The Use of Health-Care Resources in Obesity-Hypoventilation Syndrome*

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Objective: To document health-care utilization (ie, physician claims and hospitalizations) in patients with obesity-hypoventilation syndrome (OHS), for 5 years prior to the diagnosis and for 2 years after the diagnosis and initiation of treatment.

Design: Retrospective observational cohort study.

Setting: University-based sleep disorders center in Manitoba, Canada.

Patients and control subjects: Twenty OHS patients (mean [± SD] age, 52.7 ± 9.5 years; body mass index [BMI], 47.3 ± 11.0 kg/m²; PaCO₂, 59.7 ± 13.8 mm Hg; PaO₂, 51.6 ± 12.4 mm Hg) were matched to two sets of control subjects. First, each case was matched to 15 general population control subjects (GPCs) by age, gender, and geographic location, and, second, each case was matched to a single obese control subject (OBC) who was matched using the same criteria as for the GPCs, plus the measurement of BMI.

Measurements and results: In the 5 years before diagnosis, the 20 OHS patients had (mean ± SE) 11.2 ± 1.8 physician visits per patient per year vs 5.7 ± 0.8 (p < 0.01) visits for OBCs and 4.5 ± 0.4 (p < 0.001) visits for GPCs. OHS patients generated higher fees, $623 ± 96 per patient per year for the 5 years prior to diagnosis compared to $252 ± 34 (p < 0.001) for OBCs and $236 ± 25 (p < 0.001) for GPCs. OHS patients were much more likely to be hospitalized than were subjects in either control group in the 5 years prior to diagnosis (odds ratio [OR] vs GPCs, 8.6) (95% confidence interval [CI], 5.9 to 12.7); OR vs OBCs, 4.9 (95% CI, 2.3 to 10.1). In the 2 years after diagnosis and the initiation of treatment (usually continuous positive airway pressure or bilevel positive airway pressure), there was a significant linear reduction in physician fees. In the 2 years after the initiation of treatment, there was a 68.4% decrease in days hospitalized per year (5 years before treatment, 7.9 days per patient per year; after 2 years of treatment, 2.5 days per patient per year [p = 0.01]).

Conclusions: OHS patients are heavy users of health care for several years prior to evaluation and treatment of their sleep breathing disorder; there is a substantial reduction in days hospitalized once the diagnosis is made and treatment is instituted. (CHEST 2001; 120:377–383)

Key words: apnea; hypoventilation; obesity; sleep; utilization

Abbreviations: AHI = apnea-hypopnea index; BMI = body mass index; CI = confidence interval; CPAP = continuous positive airway pressure; GPC = general population control subject; MHDB = Manitoba Health Database; OBC = obese control subject; OHS = obesity-hypoventilation syndrome; OR = odds ratio; OSAHS = obstructive sleep apnea-hypopnea syndrome; SaO₂ = arterial oxygen saturation

It is widely accepted that society is in the midst of an epidemic of obesity.1–4 Obesity results in an increase in the use of health care,5,6 which is the result of treatment for the major comorbidities hypertension, diabetes mellitus, and coronary artery disease.4 Another often unappreciated complication of obesity is its effect on the respiratory system, which can result in significant morbidity and use of health-care resources.

Obesity, which can impair the function of the respiratory system, is a significant contributor to obstructive sleep apnea-hypopnea syndrome (OSAHS). Before OSAHS was described, it was known that morbid obesity might result in hypoventilation.7–10 Several terms have been used to describe the combination of obesity and hypoventilation, including pickwickian syndrome and, more recently, obesity-hypoventilation syndrome (OHS). Although both OSAHS and OHS pa-
tients have excessive daytime hypersomnia, there are fundamental differences between the two conditions. In OSAHS, disordered breathing is present typically only during sleep and obesity is not always present. In OHS, hypoventilation is present during sleep and wakefulness, and by definition obesity is always present. Manifestations frequently associated with OHS include polycythemia, pulmonary hypertension, right-sided heart failure, and awake respiratory failure as documented by daytime hypercapnia.8,11

MacGregor et al12 reported a high level of mortality, including sudden death, in patients with pickwickian syndrome and a subsequent reduction in mortality with the institution of mechanical ventilation. It is now generally agreed that the severe and often life-threatening cardiopulmonary sequelae resulting from hypoventilation often demand instituting therapy, frequently on an emergency basis.13

Although we have shown that OSAHS patients are heavy users of health-care resources,14,15 the long-term health-care utilization of OHS patients has not been rigorously reviewed. It is reasonable to hypothesize that OHS patients are heavy users of health-care resources in a manner that is similar to that by OSAHS patients and that the institution of treatment also will result in a reduction in health-care utilization. To test our hypothesis, we compared the physician claims for payment and hospitalizations in patients with OHS before and after diagnosis, to obese control subjects (OBCs) and to non-OBCs.

**Materials and Methods**

This study was conducted in the Province of Manitoba (1997 population, 1,147,90016) where all residents have equal access to government-funded health care. Standardized data, based on every physician and hospital contact, are submitted to Manitoba Health, the provincial agency responsible for funding. This information (including patient identification, physician claims, diagnoses, costs, hospitalization, and institutionalization data) is maintained and controlled in the Manitoba Health Database (MHDB), which has been utilized and described elsewhere.17

With this system, one can track resource utilization over time for any given patient and/or particular medical diagnosis, including all physician claims and hospitalization data. It does not include any given patient and/or particular medical diagnosis, including some patient visits outside the province, some physician salaries (ie, those paid to provide specific services, such as ICU coverage, or to trainees), medication, or home-care costs. Hospitals in Manitoba operate using a global budget. Hospitalization is an insured service, and there is no charge to the patient. Thus, we are able to track hospital days (and ICU stays) very accurately but are only able to estimate the costs incurred in the hospitalization, since these costs are not tracked in the database.

Manitoba Health protects patient confidentiality by encrypting the health insurance numbers of individuals, thereby creating a unique subject number. This procedure was performed by Manitoba Health before submitting their data to us. We then constructed a final working database that included, for example, complete health-care utilization and diagnosis for each selected patient and the randomly matched selected control subjects (see below). The Human Ethics Committee of the University of Manitoba and the Access and Confidentiality Committee of Manitoba Health approved the study.

**Patient Selection and Evaluation**

We selected all patients who had received a diagnosis of OHS and were studied at our sleep disorders center from 1990 to 1995. This disorder was defined as the combination of obesity (body mass index [BMI] of >30 kg/m2) and awake hypventilation (PaCO2 of >45 mm Hg) during a medically stable period. All patients were residents of Manitoba for the duration of this study. They all were assessed with formal polysomnography and were evaluated by a sleep physician specialist. Data were available in the database for the 5 years before polysomnography and for the 2 years after the institution of treatment. We confirmed that the patients were alive at the end of the 2 years they received treatment, since the health database was linked to the population registry that tracks deaths in the province. Data were available on 26 patients who had received a diagnosis of OHS. Six patients were excluded from the data analysis (see “Exclusion Criteria” section).

**Exclusion Criteria**

Patients were excluded if their age was <18 years (n = 1) or >70 years (n = 3), or if they did not have utilization data for the period of 5 years before and 2 years after diagnosis (n = 2, one patient died and one left the province). Age limits were set to avoid the influence of other significant diseases skewing the limited patient data and to allow for the presence of OBCs, who also had an age limit in the Manitoba Heart Health Study (see below).

**Polysomnography**

The study included multichannel monitoring, including the following: oxygen saturation; electrocardiography; electro-oculography; electromyography; and electroencephalography. PaCO2 in the nares was monitored using a capnometer (Normocap 200; Datex; Madison, WI), which was used as an indicator of airflow. Because entrained air could dilute the sample, the measured PaCO2 values were lower than actual end-tidal PCO2 levels. However, when the measurement of nasal PaCO2 was elevated, it provided evidence of hypoventilation. Two plethysmograph belts were used to monitor thoracic and abdominal movements. The apnea-hypopnea index (AHI) was used as an indication of the severity of the apnea. A hypopnea was defined as a visual reduction by 50% in flow or movement combined with an arousal or a desaturation of arterial oxygen saturation (SaO2) of >3%.

The severity of desaturation during sleep was measured by evaluating the SaO2 time <90%. Based on polysomnography findings, patients were started on a regimen of home ventilatory assistance (either continuous positive airway pressure [CPAP] or bilevel positive airway pressure).

**Control Subjects**

Two sets of control subjects were established for each OHS patient. First, an OBC, who was matched according to the closest BMI, age, gender, and postal code (to control for geographic and socioeconomic variables), was selected from the Manitoba Heart Health Study database. This database, which has been described elsewhere,18–20 was part of a Canadian population-based investigation of cardiovascular disease risk factor prevalence. Adults aged 18 to 70 years (n = 2,792) were randomly selected from the
Manitoba population, and 2,212 individuals (79.2%) were interviewed and examined. BMI and other data were collected on each individual.

Second, each OHS patient also was matched to 15 control subjects selected from the entire MHDB (general population control subjects [GPCs]). These control subjects again were matched to patients for age, gender, and postal code but not for BMI, because BMI data are not stored in the MHDB. Patients and control subjects had been residents of Manitoba continuously for the 7-year period. Exclusion criteria for control subjects were the same as for the case patients, with the additional requirements of being noninstitutionalized and having not received a diagnosis for a chronic psychiatric condition.

Data Analysis

The data were compiled on a yearly basis, with the 5 years prior to the date of initial sleep laboratory evaluation being labeled years −5 to −1, and the 2 years after diagnosis being labeled years +1 and +2. In order to facilitate trend analysis and cost utilization prior to and after evaluation, year −1 was included in the two analyses, years −5 to −1 and years −1 to +2.

Data were analyzed utilizing a three-way analysis of variance model with repeated measurements on subjects.21 Linear contrasts also were utilized to compare differences between OHS patients and both the OBCs and GPCs. The two periods in which this was performed included the following: the first year of the study (year −5) to the year prior to diagnosis and treatment (year −1); and the period year −1 to the second year after diagnosis (year +2). A χ² statistic was used to analyze hospitalization data and to calculate the odds ratios (ORs) for admissions and comorbidity analysis. A Fisher’s Exact Test also was utilized where appropriate.

Results

The group of 20 OHS patients was made up of 8 men and 12 women. The mean (± SD) patient age was 52.7 ± 9.5 years, and the average BMI was 47.3 ± 11.0 kg/m² (range, 33.9 to 69.0 kg/m²). The mean FEV₁ was 64.4 ± 17.3% predicted, and the mean FEV₁/FVC ratio was 77.0 ± 12.7%. The patients were significantly hypercapnic and hypoxemic (PaCO₂, 59.7 ± 13.8 mm Hg; PaO₂, 51.6 ± 12.4 mm Hg).

Polysomnography revealed an average AHI of 20.7 ± 23.9 and marked hypoxemia during sleep, with patients spending 63.0 ± 33.8% of sleep time with SaO₂ levels of < 90%. Patients were assessed (usually on the same night using a split-night protocol) during treatment (usually with CPAP or bilevel pressure). AHI decreased to 9.7 ± 21.2, and the time spent with SaO₂ levels of < 90% decreased to 37.1 ± 28.1% of sleep time. In this very ill group of patients, we were not always able to completely correct hypoxemia with ventilatory assistance. Pa-
tients were sent home to use the equipment on settings determined in the sleep laboratory.

Of the two control groups, the OBCs numbered 20 and the GPCs totaled 296. We attempted to match 15 control subjects per OHS patient, which was not achieved in all instances, since we excluded subjects who had received a diagnosis of a chronic psychiatric condition or were institutionalized. In 4 of the patients, we were only able to match 14 instead of 15 GPCs.

The OHS group had an average BMI of $47.3 \pm 11.0 \text{ kg/m}^2$, and the OBC group had an average BMI of $43.4 \pm 5.1 \text{ kg/m}^2$. The two groups were matched for other criteria (ie, age, location, and gender) in addition to BMI. Despite matching to the closest BMI, because some of our case patients were so morbidly obese (eg, BMI, 72.86; 64.14 kg/m²), the average BMI for the two groups differed statistically ($p = 0.04$) by paired $t$ test.

**Physician Visits**

Each physician encounter resulted in the creation of the following three variables: the number of physician visits; the number of physician claims; and physician fees. Each physician visit could possibly result in several services being used (eg, investigations), therefore, there are more claims than visits. Fees are generated from each physician visit claim and are recorded in Canadian dollars. Overall, OHS patients utilized significantly more physician visits and claims, and they generated higher fees than either the OBCs or GPCs. There was no difference between the two control groups in any category. Only the physician fees resulted in a significant linear relationship increasing for the 5 years prior to diagnosis and decreasing over years −1 to +2.

Over the 5-year period prior to diagnosis and treatment, the OHS patients had an average (± SE) of 11.2 ± 1.8 physician visits per patient per year vs 5.7 ± 0.8 physician visits for the OBCs ($p < 0.007$) and 4.5 ± 0.4 physician visits for the GPCs ($p < 0.0001$; Fig 1). For the same 5-year period for OHS patients, physician claims averaged (± SE) 32.4 ± 5.2 claims per patient per year vs 14.4 ± 1.6 for OBCs ($p < 0.002$) and 13.4 ± 1.6 for GPCs ($p < 0.0005$).

The fees for OHS patients averaged $623 \pm 96$ per patient per year over the 5 years prior to diagnosis compared to those for the OBCs ($252 \pm 34$; $p < 0.001$) and GPCs ($236 \pm 25$; $p < 0.0005$) (Fig 2). A linear contrast analysis of fees for years −5 to −1 and the years −1 to +2 showed a significant linear trend for OHS patients that increased ($p < 0.001$) for the 5 years prior to diag-

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**Figure 2.** Average fees for each group per year are plotted against each year of the study. A significant linear increase in fees submitted by OHS patients was seen yearly until diagnosis and the institution of treatment (large arrow) compared to control subjects with a significant linear decrease after diagnosis.
nosis and decreased significantly ($p < 0.001$) during the 2 years they received treatment (Fig 2).

**Hospital Stays**

*Before Treatment:* Figure 3 shows that the OHS patients had an increased number of hospital admissions culminating in the year prior to diagnosis in which 70% of the OHS patients were admitted to the hospital at least once. OHS patients were much more likely to be hospitalized than the subjects in either control group in the 5 years prior to diagnosis (OR vs GPCs, 8.6; 95% confidence interval [CI], 5.9 to 12.7 [$p = 0.001$]; OR vs OBCs, 4.9; 95% CI, 2.3 to 10.1 [$p = 0.001$]). The mean difference in hospital days (per year) between OHS patients and control subjects was 7.2 days for GPCs (95% CI, 4.0 to 10.4; $p < 0.001$) and 7.2 days for OBCs (95% CI, 3.8 to 10.7; $p < 0.001$). In the 5 years before treatment, the 20 OHS patients spent a total of 76 days in ICUs, compared to 0 for the OBCs and 18 for the 296

![Diagram showing hospitalization rates over years](image)

**Figure 3.** The percentage of patients hospitalized at least once per year is shown. OHS patients were hospitalized more frequently than were control populations, with 70% of them being hospitalized in the year prior to diagnosis. There was a significant reduction in the number of days hospitalized in group of OHS patients.

**Table 1**—Diagnoses Submitted With Physician Claims Prior to OHS Diagnosis*

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>OHS Patients (n = 20)</th>
<th>OBCs (n = 20)</th>
<th>GPCs (n = 296)</th>
<th>OR</th>
<th>95% CI</th>
<th>p Value</th>
<th>OR</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obesity</td>
<td>20</td>
<td>11</td>
<td>24</td>
<td>9.0</td>
<td>2.9–40.7</td>
<td>0.003†‡</td>
<td>27.69</td>
<td>12.1–63.5</td>
<td>0.001†‡</td>
</tr>
<tr>
<td>CHF</td>
<td>12</td>
<td>1</td>
<td>6</td>
<td>9.0</td>
<td>2.3–35.2</td>
<td>0.001†‡</td>
<td>58.91</td>
<td>28.1–123.6</td>
<td>0.001†‡</td>
</tr>
<tr>
<td>Hypertension</td>
<td>11</td>
<td>8</td>
<td>85</td>
<td>2.0</td>
<td>0.5–7.8</td>
<td>NS</td>
<td>3.83</td>
<td>1.5–9.8</td>
<td>0.005†‡</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>10</td>
<td>5</td>
<td>20</td>
<td>6.0</td>
<td>0.9–38.5</td>
<td>NS</td>
<td>17.24</td>
<td>7.3–40.7</td>
<td>0.001†‡</td>
</tr>
<tr>
<td>Angina</td>
<td>6</td>
<td>0</td>
<td>16</td>
<td>9.0</td>
<td>1.4–57.1</td>
<td>0.014†‡</td>
<td>7.16</td>
<td>2.9–17.8</td>
<td>0.001†‡</td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>5</td>
<td>4</td>
<td>31</td>
<td>1.5</td>
<td>0.3–8.9</td>
<td>NS</td>
<td>3.30</td>
<td>1.1–10.3</td>
<td>0.04†</td>
</tr>
<tr>
<td>Cor pulmonale</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>9.0</td>
<td>1.4–57.1</td>
<td>0.014†‡</td>
<td>89.9</td>
<td>15.8–512.5</td>
<td>0.001†‡</td>
</tr>
<tr>
<td>Hypothyroidism</td>
<td>5</td>
<td>1</td>
<td>14</td>
<td>5.0</td>
<td>0.7–34.5</td>
<td>NS</td>
<td>6.48</td>
<td>2.4–17.5</td>
<td>0.001†‡</td>
</tr>
</tbody>
</table>

*CHF = congestive heart failure; NS = not significant. The ORs were calculated taking into account the matching of patients and their control subjects. Where logit estimators were used the ORs likely underestimate the true differences between patients and control subjects.

†Denotes that the logit estimators use a correction of 0.5 in every cell of those tables that contain zero.

‡$p < 0.05$ using Mantel-Haenszel statistics and test-based estimates.
GPs. In the 5 years before treatment, the mean number of ICU days per person for the OHS patients (3.8 ± 1.49) was greater than that for the OBCs (0; p = 0.020) and the GPCs (0.06 ± 0.03; p = 0.021).

After Treatment: The proportion of OHS patients having one or more hospital admissions decreased from 70% in the year prior to the initiation of treatment to 15% in the second year after the initiation of treatment (p < 0.01). In the OHS patients, the mean (±SE) number of days spent annually in the hospital decreased 68.4% from 7.9 ± 1.8 days per patient per year (in the 5 years prior to treatment) to 2.5 ± 1.1 days per patient per year (in the 2 years after the institution of treatment) (p = 0.01). OHS patients were no more likely to be hospitalized than were subjects in either control group during their second year of treatment (OR vs GPCs, 2.2 [95% CI, 0.5 to 9.2]; difference not significant); OR vs OBCs, 0.8 [95% CI, 0.2 to 3.3]; difference not significant). The 20 OHS patients spent a total of 8 days in the ICU during the 2 years that they received treatment.

What Patients Were Being Treated for Prior to the Diagnosis of OHS: The MHDB was analyzed for years −1 to −5 for all groups to obtain various diagnoses submitted at any time by a physician. A diagnosis must accompany every physician claim (Table 1). Compared to the OBCs, OHS patients were more likely to have received a diagnosis of congestive heart failure, angina, and chronic pulmonary heart disease. Although half the patients in the OHS group had a claim for diabetes, which was twice the rate of the OBC group, this did not quite achieve statistical significance. In all the diagnoses listed in Table 1, OHS patients had significantly higher claims than did the GPCs (Table 1).

Follow-up: The government-funded ventilatory assistance program in the city provided the equipment and annual disposables at no cost to the patients, taught the patients how to use the equipment, and kept track of the patients with telephone support and contact as needed. There was contact with the patients at least once a year for 14 of the 20 patients living in Winnipeg. This program did not follow-up six patients who lived elsewhere in the province. Respiratory therapists in their own communities observed them. The 20 patients all were alive at the end of the 2-year follow-up.

Discussion

An individual is overweight with a BMI of > 25 kg/m², and obesity can be defined as a weight that is > 20% above ideal body weight or a BMI if > 30 kg/m².1 Obesity is becoming a worldwide problem.1–4 Morbid obesity, BMI (> 40 kg/m²), results in serious sequelae that place a burden on the healthcare system. It has been estimated that the direct cost of obesity in Canada is about $2 billion per annum, or 2.4% of the total health-care budget.5 This is a result of long-term detrimental health effects due to obesity, which have been well-documented.4,22,23 These effects include an increased risk of pulmonary, cardiovascular, metabolic, GI, and orthopedic problems, often accompanied by a shortened life expectancy.

Up to 8 to 12.5% of morbidly obese patients undergoing gastric surgery in previous studies were found to have OHS.24,25 Why some obese patients develop OHS is not fully understood. Contributing factors may include the restrictive pulmonary function defect, increased work of breathing and CO₂ production, and altered central respiratory control.26 Although in most series about three quarters or more of OSAHS patients are men,27 we were surprised that most of our OHS patients were women. This may explain, in part, the relatively low AHI of our OHS patient group since women with sleep breathing abnormalities tend to have lower AHI values.27

We found that compared to GPC, OHS patients were much more likely to have cardiovascular disease (eg, congestive heart failure, angina pectoris, or cor pulmonale), a history of metabolic disease (eg, diabetes or hypothyroidism), and osteoarthritis. Interestingly, osteoarthritis was not more common in OHS patients than in their matched OBCs. OSAHS patients also have increased comorbidity, as we have previously documented.15 Fletcher and colleagues13 have reported previously that OSAHS patients requiring ICU admission often have associated COPD and are more likely to present with progressive respiratory failure.

We have shown in this report that in OHS patients there is increased medical resource utilization, which decreased with treatment. Previously, we have shown that obese OSAHS patients without hypventilation are heavy users of health-care resources for a decade prior to diagnosis15 and that with the institution of treatment there was a significant reduction within a 2-year period.14

In OHS patients, only physician fees showed a significant linear trend, increasing to the year prior to diagnosis and decreasing for the 2 years after diagnosis. The number of physician visits and claims reflected the same trend but did not achieve statistical significance. Funds paid to physicians are actually underestimated by our data, as salaries are paid to physicians for work in ICUs, for some hospital services, and if they are trainees (house staff). These
salaries are not tracked by the database. In addition, the database does not track home-care costs (including mechanical ventilation equipment and nursing supervision), medications, and in-hospital expenditures. Since none of the latter is tracked in a single database, such costs can only be estimated.

OHS patients used significantly more total hospital days than both control groups prior to diagnosis, and this was reduced significantly by treatment. The cost savings due to the reduction in days hospitalized alone (5.4 days per year per patient) can be estimated to be about $5,400 per patient per year, assuming that 1 day spent in the hospital costs about $1,000. The cost of the mask and the disposables is about $250. The cost of a CPAP system is about $700, and the annual cost of the sleep evaluation per patient in our center was about $410. If we conservatively estimate that the provision of a CPAP or a bilevel system is about $1,000 per patient per year, then the net savings to the health-care system is estimated to be about $3,900 per patient in the first year, and $4,400 in the second year and each additional year. These numbers are conservative because the capital cost of a CPAP system is about $700, and the annual cost of the mask and the disposables is about $250. Clearly, in other locations the costs and savings would be different.

CONCLUSIONS

OHS patients are heavy users of health-care resources for several years prior to the evaluation and treatment of their sleep breathing disorder, and there is a substantial reduction in days hospitalized once treatment is instituted.

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