OXYGEN CONCENTRATORS

a report by the

NATIONAL

HEALTH

TECHNOLOGY

ADVISORY

PANEL

NOVEMBER 1987

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A REPORT BY THE

NATIONAL HEALTH TECHNOLOGY ADVISORY PANEL

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AUSTRALIAN INSTITUTE OF HEALTH

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OXYGEN CONCENTRATORS

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EXECUTIVE SUMMARY

- Oxygen concentrators are electrically powered devices that provide a constant readily available supply of oxygen from ambient air. They are alternatives to conventional cylinders for long-term oxygen therapy.

- Concentrators were introduced into Australia in 1982. All units are imported and are mainly used in the home.

- Guidelines for the use of oxygen in the home have been issued by the Thoracic Society of Australia and some hospitals have developed protocols for the selection and management of patients entered in their home oxygen programs.

- The capital cost of concentrators ranges from $3,000 to $3,600. The various models differ in weight, size, power consumption, noise production and safety features.

- Most concentrators are rented. The annual cost of using a rented concentrator continuously is estimated to be about $2700. The cost of continuous use of cylinder oxygen at 2 litres/minute (L/min) is estimated to be about $7,000.

- Overseas and Australian medical literature report that this technology is cost effective. Estimates by the Panel indicate that concentrators (on a rental basis) are cost effective when oxygen therapy is required for more than 13 hours daily at 1 L/min and for more than 5 hours daily at 2 L/min.

- In Australia, provision of home oxygen is not covered by Medicare or private health insurance. In some cases it is available free through State programs from public hospitals.

- The Panel considers that

  -concentrators are proven cost effective devices

  -because of the considerable savings that might be achieved appropriate Commonwealth and State bodies should explore the wider application of this technology

  -an Australian Standard for oxygen concentrators should be developed

  -manufacture of oxygen concentrators in Australia should be encouraged

  -regular preventive maintenance schedules will help to ensure that concentrators perform reliably.

OXYGEN CONCENTRATORS

INTRODUCTION

Oxygen concentrators are electrically powered devices that provide a constant readily available supply of oxygen from ambient air. They were developed as alternatives to conventional cylinders in providing long-term continuous oxygen therapy. They have been available in the United States and the United Kingdom since the mid 1970s, and in Australia since 1982.

Recent reports in the Australian literature have drawn attention to the utility of oxygen concentrators and the comparative cost savings they can achieve in providing long-term domiciliary oxygen (1-4).The Panel considered that an examination of this technology would be timely. This report reviews the safety, efficacy, and cost effectiveness of oxygen concentrators and considers what actions should be taken in the light of their increasing use in Australia.

DESCRIPTION AND APPLICATIONS OF OXYGEN CONCENTRATORS

Oxygen concentrators fall into two main classes according to the mechanism of gas separation. In the first, air is pressurised and exposed to molecular sieve material which selectively retains the non-oxygen components. In the second type of concentrator,oxygen selectively permeates a membrane.

Most modern concentrators are of the molecular sieve type with columns of synthetic aluminium silicate (zeolite) for the selective removal of nitrogen and other components of ambient air. A compressor supplies pressurized atmospheric air to the columns. A continuous supply of oxygen is achieved by using two sieve beds in a synchronized adsorption-desorption process. As one sieve adsorbs nitrogen under pressure, the other (saturated) sieve is depressurised and purged.

The oxygen concentration produced by sieve concentrators varies inversely with the flow of gas through the zeolite containers. The lower the flow rate, the higher the oxygen concentration in the product gas. The final oxygen concentration achieved may vary from 95% at a flow rate of 1-3 L/min to 40% at a flow of 10 L/min.

The product gas is fed into a holding tank and then delivered to the patient through a pressure regulator and adjustable flow meter. It is also generally passed through a bubble humidifier.

In membrane oxygen concentrators, use is made of the selective permeation properties of membranes to extract oxygen from ambient air. Oxygen is concentrated by drawing ambient air through the membranes with a vacuum pump. The gas produced contains carbon dioxide at 3.5 to 3.9 times the ambient air concentration and is humidified up to 5 times the ambient relative humidity. Unlike molecular sieve concentrators, the membrane types produce only one oxygen concentration which does not vary with changes in flow

rate. A typical product gas will contain 40% oxygen.

At the time this report was being compiled, membrane oxygen concentrators were not available in Australia.

The usual device for delivering the oxygen to the patient is the nasal cannula, sometimes called nasal prongs. The patient is able to eat and talk without removing the device.

A review of oxygen concentrators has been published by Chusid (5). A number of papers have also been published on the relative performance of different types of concentrators (6-9).

Oxygen concentrators are mainly used in the home by persons with chronic respiratory disease for long-term oxygen therapy . Users include persons suffering from chronic bronchitis, emphysema, cystic fibrosis and refractory asthma. Institutions such as hospices and nursing homes have shown increasing interest in the use of concentrators for individual in-patients (10).

Normally hospitals use piped oxygen from cylinders to meet in-patient needs. However a growing number of hospitals overseas are using concentrators to supply their oxygen (11). The technique is somewhat different to that used in the home, where demand is constant while oxygen is required. In a hospital, oxygen needs to be constantly available, but the level of demand can vary very quickly. Since the performance of molecular sieve oxygen concentrators is flow dependent it is necessary to use a cascade method in order to produce gas of a constant composition under conditions of varying demand. This method involves a number of separate concentrators which are brought into or out of operation as the demand for oxygen increases or decreases. In the UK plants have recently been installed in hospitals in Chester, Ely and Barnsley, and hospital authorities are considering the installation of oxygen concentrators on several offshore islands (11).

As far as the Panel is aware oxygen concentrators are not being used in this form in Australian hospitals.

EFFICACY OF LONG TERM DOMICILIARY OXYGEN THERAPY

In the 1970s there was a growing demand for the use of supplementary oxygen in the home for certain patients with chronic pulmonary disease.

Because home oxygen therapy was expensive and its benefits not definitely established, both the Medical Research Council of the UK and the US National Institutes of Health sponsored randomized clinical trials of oxygen therapy in the late 1970s. The results were reported in 1980/81. Entry criteria were closely similar for both trials, the chief selection criterion being hypoxaemia (deficient oxygenation of the blood). The design of the two trials was complementary. The British study compared no oxygen therapy with 15 h of nocturnal therapy and the US trial compared 12 h of nocturnal therapy with continuous therapy (12, 13).

Both trials showed clear differences in survival between treatment groups. In the British trial, five year survival for

patients receiving no oxygen therapy was approximately 20% with an annual death rate of about 30%. On 15 h of oxygen therapy daily, the five year survival was about 40% with an annual death rate of about 18%. In the American trial, annual mortality was about 20% with 12 hours per day of nocturnal therapy and about 11% with continuous therapy of at least 19 hours per day. The general conclusion was clear. In hypoxaemic chronic obstructive lung disease (COLD) survival is improved with home oxygen therapy, and the more continuous the therapy the greater the improvement. Table 1 summarises the results of these two clinical trials.

TABLE 1
RESULTS OF CLINICAL TRIALS OF OXYGEN THERAPY

	UK TRIAL (12)		US TRIAL (13)	
	No therapy	15 hours therapy per day	12 hours nocturnal therapy	19 hours therapy per day
5 year survival	20%	40%		
Annual death rate	30%	18%	20%	11%

With respect to quality of life aspects a subsequent study of patients involved in the American trial found that oxygen therapy caused modest improvement in neuropsychological functioning, particularly in the area of cognitive functioning(14). No appreciable change in self-reported emotional status or general life quality was observed (14).

GUIDELINES FOR DOMICILIARY OXYGEN THERAPY

Guidelines for the use of oxygen in the home have been developed in the USA (15,16) and in the UK (17,18).

In August 1984 the Thoracic Society of Australia issued a statement on domiciliary oxygen therapy (19). The statement categorized patients according to their need for oxygen as follows:

Continuous (at least 15 hours/day)

Long-term continuous oxygen therapy may be considered for patients with stable chronic lung disease, who when breathing air at rest and awake, have an arterial oxygen pressure consistently less than 50-55 mm Hg. In the case of chronic airflow obstruction, continuous oxygen therapy is of most benefit for those patients with an increased arterial carbon dioxide pressure (greater than 45 mm Hg).

Intermittent

In patients with obstructive or fibrotic lung diseases whose muscular exercise is limited by hypoxaemia, the use of supplementary oxygen during the exercise may prevent hypoxaemia and improve exercise capacity. Intermittent oxygen can be useful for acute asthma in patients living in isolated areas while they are awaiting the arrival of medical attention. Supplementary oxygen may also provide symptomatic relief of late stage interstitial or neoplastic lung disease where hypoxaemia is a significant feature in the illness.

Nocturnal

Supplementary oxygen for use at night may be indicated for patients who show hypoxaemia during sleep as well as the secondary effects of chronic hypoxia. The possibility of nocturnal hypoxaemia should be considered in subjects who exhibit daytime somnolence and polycythaemia, but whose arterial gases, when awake, remain at an acceptable level. Distinguishing patients with primary sleep apnoea from those with chronic lung disease who show hypoxaemia during sleep requires formal sleep studies.

The statement noted that supplementary oxygen is not indicated for patients with severe airflow obstruction whose main complaint is dyspnoea (difficult breathing), but who maintain an arterial oxygen pressure of 60 mm Hg and who do not show the secondary effects of chronic hypoxia. Oxygen is not indicated for subjects still smoking cigarettes, for subjects who have not received appropriate therapy of other kinds (for example, inhaled and oral bronchodilators, and vigorous treatment of right ventricular failure and of any respiratory infection) or for those subjects who are not sufficiently motivated to accept the discipline involved in the application of oxygen therapy.

The statement listed the investigations that should be undertaken to determine pulmonary status and also stressed the need for periodic reassessment following commencement of oxygen therapy. The statement also provided a comparison of the various methods for oxygen delivery to the patient to assist in the selection of the appropriate delivery system. The point was made that if a patient was using one size E cylinder (3,800 litres) per week or more, then it is cheaper to change over to an oxygen concentrator. The Thoracic Society commented that there is no significant difference in the quality of oxygen to the patient with any of the delivery systems considered (cylinders, oxygen concentrators and liquid oxygen systems).

Some hospitals have developed protocols for the selection and management of patients entered into their home oxygen programs (4,20).

SAFETY ASPECTS

In an evaluation of six molecular sieve oxygen concentrators Johns, Rochford and Streeton have identified a number of safety features considered to be desirable (6). They are:

- Electric shock hazard
  The device should be electrically safe and insulation, earthing and leakage current need to conform to individual countries' electrical safety requirements for medical equipment.

- Fire hazard
  The device should be constructed of fire proof materials and the circuitry should have a thermal cut-out to turn off the unit in the event of overheating. A mains power circuit breaker should be installed in preference to replaceable fuses.

- Purity of the gas
  The device should have an outlet filter to exclude the possibility of sieve material reaching the patient and inlet filter(s) for both dust and bacteria.

- Correct function
  The device should have :
  . visual and audible alarms to include indication of power failure and inlet filter pressure failure;

  . an alarm test facility whereby the integrity of the battery powering the alarm can be checked;

  . a power on/off switch that illuminates when in the 'on' position;

- Dosage (and maintenance scheduling)
  The device should incorporate a time elapsed meter.

Of these safety features , only the audible alarm, time elapsed meter, and inlet filter were present in all the devices tested. No concentrator incorporated all the safety features. The authors suggested that this lack of uniformity between manufacturers of oxygen concentrators pointed to the need for a specific standard defining minimum requirements for such devices (6). This was seen as particularly important since the user is the patient and not a professionally trained operator of medical equipment. The failure of three of the six devices to indicate flow rate to within 10% of the true value, and the failure of all but one device to meet their specifications for oxygen concentration produced, also indicated to the authors the need for the development of a formal standard (6).

Standards specifying minimum requirements for the safety and performance of oxygen concentrators for medical use have been issued by the British Standards Institution (BS 5724: Section 2.23) and the American National Standards Institute Inc. (ANSI Z79.13). There is no Australian Standard covering oxygen concentrators for medical use. Compliance with the Standard AS 32000-1986 for electromedical equipment may ensure a general level of safety (21), but a specific Australian standard for concentrators to include consideration of the safety features described by Johns et al would be desirable. The Standards Association of Australia is currently participating in the development of an International Standard for oxygen concentrators

(21).

A crucial component of an oxygen concentrator is the compressor which delivers ambient air, under pressure, to the sieve bed. The Panel has been informed that with regular maintenance the compressor has a life time of about 5 years (22). A disadvantage of concentrators compared with cylinders is the possibility of failure due to an interruption in the power supply. The agents generally provide under rental arrangement a backup supply of oxygen in the form of a size E cylinder with accessories.

As with other electrical medical equipment, regular preventive maintenance performed according to the manufacturer's recommendations will minimise the risk of breakdown of the device. Patients also must be familiar with the safe use of their oxygen concentrator.

The product gas from oxygen concentrators includes argon in concentrations of 2-5%(5). The physiological effects of argon at this level are not fully known, but the concentration range does not approach respiratory or cerebral toxic levels of this gas (greater than 50%). It has been assumed on the basis of previous testing that 5% argon is not noxious (5).

Molecular sieve materials can retain gases such as carbon monoxide and low molecular weight hydrocarbons but it has not been demonstrated unequivocally that all atmospheric pollutants are removed (6). Thus the possibility of creating a physiologically harmful gas mixture by concentrating toxic gases, particularly in heavily polluted areas, may need to be considered (6). The Panel has been advised that concentrators have been used over the last 10 years in high pollution areas of the USA with no adverse effects reported to date (23). However it has been suggested that the presence of industrial pollution while a concentrator is in use may cause premature exhaustion of the molecular sieve (24).

Experience over a number of years overseas indicate that the provision of domiciliary oxygen therapy is not associated with an increased risk of fires or explosions in the home (25).

Potential complications of long-term oxygen therapy are hypercapnia (excess of carbon dioxide in the blood), carbon dioxide narcosis and oxygen toxicity (26). The degree of hypercapnia is usually modest, and rarely necessitates cessation of the treatment. Pathological studies of the lungs of persons who were receiving long-term oxygen therapy in life have shown minor alveolar proliferative changes but they were considered not to be due to oxygen toxicity (27).

OXYGEN CONCENTRATORS IN AUSTRALIA AND OVERSEAS

All currently available oxygen concentrators for domiciliary use in Australia are imported. Table 2 lists the available models together with selected specifications.

The various models of oxygen concentrators differ in size, weight, power consumption, noise production and safety features. The price varies from $3,000 to $3,6000, with the most expensive model incorporating an oxygen analyser.

TABLE 2
OXYGEN CONCENTRATORS IN AUSTRALIA

	HUDSON 6400	UNION CARBIDE MK IV	DeVO/44	ROOMATE III	ECONO2, MINIO2
Manufacturer	Ventronics, USA	Union Carbide Corp, USA	De Vilbiss Corp, USA	Cryogenics Associates, USA	Mountain Medical Equipment, USA
Distributor in Australia	Anaesthetic Supplies Pty Ltd, NSW	Medical Gases Australia, NSW	Medical Gases, Australia, NSW	Wyett Technical Services Bedford Park SA	CIG Medishield, NSW
Capital Cost (in April 1987)	$3,600	$3,200	$3,150	$3,000	$3,183
Dimensions (HxWxD, cm)	61x42x34	66x38x38	60x41x33	68x35x25	69x46x41 38x40x58
Weight (Kg)	27	28	20	25	52 26
Sound Level (dbA)	47	46	49	52	55-59 NK*
Power Consumption(W)	330	320	330(approx)	300	390 325
Safety Features					
-oxygen analyser	yes	no	no	no	no no
-visual alarms	yes	yes	yes	yes	yes yes
-power failure alarm	yes	yes	yes	yes	yes yes
-alarm test facility	yes	yes	yes	yes	yes yes
-thermal cutout	yes	yes	yes	yes	yes yes
-circuit breaker	yes	yes	yes	yes	yes yes
-bacteria filter	yes	yes	yes	yes	yes yes
-outlet filter	yes	NK	NK	no	NK NK

*NK = Not known
Source : Data supplied by Australian distributors

In a limited survey of selected public hospitals in NSW and Victoria, the Panel found that about 14% of patients who receive home oxygen therapy use concentrators. The Panel estimates that there are between 700 and 1100 concentrators currently in use in Australia. It has been suggested that as the value of home oxygen therapy becomes more widely known to the medical profession and to the general public the demand for home oxygen supplementation will increase (20).

Oxygen concentrators are now in use worldwide. Their use in the UK, China, Japan, Europe, USSR and North America has been documented (5).

It has been estimated that 1 million of the 9 million people with chronic heart disease in the USA may require prolonged oxygen therapy (5). There were more than 100,000 oxygen concentrators in use in the USA in 1983 (27).

PERFORMANCE AND RELIABILITY OF CONCENTRATORS IN THE HOME

In 1983 Evans, Waterhouse and Howard reported on their clinical experience with a number of models of oxygen concentrators (24). They commented that it was the first time concentrators had been studied under conditions of intensive usage. It was found that the mechanical performance of the machines was good for the most part. However, two serious mechanical faults emerged. The valve linking the sieve beds in one machine failed, resulting in the bypassing of one bed and the consequent delivery of oxygen concentration of under 50%. Partial exhaustion of the sieve occurred in three other machines.

The Panel is aware that premature exhaustion of sieve beds has sometimes occurred during routine use of concentrators in Australia. It has been suggested that this may be related to climate (28).

During a field evaluation of the concentrators by the Respiratory Unit at the Flinders Medical Centre, South Australia, it was found that some concentrators overheated during periods of high ambient temperatures ($40^{o}C$) (1). There were also some complaints about the noise level, but this was reduced for patients by placing the device outside the bedroom and connecting a longer length of tubing. The use of concentrators in this way had the advantages that it allowed patients to move around their homes without moving large cylinders and eliminated the risks associated with accidentally overturning cylinders.

In the evaluation, concentrators were found to be more acceptable to patients because they were clean and resembled furniture. The concentrator also removed the need to transfer flow meters and regulators from one cylinder to another as they were emptied, which could become a problem if the patient had little or no help at the time. The 27 patients with concentrators supported by the Flinders Medical Centre at that time were using them for an average of 19.9 hours per day, which reflects the degree of compliance in using this equipment. Overall the study showed that oxygen concentrators are an acceptable and economical method of

providing long-term domiciliary oxygen therapy at low flow rates, and are preferred by patients who had previously used cylinder oxygen (1). The Centre has commented that regular preventative maintenance at 3 monthly intervals has ensured the reliability of the machines (29).

REIMBURSEMENT FOR HOME OXYGEN THERAPY

In the UK, oxygen concentrators have been available under the NHS since December 1985,(18). In the USA both cost and coverage for oxygen are highly variable (30). Medicare generally covers 80% of allowable cost. Patients with supplementary insurance benefits, such as Blue Cross, may have the additional 20% reimbursed through the supplementary source. The US Health Care Finance Administration recently published its policy regarding eligibility for reimbursement for home-oxygen use under Medicare (16).

Since April 1985 home oxygen therapy in Japan has been covered by social (health) insurance. Under this scheme patients pay 10%-30% of expenses that comprise the costs of rental and medical management and the prescription fee (31).

In Canada the cost of home oxygen therapy is fully covered (30). In many other countries, however, long-term oxygen therapy is either not covered or is reimbursed only if the patient is hospitalised.

In Australia, home oxygen is not covered by Medicare or private health insurance. In some cases it is available free through State programs under which certain aids, including home oxygen, may be obtained from public hospitals.

During 1987, the Victorian Government extended to users of oxygen concentrators a scheme providing assistance with electricity costs to home-based users of life-support machines (20).

COST EFFECTIVENESS CONSIDERATIONS

Several studies have demonstrated the cost advantage of oxygen concentrators in home oxygen therapy (1-4,18,24,32,33).

A British study on the costs to the NHS of providing long term oxygen therapy showed a cost advantage for concentrators for all but small numbers of patients (32). Costings were based on purchase of the machines and their maintenance by hospital facilities and technicians. Another study indicated that if oxygen concentrators were used for patients with a high consumption of oxygen (for some, up to 15 cylinders a week), the NHS would save up to £1m a year (18). The use of an oxygen concentrator with a low birth weight infant requiring home oxygen therapy saved £1400 over a 5 month period (33)

A recent review of domiciliary oxygen usage in the Hunter Region of NSW confirmed the economic advantage of concentrators and concluded that they should be supplied where the patient is using more than one size E cylinder each week (4). The authors commented that variations in service and maintenance charges among suppliers and from area to area will influence the decision of whether to rent or buy concentrators and that each centre should

evaluate its own situation (4). Their cost comparison calculations of July 1986 showed that purchase was cheaper than rental over 5 years ($6866 for purchase versus $7380 for rental). However, this did not take into account the cost of replacement parts which may be quite substantial. It appears that the majority of concentrators in use are rented rather than purchased (34).

It has been suggested that hospitals can expect increasing numbers of patients to be enrolled in home oxygen therapy programs and that once enrolled, patients would continue on this form of therapy for longer periods (20). Because of the anticipated growth in the number of long-term users of home oxygen therapy the Alfred Hospital, Melbourne has purchased oxygen concentrators. The hospital calculated that in 1985 the cost of providing 24 heavy oxygen users with concentrators was $75,448 (including capital costs) as compared with an estimated $90,875 had cylinder oxygen been used (20).

The Panel has calculated the costs of using an oxygen concentrator (on a rental basis) and cylinder oxygen using the cost elements and charges (21) set out in Table 3 in the Appendix. Table 4 in the Appendix compares the annual costs of providing oxygen by the two methods at different flow rates for varying daily durations in the Sydney metropolitan area. Allowance has been made in the calculations for the cost of portable cylinder oxygen (size C - 440L) which may be used when the patient is outside the home. Total annual costs are shown graphically in Figure 1.

The annual cost of using a concentrator continuously is estimated by the Panel to be approximately $2,700. The cost of using cylinder oxygen at 2 L/min (the most frequently used flow rate) is about $7,000. The annual cost saving is therefore approximately $4,300 for each patient requiring continuous oxygen.

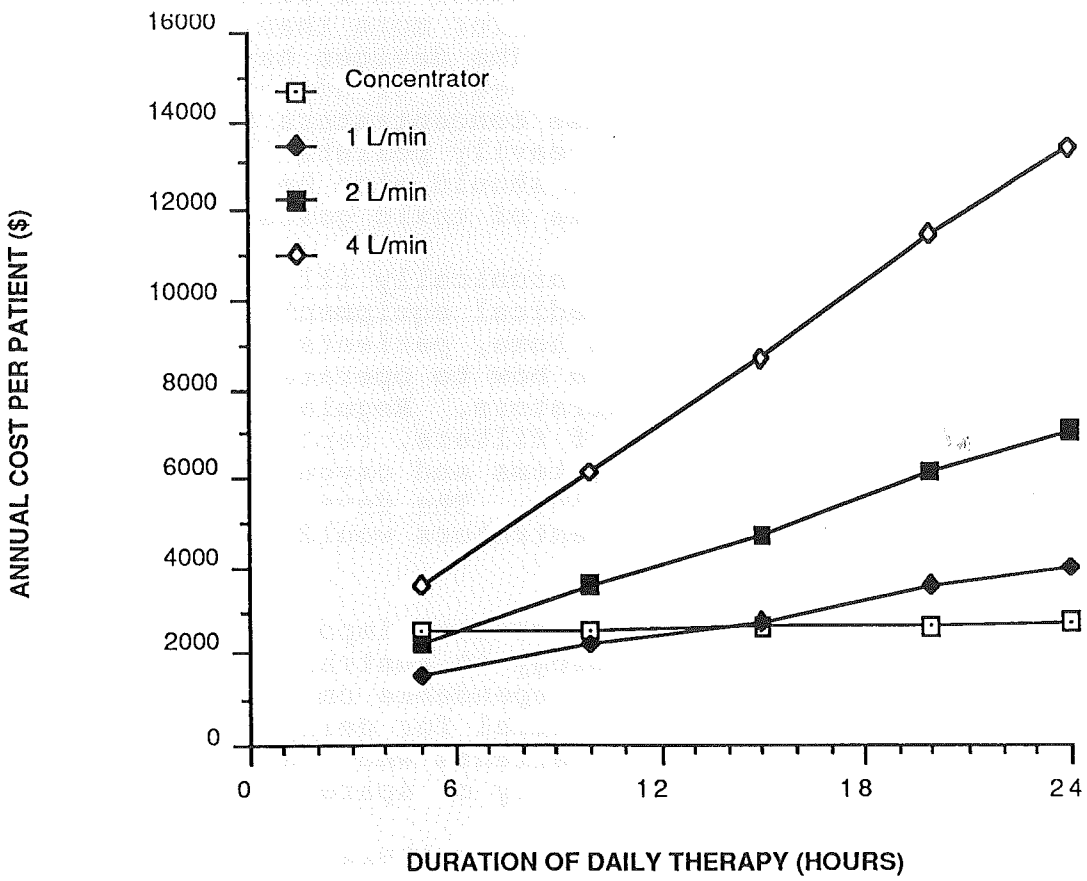
The Panel has calculated that 61% of the cost of operating a concentrator continuously is attributable to rental charges, 9% to power costs and 30% to portable cylinder oxygen costs. The latter cost component will vary with the mobility of the patient. In the main those patients requiring continuous oxygen would probably not require as much portable oxygen as allowed for in the Panel's calculations.

Figure 1 shows that there are cost savings in using oxygen concentrators when oxygen is required for more than 13 h daily at 1 L/min and for more than 5 h at 2 L/min.

An evaluation of a concentrator system providing "piped" oxygen at the Countess of Chester Hospital, Chester, UK, found that it would not normally be economic unless the system is combined with the medical air plant (35). A pay back period of 5 years was calculated for the combined installation when compared with cylinder oxygen supplies supplies. The experience of the Chester

FIGURE 1

ANNUAL COST PER PATIENT OF OXYGEN THERAPY



Hospital suggests that oxygen concentrators would not be cost effective for large oxygen users on mainland sites in urban areas with access to liquid oxygen supplies. Typical installations which are expected to benefit from concentrator technology are smaller, offshore or inaccessible sites where the transportation of oxygen is difficult or expensive (35). Two disadvantages of an oxygen concentrator for a hospital are that it needs skilled maintenance, and that regular measurement of the oxygen output is necessary. It may be difficult to arrange for these tasks to be carried out reliably in the remote locations which would particularly benefit from the apparatus (11).

CONCLUSIONS

Oxygen concentrators are being used widely overseas. In Australia, the use of oxygen concentrators has increased since their introduction in the early 1980's. Recent Australian medical literature has reported the rationalisation of domiciliary oxygen therapy at two centres and the savings accrued with the use of the technology.

The Panel has calculated that concentrators on a rental basis are cost effective when oxygen is required for more than 13 h each day at 1 L/min and 5 h daily at 2 L/min. The devices have proved to be a safe, convenient and efficacious means of administering oxygen in the home. However, because concentrators draw in ambient air, problems may arise in heavily polluted areas. This aspect may need further study. Care should also be taken not to use the device near potential sources of toxic gases.

Patients on domiciliary oxygen are chronically ill and not usually professionally trained to operate medical equipment. As with other medical equipment used in the home, patients should receive careful and detailed instruction on how to operate and obtain optimal benefit from oxygen concentrators. Regular maintenance to include the changing and cleaning of filters, replacement of nasal prongs and the checking of alarm systems and oxygen concentrations will minimise problems with the device. The development of an Australian Standard for oxygen concentrators would help to ensure safe and reliable performance.

Concentrators for medical use are at present imported. There is scope for manufacture of the technology in Australia. This could reduce the capital cost, and remove dependence on overseas sources for spare parts with associated potential for delays. It could make the device more acceptable to patients who have at times expressed concern about the availability of spare parts.

In view of the advantages of concentrators there could be wider applications in remote locations and in hospice and nursing home type institutions where piped oxygen may not be available. The Panel considers that State Health Authorities should give consideration to the wider applications of this technology because of the considerable saving that can be achieved.

The development overseas of banks of oxygen concentrators to produce piped oxygen in remote and offshore hospitals could have application in Australia. The Panel suggests that the relative

merits of such installations in Australia should be explored by the appropriate Commonwealth and State bodies.

The Panel considers that:

- concentrators are proven cost effective devices
- because of the considerable savings that might be achieved, appropriate Commonwealth and State bodies should explore the wider applications of this technology.
- an Australian Standard for oxygen concentrators should be developed
- manufacture of oxygen concentrators in Australia should be encouraged
- regular preventative maintenance schedules will help to ensure their reliable performance.

APPENDIX

TABLE 3
COSTS OF PROVIDING OXYGEN IN THE HOME (21)
(BASED ON APRIL 1987 RATES)

Oxygen Concentrator	Cost
. Rental (includes backup size E cylinder with accessories, preventive maintanance and instrument repair).	$139*
. Electricity This varies from State to State. In the Sydney metropolitan area the tariff is 7.39c/h/kw. For a concentrator rated at 390w, the cost is:	2.88c/h

Cylinder Oxygen	
. Size E cylinder (3,800L)	
-gas	$19
-rental of cylinder	$3.80*
-accessory hire (regulator,flowmeter etc)	$ 30**
-delivery fee	$12
. Size C cylinder (440L) (used to give the patient some mobility)	
-gas	$8.20
-rental of cylinder	$2.30*

* cost per month
** cost reduces to $12 per month after the first month

TABLE 4
COMPARISION OF ANNUAL COSTS PER PATIENT OF CYLINDER OXYGEN AND CONCENTRATOR OXYGEN

Duration of daily therapy (hours)	Concentrator* ($)	Cylinder Oxygen** ($)		
		1L/min	2L/min	4L/min
5	2530	1564	2254	3535
10	2583	2254	3535	6098
15	2634	2800	4673	8662
20	2686	3535	6098	11369
24	2728	3972	7018	13351

* Calculations include the cost of 4 size C cylinders/month (for patient mobility)

** Calculations are based on use of six E cylinders and include the cost of 4 size C cylinders/month
-Delivery charges have been estimated on 4 cylinders/delivery

REFERENCES

1. Crockett, A.J. oxygen concentrators - an economical new technology. Med. J. Aust. 1985; 142: 512-513.

2. Crockett, A.J., Alpers, J.H. and Chalmers, J.P. Cost centre management: how it helped reduce home oxygen costs. Australian Health Review 1986; 9(1): 38-42.

3. Alpers, J.H. Domiciliary oxygen: the cost-benefit dilemma. Med. J. Aust. 1987; 146:62.

4. McKeon, J.L., Saunders, N.A. and Murree-Allen, K. Domiciliary oxygen: rationalisation of supply in the Hunter region from 1982-1986. Med. J. Aust. 1987; 146: 73-78.

5. Chusid, E.L. Oxygen Concentrators, pp. 235-247 in Rendell-Baker, L. International Anaesthesiology Clinics, 1982, Vol. 20, No. 3. Problems with Anaesthetic and Respiratory Therapy Equipment, Little, Brown and Company, Boston.

6. Johns, D.P., Rochford, P.D. and Streeton, J.A. Evaluation of six oxygen concentrators. Thorax 1985; 40: 806-810.

7. Gould, G.A., Scott, W., Hayhurst, M.D. and Flenley, D.C. Technical and clinical assessment of oxygen concentrators. Thorax 1985; 40: 811-816.

8. Carter, J.A., Baskett, P.J.F. and Simpson, P.J. The 'Permox' oxygen concentrator. Anaesthesia 1985; 40: 560-565.

9. Harris, C.E. and Simpson, P.J. The 'Mini O_2' and 'Healthdyne' oxygen concentrators. Anaesthesia 1985; 40: 1206-1209.

10. Crockett, A.J., personal communication, April 1987

11. Howell, R.S.C. Oxygen Concentrators. British Journal of Hospital Medicine 1985; 34(4): 221-223.

12. Medical Research Council Working Party: Long-term domiciliary oxygen therapy in chronic hypoxic cor pulmonale complicating chronic bronchitis and emphysema. Lancet 1981; 1: 681-686.

13. Nocturnal Oxygen Therapy Trial Group: Continuous or nocturnal oxygen therapy in hypoxemic chronic obstructive lung disease: A clinical trial. Ann. Int. Med. 1980; 93: 391-398.

14. Heaton, R.K., Grant I., McSweeney A.J et. al. Psychologic effects of continuous and nocturnal oxygen therapy in hypoxemic chronic obstructive pulmonary disease. Arch. Intern. Med. 1983; 143:1941-1947.

15. American Thoracic Society. Oxygen administration in the home. Am. Rev. Respir. Dis. 1977; 15:897-899.

16. Department of Health and Human Services. Health Care Financing Administration. Medicare program; Coverage of oxygen for use in a patient's home. Federal Register 1985;50(66): 13742-13750.

17. Williams, B.T. and Nicholl, J.P. Prevalence of hypoxaemic chronic obstructive lung disease with reference to long-term oxygen therapy. Lancet 1985; 2: 369-372.

18. Husain, M.H. General practitioners to prescribe oxygen concentrators. Br. Med. J. 1985; 291: 1543-1544.

19. Breslin, A.B.X., Colebatch, H.J.H., Engel, L. and Woolcock, A.J. Domiciliary oxygen therapy. August 1984. A statement prepared for the Thoracic Society of Australia.

20. Smith, M., Alfred Hospital, submission to the NHTAP, September 1987.

21. Standards Association of Australia, submission to the NHTAP, May 1987.

22. The Commonwealth Industrial Gases Limited, Medishield Division, personal communication, April 1987.

23. Crockett, A.J., personal communication, July 1987

24. Evans, T.W., Waterhouse, J. and Howard, P. Clinical experience with the oxygen concentrator. Br. Med. J. 1983; 287: 459-461.

25. Flenley, D.C. Long-term oxygen therapy - State of the art. Respiratory Care 1983; 28(7): 876-884.

26. Ruffin, R.E and Alpers, J.H. Domiciliary oxygen therapy. Med. J. Aust. 1985; 142: 510-512.

27. West, G.A. and Primeau, P. Nonmedical hazards of long-term oxygen therapy. Respiratory Care 1983; 28(7):906-912.

28. Murree Allen, K., submission to the NHTAP, September 1987.

29. Crockett, A.J, submission to the NHTAP, July 1987.

30. McDonald, G.J. long-term oxygen therapy delivery systems. Respiratory Care 1983;28(7):898-905.

31. Kawane, H. and Soejima R. The cost of domicilidary oxygen in Japan. Med.J.Aust 1987; 146:662

32. Lowson, K.V. Drummond M.F. and Bishop J.M. Costing new services: Long-term domiciliary oxygen therapy. Lancet 1981;1:1146-1149.

33. Lloyd ,D.J. Chronic lung disease - home management with an oxygen concentrator. Arch. Dis. Child. 1986; 61(6):623.

34. The Commonwealth Industrial Gases Limited, Medical Division, submission to the NHTAP, September 1987.

35. Chester Health Authority (July 1984). An evaluation of the cascade oxygen concentrator installed to supply oxygen at the Countess of Chester Hospital.

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