adult OSA males, *i.e.* are 20-yr-olds much the same as 39-yr-olds when it comes to total healthcare expenditure? It was found that age did not predict costs among the most costly OSA males. However, it was demonstrated that the risk of CVD, and probably its related costs, increases with age among OSA patients aged >40 yrs [4–6].

Hyperlipidaemia was the only determinant found to increase the odds of being included among the most costly young adult males with OSA, suggesting that these patients are at greater risk of irreversible arteriosclerotic processes [13]. However, it is possible that, since the number of subjects (n=39) in the most costly subgroup is small, this may result in statistical under-powering. The relationship between hyperlipidaemia and excess health service use needs to be interpreted with caution in further studies. Among all young male OSA patients, the high utilisation is due to respiratory tract diseases, as indicated by significantly more visits to otolaryngology surgeons and pulmonologists, in addition to supplying more respiratory category drugs. This finding is valid even after excluding the obstructive airway diseases category, which was distributed equally among all groups studied.

Mechanisms linking OSA with CVD are complex and multi-factorial, *i.e.* AHI [5], haemodynamics, neural, metabolic, endothelial, coagulatory or inflammatory consequences of nocturnal respiratory events, oxidant stress and low socio-economic status [11, 37]. None of the PSG objective findings of OSA severity (AHI, t_{90} and arousal and awakening index) or BMI adds to the prediction of the most costly young adult male OSA patients or CVD, supporting earlier reports [1, 2, 11, 38]. The present patients with AHIs of >20 and >30 events·h^{-1} show similar healthcare utilisation. The AHI is probably an imperfect linear measure of OSA severity, and obesity is not necessarily a cause of healthcare consumption [39]. Healthcare utilisation does not reflect OSA severity. Many of the present OSA patients require treatment, and these patients probably had an AHI above the CVD threshold [2]. In addition, factors directly responsible for CVD, such as inflammatory mediators and oxidant stress [37], are genetically determined responses to the OSA stimulus. It was not permissible to contact the controls to obtain their BMIs due to legislation protecting patient confidentiality [2, 11]. This is a limitation when analysing utilisation in a healthcare system in which legislation protecting patient confidentiality exists. A high BMI ($\geqslant 38$ kg·m^{-2}) and CVD increase the odds of being included among the most costly middle-aged OSA patients. The presence of CVD as a risk factor in the most costly middle-aged OSA patients in the present study is in accordance with previous reports [1, 2, 11].

The present data represent a healthcare system similar to others, such as that in Canada [1, 7–10, 12]. These results reflect the true consumption of healthcare resources, since there is no economic incentive to refer patients to PSG studies [2, 11, 19–21, 27]. In the present healthcare system, the cost per visit to a specialist is fixed regardless of the length of the visit. Further studies are needed to explore whether differences exist between the OSA groups and controls with respect to encounter intensity (*i.e.* dose, strength and length of visit). It was not possible to determine whether or not increased exposure to the healthcare system increased the risk of elevated healthcare utilisation [21]. It was not permissible to contact controls or patients to obtain additional information due to legislation protecting patient confidentiality [2, 11, 19–21]. Finally, the ability of patients to pursue medical help may be influenced by socioeconomic status; this effect was mini-mised by selecting controls from the same geographical location [2].

CONCLUSION

In comparison with middle-aged males with obstructive sleep apnoea, in whom increased expenditure was related to cardiovascular disease and body mass index, healthcare utilisation was not related to any specific disease in younger cases.

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