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A national register for long-term oxygen therapy in chronic hypoxia: preliminary results

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A national register for long-term oxygen therapy in chronic hypoxia: preliminary results. K. Ström, J. Boe.

ABSTRACT: A national register of patients undergoing long-term oxygen therapy in Sweden was started in 1987. Of the population of 8.4 million, 560 patients (267 males) were registered as undergoing domiciliary oxygen treatment on January 1, 1987. These registered patients, aged between 2–86 yrs (mean age 65 yrs), constituted some 90% of all patients receiving domiciliary oxygen therapy because of chronic hypoxaemia on that date. The chronic respiratory diseases leading to hypoxaemia (more than one diagnosis could be registered for each patient) were: chronic obstructive pulmonary disease (COPD) (393), sequelae from pulmonary tuberculosis (92), thoracic deformity (97), interstitial fibrosis (44), benign pleural disease (22) and others (84). Concentrators were used by 253 patients and high-pressure compressed gas cylinders by 307. Arterial blood gas analyses were registered for 547 patients. The mean arterial oxygen tension (Pa_{O_2}) when breathing air was 6.5±1.1 kPa and 9.0±1.4 kPa when breathing oxygen. The mean arterial carbon dioxide tension (Pa_{CO_2}) without oxygen was 6.5±1.5 kPa and 6.8±1.5 kPa with oxygen. The register forms a data-base which can be used for the evaluation of different home oxygen systems, regional differences in the access to treatment and treatment performance and decisions relating to health care economics.

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It has been suggested for some twenty years that long-term oxygen therapy may improve pulmonary hypertension [1, 2]. The controlled Nocturnal Oxygen Therapy Trial (NOTT) (1980) [3, 4] and Medical Research Council (MRC) trial (1981) [5] revealed improved survival in the case of chronic respiratory insufficiency caused by chronic obstructive pulmonary disease (COPD) as a result of long-term domiciliary oxygen therapy. The MRC study showed that 15 h of oxygen, including night-time, improved survival when compared with no oxygen. The NOTT study demonstrated improved survival and neuropsychiatric function in patients receiving "continuous" oxygen (slightly less than 20 h) compared with patients receiving only 12 h of oxygen, including their hours of sleep. No controlled clinical trials have been conducted to evaluate the effect of long-term home oxygen therapy in diseases causing chronic hypoxaemia and cor pulmonale other than COPD. Prescription principles similar to those used for COPD have been recommended for these diseases [6].

Sweden with its 8.4 million inhabitants, is divided into seven health regions, each consisting of 2–5 counties. The use of domiciliary oxygen therapy has spread considerably following the NOTT and MRC studies and is usually prescribed by chest physicians, except in some areas without a county chest department.

High-pressure compressed gas cylinders and stationary oxygen concentrators are available for domestic use. Ambulatory patients on continuous oxygen also use small gas cylinders. Only compressed gas cylinders are paid for by the National Insurance Service. Concentrators are paid for by some county health authorities.

Due to the regional differences in access to and the performance of domiciliary oxygen therapy the Swedish Society of Chest Medicine started a register of patients undergoing long-term home oxygen therapy. This register forms a data-base that can be used to evaluate the long-term effects of oxygen therapy at home in patients with chronic hypoxia of varying origin. It also makes it possible to compare different home oxygen systems and could be used to compare different health regions in terms of home oxygen therapy. This register could also guide health authorities when it comes to the reallocation of resources for home oxygen therapy. This is the first presentation of the register which includes all the registered patients undergoing domiciliary oxygen therapy on January 1, 1987.

Methods

All the Departments of Chest Medicine in Sweden are participating in the study. One to four physicians are

responsible for the registration of data in each county. The record forms were discussed in a reference group and contain information on age, sex, diagnosis, present or former occupation, smoking habits, medication, presence of peripheral oedema, blood gas analyses and parameters linked to oxygen treatment (such as the form of administration, type of nasal cannulae, oxygen dose, length of treatment in hours per day).

Table 1. – Prescribing guidelines for long-term oxygen therapy in chronic hypoxaemia

Patient selection criteria:

- COPD or other diseases leading to chronic hypoxaemia;
- stable course of disease on optimum medical therapy for at least three weeks;
- arterial oxygen tension when breathing air still less than 7.0–7.5 kPa or signs of cor pulmonale or haematocrit >50% and room air PaO_2 of around 7.5 kPa.

Oxygen dose:

- oxygen treatment should be started and the dose adjusted while the patient is in hospital;
- continuous flow by double or single nasal cannulae, minimum 16 h, (hours of night included), preferably 24 h;
- arterial PaO_2 of 8 kPa or higher.

COPD: chronic obstructive pulmonary disease; PaO_2: arterial oxygen tension.

The guidelines for prescribing long-term domiciliary oxygen therapy have been issued by the Swedish Association of Chest Medicine (table 1). Patients already on home oxygen therapy on January 1, 1987, and patients discharged from hospitals on home oxygen for the first time after this date are included in a prospective study. All the record forms, including follow-up record forms every six months, are sent to the registration centre in Växjö for data processing and statistical evaluation. The data processing is performed with the aid of the Quest data-base programme [7]. Comparisons between groups were performed using t-tests. Mann-Whitney non-parametric tests were used for small groups [8]. Informed consent was obtained from each patient and the study was approved by all the regional Ethical Committees, the Swedish Board of Health and Welfare and the Data Inspection Board.

Results

Patients

During the first months of 1987, 560 patients undergoing home oxygen treatment because of chronic hypoxia on January 1, 1987, had been reported to the registration centre in Växjö. The prevalence of patients receiving home oxygen therapy due to respiratory failure was estimated with the aid of reports given by the local pharmacies supplying oxygen cylinders and local hospital technical workshops supplying oxygen equipment to the participating physicians. The majority of hypoxic patients who were not registered lived in Stockholm. An additional check on the use of home oxygen in Stockholm was therefore made by the National Corporation of Swedish Pharmacies and the results were reported to the registration centre in Växjö.

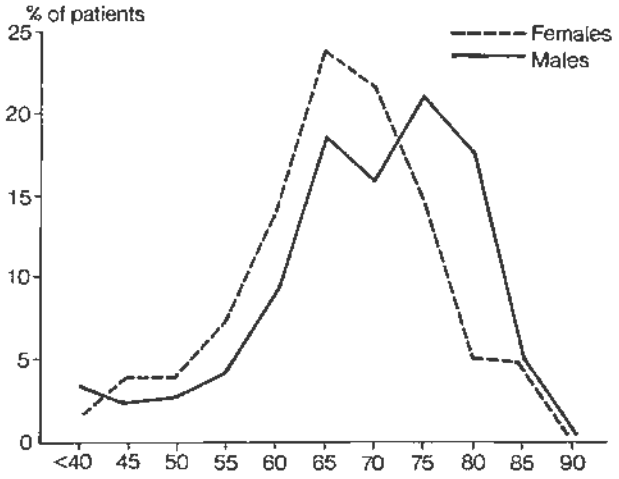

Fig. 1. – Age and sex distribution (n=560). --- Females; —Males

This survey found 76 unregistered patients receiving domiciliary oxygen therapy because of respiratory failure, including patients who had been asked to participate in the register but had refused. In an additional seven patients no diagnosis was found. Taken together, these reports have shown that some 90% (1987–1988) of all patients in Sweden receiving domiciliary oxygen therapy because of respiratory failure were included in the register. There were 267 men and 293 women with a mean age of 65 yrs (range 2–86 yrs). Two patients were less than twenty years old (fig. 1). A history of peripheral oedema was found in 327 patients (63%). Twenty-six patients (5%) were still at work (housework not included). 507 patients (91%) lived at home, while 40 patients lived in flats or homes for the elderly. Domiciliary oxygen is not recommended for smokers. Nevertheless, 44 patients (8%) were noted as current smokers.

Diagnosis

More than one diagnosis could be registered for each patient and the record forms did not permit the ranking of the different diagnoses noted. COPD was one cause of hypoxaemia in 393 patients; in other words, COPD was not present in 167 patients (30%). Sequelae of tuberculosis was the cause of or a contributory factor to hypoxaemia in 102 patients (18%). In 106 patients (19%) neither COPD nor sequelae of tuberculosis was a factor contributing to respiratory failure (table 2).

Arterial blood gas analyses

Arterial blood gas analyses were registered for 547 patients. The most recent blood gas analyses breathing

Table 2. – Cause of hypoxaemia

	No. of patients n=560	%
COPD	393	70
Sequelae of tuberculosis	102	18
pulmonary sequelae	92	16
thoracic deformity	57	10
Interstitial fibrosis	44	8
Kyphoscoliosis	40	7
Benign pleural disease	22	4
Pulmonary emboli	14	3
Sarcoidosis	10	2
Neuromuscular diseases	9	2
Primary pulmonary hypertension	7	1
Tumour in lung and/or pleura	7	1
Pneumoconiosis	7	1
Miscellaneous	30	5

More than one diagnosis could be registered for each patient. COPD: chronic obstructive pulmonary disease.

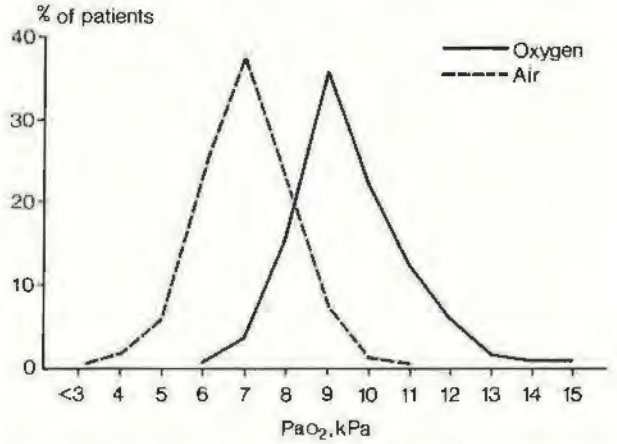

Fig. 2. – Distribution of arterial oxygen tension (Pa_{O_2}) on room air and oxygen (kPa) (n=547). --- Air; —— O_2.

room air revealed hypoxaemia (arterial oxygen tension (Pa_{O_2}) of less than 8 kPa) in 91% of the 547 patients (497 patients). Hypercapnia (arterial carbon dioxide tension (Pa_{CO_2}) of 6.1 kPa or higher) breathing air was found in 59% of the 547 patients and in 15% (82 patients) the Pa_{CO_2} was 8 kPa or higher. When breathing oxygen the mean Pa_{O_2} increased from 6.5±1.1 to 9.0±1.4 kPa (fig. 2), while the mean Pa_{CO_2} increased from 6.5±1.5 to 6.8±1.5 kPa (fig. 3). With oxygen the Pa_{O_2} exceeded 8 kPa in 441 patients, *i.e.* 80% of the 547 patients in whom arterial blood gas analyses were registered. No difference was found between the Pa_{O_2} and Pa_{CO_2} on room air and oxygen in COPD patients and patients with other diagnoses.

Medication

$Beta_2$-agonists and theophylline were used by most

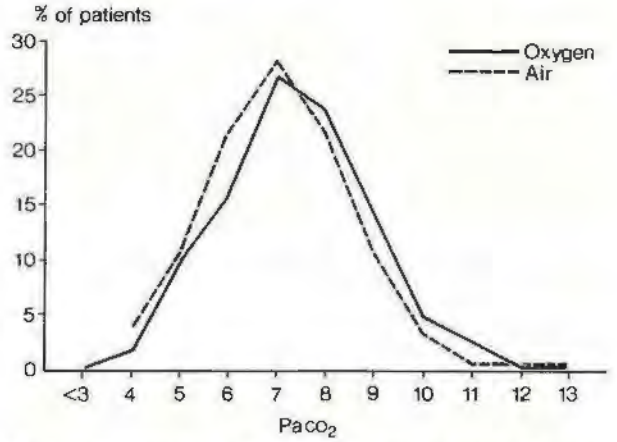

Fig. 3. – Distribution of arterial carbon dioxide tension (Pa_{CO_2}) on room air and oxygen (kPa) (n=547). --- Air; —— O_2.

Table 3. – List of medication used by patients with and without COPD

Medication	No. of patients with COPD n=393	%	No. of patients without COPD n=167	%
Oral $ß_2$-agonist	268	68	47	28
Inhaled $ß_2$-agonist	311	79	54	32
Theophylline	292	74	59	35
Oral steroid	192	49	38	23
Inhaled steroid	132	34	16	10
Digoxin/digitoxin	134	34	65	39
Loop diuretic	329	84	139	83
Spironolactone	145	37	61	37
Calcium antagonist	26	7	17	10
Anticoagulant	10	3	10	6

COPD: chronic obstructive pulmonary disease.

patients with COPD, as was expected, but they were also used by approximately one third of the patients without COPD. Loop diuretics were used by 468 patients (84%) (table 3).

Oxygen therapy

Oxygen concentrators from four different manufacturers (102 Briox, 85 OECO, 35 Zefir and 31 DeVilbiss) were used by 253 patients (45%). Thirteen patients also received home ventilator treatment. Double nasal cannulae were used by 412 patients (76%) and single nasal cannulae by 120 patients (22%). Six patients had transtracheal catheters. The humidification of oxygen was common, regardless of the oxygen dose. The oxygen dose varied between 0.2–8 $l \cdot min^{-1}$, mean 1.4 $l \cdot min^{-1}$ (fig.4). No difference in oxygen dose was found between COPD patients and patients without COPD. Oxygen was prescribed for a mean of 19 h (range 1–24 h) (fig. 5).

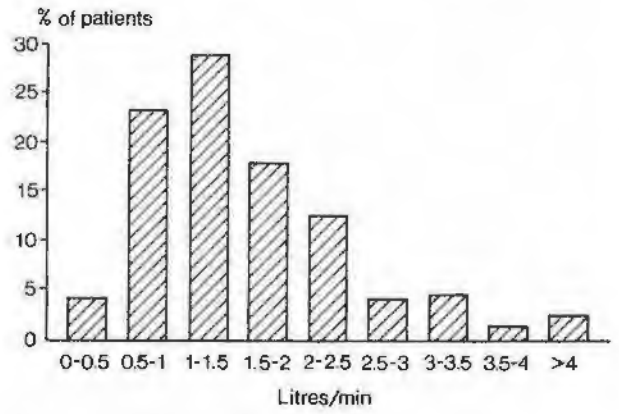

Fig. 4. – Oxygen flow rate (n=559).

Table 4. – Age at start of home oxygen therapy (years, mean values, range)

Cause of hypoxaemia	Age yrs Males	Females	Missing data
COPD n=393	66 (26–84) n=195	62 (34–83) n=190	8
Sequelae of tuberculosis	67 (45–78) n=43	65 (46–81) n=56	3
Others n=106	56 (2–77) n=43	57 (33–84) n=59	4
All causes n=560	64 (2–84) n=262	61 (33–84) n=283	15

COPD: chronic obstructive pulmonary disease.

Age at start of oxygen therapy and mean duration of oxygen therapy. The age of the patients at the start of home oxygen therapy varied depending on their sex and the cause of hypoxaemia (table 4). Among COPD patients women were younger when therapy began

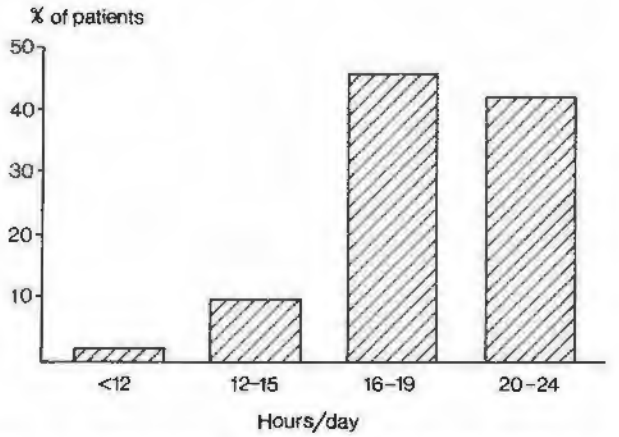

Fig. 5. – Hours of supplementary oxygen per day as prescribed for patients (n=560).

Table 5. – Mean duration of oxygen therapy (months) since January 1, 1987, related to diagnosis

Diagnosis	Mean therapy duration	No. of patients
COPD	21	385
Sequelae of tuberculosis	29	99
pulmonary	27	89
thoracic deformity	35	53
Others (COPD, sequelae of tuberculosis excluded	24	102
Interstitial fibrosis	19	43
Kyphoscoliosis	40	38
Benign pleural disease	30	21
Pulmonary emboli	29	13
Sarcoidosis	25	10
Neuromuscular diseases	25	7
Primary pulmonary hypertension	22	7

COPD: chronic obstructive pulmonary disease.

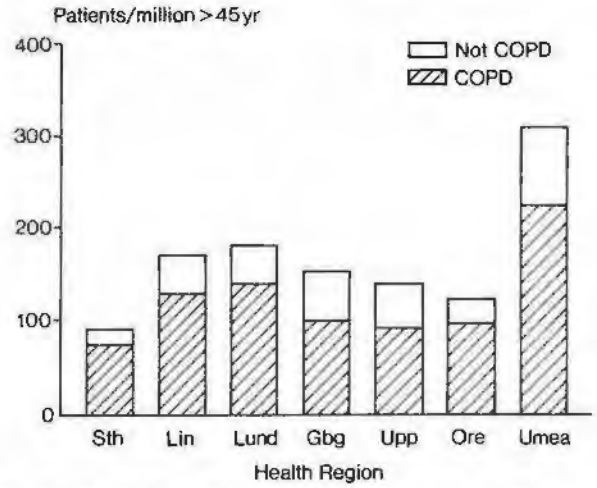

Fig. 6. – Regional distribution of patients aged >45 yrs per million inhabitants aged >45 yrs. Patients with COPD (n=382) and patients without COPD (n=158). Health regions: Sth: Stockholm; Lin: Linköping; Lund; Gbg: Gothenburg; Upp: Uppsala; Öre: Örebro; Umeå; COPD: chronic obstructive pulmonary disease. ☐ Not COPD; ▨ COPD.

Table 6. – Mean duration of oxygen therapy (months) since January 1, 1987, related to diagnosis and sex

Diagnosis	Mean therapy duration		No. of patients	
	Males	Females	Males	Females
COPD	19	22	195	190
Sequelae of tuberculosis	23	33	43	56
Others (COPD, sequelae of tuberculosis excluded)	16	29	43	59

COPD: chronic obstructive pulmonary disease.

(p<0.01). Patients with diagnoses other than COPD had been treated for longer periods than COPD patients (p=0.01) (table 5) and women had been treated for longer periods than men (p<0.01) (table 6). The longest treatment period, eleven years, was found in two women with late sequelae of tuberculosis.

Geographical variations. A marked regional variation in the use of home oxygen therapy was found. The number of patients varied between 36 and 133 per million in different health regions (fig. 6). The differences were even greater at county level (13–196 per million). A small part of this variation is due to the low proportion of registered patients in certain counties.

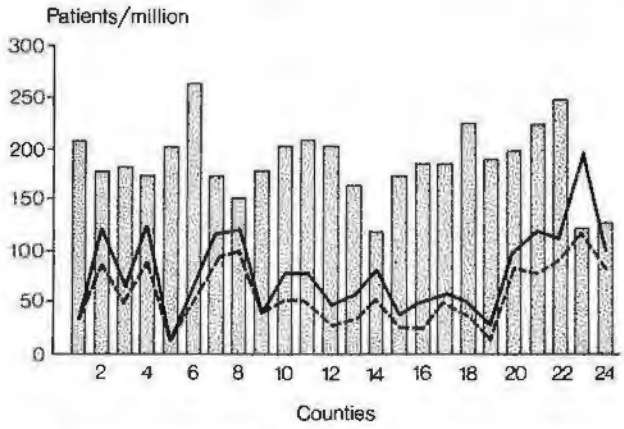

Fig. 7. – Distribution of domiciliary oxygen usage, all cases (unbroken line) and COPD (dotted line) in relation to mean annual crude death rate per million, 1983–1985, from bronchitis, emphysema and asthma (bars) in 24 Swedish counties. COPD: chronic obstructive pulmonary disease.

No data are available on the prevalence of COPD in the whole of Sweden. We therefore used the mean annual crude death rate per million inhabitants from bronchitis, emphysema and asthma between 1983 and 1985 [9] as an approximate measurement of the prevalence of COPD. No correlation was seen between the level of domiciliary oxygen usage per unit of the population and the mean annual crude death rates in different counties (fig. 7).

Discussion

An almost equal number of men and women were receiving oxygen at home because of chronic hypoxaemia caused by COPD, while more women than men were being treated for hypoxaemia which was not caused by COPD. Recent studies of long-term oxygen therapy in COPD [3, 5, 10] include relatively few women (21–26%). An analysis of a national survey of 8,000 patients in France receiving home oxygen therapy or assisted ventilation by ANTADIR (Association Nationale pour le Traitement A Domicile de l'Insuffisance Respiratoire Chronique Grave) revealed that only 26% of these unselected patients with respiratory failure from various causes were females [11]. This difference in sex distribution may be due in part to different smoking habits in males and females. The average age of the patients in France (61.5 yrs) was somewhat lower than that in Sweden (65 yrs).

Due to the retrospective nature of this investigation, including patients who were alive on January 1, 1987, it was not possible to assess survival rates. The mean duration of home oxygen therapy varied according to the cause of hypoxaemia and sex. Patients without COPD had been treated for longer than COPD patients. A longer survival for patients with restrictive diseases is consistent with this finding and was found among 146 tracheotomized patients in Lyon receiving assisted ventilation at home [12]. In adults with severe thoracic spinal deformity acute respiratory failure with cor pulmonale has been considered to be a preterminal event with a median survival of one year [13]. In some patients with severe kyphoscoliosis night-time ventilation appears necessary in order to improve survival [14]. However, Libby *et al.* [15] demonstrated longer survival in these patients after the first episode of respiratory failure compared with patients with severe COPD (forced expiratory volume in one second (FEV_1) <0.75 *l*) receiving conservative treatment including oxygen therapy in the ease of hypoxaemia. In this register a longer mean duration of oxygen therapy was found in patients with kyphoscoliosis than in patients with COPD (p<0.01).

The simple record forms make it impossible to judge whether the patient selection criteria had been strictly complied with. The fact that 91% of the patients were hypoxaemic when breathing air indicates that oxygen therapy was justified in the vast majority of cases. Most patients received oxygen from high-pressure compressed gas cylinders despite the inconvenience of heavy cylinders, frequent deliveries and higher cost compared with concentrators; this applies particularly to patients who do not need portable oxygen [16, 17]. In some counties all of the patients had concentrators with portable gas cylinders when needed, while in others all of the patients had cylinders only. The reason for this is that the local county councils have to pay for the concentrators and only some of them do so. The routine humidification of oxygen from cylinders or molecular sieve concentrators is of doubtful value and has been recommended only for oxygen flow rates higher than 4 $l \cdot min^{-1}$ when the environmental humidity is adequate [18, 19]. In Sweden, the recommendations vary and almost half of the patients have extra humidification. The elimination of unnecessary bubble humidifiers could result in savings and might also eliminate a source of infection [20].

The distribution of diseases leading to respiratory failure among 6,897 patients receiving domiciliary oxygen treatment in France in 1986 was similar to that found in our register [21]. Concentrators were used by a higher proportion of patients in France: 58% as compared to 45% in Sweden. Another difference between

the two countries was the proportion of oxygen prescriptions made by chest physicians: 44% in France and more than 80% in Sweden. This may have something to do with the fact that only 59.4% of the French patients were prescribed oxygen for more than 12 h daily. Oxygen treatment for less than 15 h daily is of unproven therapeutic benefit, at least in COPD patients, and only 8% of the registered patients received so little treatment.

The geographical distribution of home oxygen therapy was found to be markedly uneven. The same situation has been found in England where home oxygen therapy is usually prescribed by general practitioners [22, 23]. During this century the prevalence of tuberculosis has been higher in the north of Sweden [24] and this may account for a small proportion of the regional differences. The large geographical variation in home oxygen therapy for COPD cannot be explained by variations in the age of the population or in the prevalence of the disease estimated from the mean annual crude death rate from bronchitis, emphysema and asthma. The mean age at the start of oxygen therapy as well as the mean duration of therapy was the same in the county with the highest prevalence of home oxygen therapy as in the whole of Sweden. This suggests that the start of oxygen therapy at an earlier stage in the course of the disease does not explain the greater use of oxygen in this county. This county has one of the major university chest clinics. A substantial part of the geographical variation can be explained by variations in the knowledge and interest of the physicians in charge of patients with respiratory failure. In some counties domiciliary oxygen therapy has a long tradition, while in others the therapy has only been introduced in recent years. With a few exceptions domiciliary oxygen is used more frequently in counties with a chest clinic than in countries where patients with respiratory failure are seen by specialists in other disciplines. The highest county prevalence of home oxygen therapy was 0.048% of the population aged 45 yrs or over. This county had the second lowest death rate for COPD. It can be assumed that the prevalence of respiratory failure is no lower in the county as a whole and this means that a minimum of 1,700 patients may be candidates for home oxygen therapy in Sweden.

We have found that home oxygen therapy performs well and is prescribed for the right patients when it is initiated and controlled by chest physicians. The uneven geographical distribution means that patients in several counties have poor access to this therapy. The use of concentrators, the most convenient therapy for most patients, also varies to a great extent.

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Le registre suédois d'oxygénothérapie. Un registre national pour l'oxygénothérapie au long cours dans l'hypoxie chronique. Résultats préliminaires. K. Ström, J. Boe.

RÉSUMÉ: Un registre national de patients soumis à une oxygénothérapie au long cours a commencé en Suède en 1987. Pour une population de 8.4 millions d'habitants, 560 patients (dont 267 hommes) ont été enregistrés comme étant soumis à une oxygénothérapie à domicile le 1er janvier 1987. Ces patients enregistrés, âgés de 2 à 86 ans (âge moyen 65 ans), représentent environ 90% de tous les patients recevant de l'oxygénothérapie à domicile pour hypoxémie chronique à cette date. Les maladies chroniques respiratoires conduisant à l'hypoxémie ont été les suivantes (plus d'un diagnostic peut être enregistré pour chaque patient): BPCO (393), séquelles de tuberculose pulmonaire (92), déformations thoraciques (97), fibroses interstitielles (44), affections pleurales bénignes (22), autres (84). Les concentrateurs ont été utilisés chez 253 patients et des écylindres de gaz comprimé à haute pression chez 307. Les analyses des gaz du sang artériel ont été enregistrées chez 547 patients. La pression artérielle moyenne d'oxygène sous respiration d'air est de 6.5±1 kPa; elle est de 9.0±1.4 kPa sous respiration d'oxygéne. La $PaCO_2$ moyenne sans oxygène est de 6.5±1.5 kPa et de 6.8±1.5 kPa sous oxygène. Ce registre constitue une base de données utilisable pour l'évaluation des différents systämes d'oxygénothérapie à domicile, pour celle des différences régionales dans l'accessibilité au traitement, pour celle des résultats du traitement et de décisions en rapport avec l'économie de la santé. *Eur Respir J., 1988, 1, 952–958.*