ORIGINAL ARTICLE

# Preschool healthcare utilisation related to home oxygen status

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**Objective:** To determine, in prematurely born children who had bronchopulmonary dysplasia (BPD), if respiratory morbidity, healthcare utilisation, and cost of care during the preschool years were influenced by use of supplementary oxygen at home after discharge from the neonatal intensive care unit.
**Design:** Observational study.
**Setting:** Four tertiary neonatal intensive care units.
**Patients:** 190 children, median gestational age 27 weeks (range 22–31), 70 of whom received supplementary oxygen when discharged home.
**Interventions:** Review of hospital and general practitioner records together with a parent completed respiratory questionnaire.
**Main outcome measures:** Healthcare utilisation, cost of care, cough, wheeze, and use of an inhaler.
**Results:** Seventy children had supplementary oxygen at home (home oxygen group), but only one had a continuous requirement for home oxygen beyond 2 years of age. There were no significant differences in the gestational age or birth weight of the home oxygen group compared with the rest of the cohort. However, between 2 and 4 years of age inclusive, the home oxygen group had more outpatient attendances ($p = 0.0021$) and specialist attendances ($p = 0.0023$), and, for respiratory problems, required more prescriptions ($p<0.0001$). Their total cost of care was higher ($p<0.0001$). In addition, more of the home oxygen group wheezed more than once a week ($p = 0.0486$) and were more likely to use an inhaler ($p<0.0001$).
**Conclusions:** Children with BPD who have supplementary oxygen at home after discharge have increased respiratory morbidity and healthcare utilisation in the preschool years.

Bronchopulmonary dysplasia (BPD) is a common outcome following very premature birth[1] mainly due to the improved survival rates of these infants. The most severely affected continue to require supplementary oxygen beyond term. Provision of home oxygen therapy can enable early discharge from the neonatal unit of affected infants,[2] particularly if they are sent home while still requiring nasogastric tube feeding with appropriate support in the community.[3] We have previously shown, however, that patients with BPD discharged home in supplementary oxygen compared with those who were not required significantly more and longer admissions and more outpatient attendances, and their cost of care was significantly higher in the first two years after birth.[4] It is not known whether this increased morbidity is ongoing, yet such data are important for resource allocation planning and counselling of parents. The aim therefore of this study was to test the hypothesis that patients with BPD who had required home oxygen therapy had increased respiratory morbidity, healthcare utilisation, and cost of care during their preschool years.

## METHODS

To test our hypothesis, we reanalysed data collected in a four centre study to assess healthcare utilisation of prematurely born children who had developed BPD.[5] The study was approved by the local research ethics committee of each of the four hospitals, and parents gave informed written consent for their children's data to be collected.

The study sample consisted of neonates born at less than 32 weeks gestation who had been admitted during the first week after birth to one of four neonatal intensive care units between 1 July 1994 and 1 July 1997 and subsequently developed BPD (defined as oxygen dependency beyond 28 days after birth). All four units provided tertiary intensive care for infants of women receiving all their antenatal care within the hospitals, infants whose mothers had been referred antenatally as it was perceived that their infant might need tertiary care, and infants delivered in neighbouring hospitals who required tertiary care. A retrospective review had been made of their neonatal unit admission, their care during any hospital admission after discharge from the neonatal intensive care unit, and their care in the community between the ages of 2 and 4 years inclusive. In addition, parents had been asked to complete a respiratory questionnaire when their child was 5 years old.

From the neonatal admission, the data retrieved included: birth weight; use of antenatal steroids and postnatal surfactant; the development of an air leak (pneumothorax/pulmonary interstitial emphysema); patent ductus arteriosus (clinical diagnosis with or without echocardiographic confirmation); the durations of ventilatory support, supplementary oxygen, and neonatal unit stay; the use of high frequency oscillation and/or nitric oxide.

From the records of the general practitioner (GP), the data retrieved included: hospital admissions; the number of GP consultations; all drugs prescribed; the use of home oxygen; referrals to a health visitor or community paediatric nurse; the use of community support services—for example, physiotherapists, speech therapists, or educational psychologists. For simplicity, any member of the primary healthcare

**Abbreviations:** BPD, bronchopulmonary dysplasia; GP, general practitioner

**Table 1** Neonatal data on infants in relation to their home oxygen status

| | Home oxygen | No home oxygen | p Value |
|---|---|---|---|
| Number | 70 | 120 | |
| Gestational age (weeks) | 27 (23–31) | 27 (23–31) | 0.99 |
| Birth weight (g) | 920 (510–2178) | 934 (515–3000) | 0.71 |
| Antenatal corticosteroids | 95.3% | 81.8% | 0.033 |
| Postnatal surfactant | 91.4% | 82.5% | 0.089 |
| CPAP | 41.4% | 75.7% | <0.0001 |
| IPPV | 95.6% | 97.3% | 0.67 |
| Duration of IPPV (days) | 13 (0–103) | 10 (0–96) | 0.329 |
| Duration of supplementary oxygen (days) | 83 (0–1213) | 60 (4–457) | 0.027 |
| HFOV | 4.4% | 4.6% | 1.00 |
| Inhaled nitric oxide | 4.3% | 4.3% | 1.00 |
| Pneumothorax | 12.9% | 9.2% | 0.44 |
| Postnatal dexamethasone | 41.4% | 36.3% | 0.49 |
| PIE | 5.7% | 2.5% | 0.43 |
| PDA | 37.1% | 31.1% | 0.39 |
| At discharge/transfer | | | |
| Postnatal age (days) | 103 (10–827) | 70 (2–464) | 0.0435 |
| Postmenstrual age (weeks) | 38.6 (28.6–143.1) | 37.6 (25.9–92.3) | 0.0147 |

Data are given as median (range) or percentages.
CPAP, Continuous positive airway pressure; IPPV, intermittent positive pressure ventilation; HFOV, high frequency oscillatory ventilation; PIE, pulmonary interstitial emphysema; PDA, patent ductus arteriosus.

team other than the GP was labelled a specialist. For each hospital admission, the information recorded included: the diagnosis or symptoms leading to the admission; the duration of stay; whether the child was admitted to a general paediatric ward or to an intensive care unit. Each child's hospital record was examined to ascertain the number of outpatient attendances. In addition, primary care contacts, hospital admissions, and outpatient attendances were identified as being for respiratory or other problems by using ICD codes (ICD 10).

The mean cost of each admission was calculated using data from the *National scheme of reference costs* (2002). Medicine costs were calculated from the *British national formulary* prices; these costs included all domestic oxygen therapy costs. The cost of an outpatient attendance was estimated assuming 15 minutes with a consultant paediatrician and using the mean of the outpatient costs of the four main hospitals. The cost of care by a GP was estimated assuming an 8.4 minute consultation at the surgery (£18 per consultation). The cost of a GP's time was based on average net remuneration allowing for capital costs and overheads. The cost of a domiciliary visit by community staff was estimated assuming a 20 minute consultation. The cost of domiciliary visits for health visitors, paediatric nurses, and oxygen nurse specialists was based on average net remuneration for specialist nurses allowing for superannuation, national insurance, travel, and capital overheads (£27 per visit). All primary care costs were those reported by Netten *et al*.[6] All visits to practice nurses or routine visits to health visitors—for example, for immunisations—were not recorded, as these were considered the usual costs for children.

When their child was aged 5 years, the parents were sent a respiratory questionnaire. The parent(s) was asked to reply to questions on maternal smoking during pregnancy, whether there was a member of the household who currently smoked, if there was a family history of atopy, the number of long haired pets, whether the child had siblings, the occurrence of any respiratory symptoms (cough and wheeze) and whether this was more than once a week, whether their child had used an inhaler, and if the child had required home oxygen beyond 2 years of age. The child was defined as having a positive family history of atopy if the parents reported that at least either a parent or a sibling suffered from asthma, eczema, or hay fever.

## Analysis

Healthcare utilisation and cost of care in years 2–4 inclusive and respiratory morbidity (cough, wheeze, and/or use of an inhaler) were analysed according to home oxygen status. Differences between groups for continuous variables were assessed for statistical significance using a Kruskal Wallis or Student's *t* test as appropriate. Differences between groups for categorical data were tested using either a $\chi^2$ test or Fisher's exact test as appropriate.

**Table 2** Healthcare utilisation in years 2–4 inclusive related to home oxygen status

| | Home oxygen (n = 70) | No home oxygen (n = 120) | p Value |
|---|---|---|---|
| All admissions | | | |
| Number | 0 (0–5) | 0 (0–18) | 0.8510 |
| Duration (days) | 0 (0–72) | 0 (0–62) | 0.9387 |
| Admissions to paediatric ward | | | |
| Duration (days) | 0 (0–85) | 0 (0–61) | 0.9829 |
| Admission to PICU | | | |
| Duration (days) | 0 (0–0) | 0 (0–5) | 0.1836 |
| Outpatient attendances | 8 (0–39) | 5 (0–39) | 0.0021 |
| Specialist attendances | 3 (0–104) | 1 (0–62) | 0.0023 |
| Contacts with GP | 9 (0–43) | 10.5 (0–68) | 0.5023 |
| Prescriptions | 13 (0–140) | 10 (0–103) | 0.0861 |

Data are expressed per child and shown as median (range).
PICU, Paediatric intensive care unit; GP, general practitioner.

**Table 3** Cost of care (UK pounds) according to home oxygen status

| | Home oxygen (n = 70) | No home oxygen (n = 120) | p Value |
|---|---|---|---|
| Years 2–4 inclusive | | | |
| Hospital admissions | 0 (0–6905) | 0 (0–14399) | 0.8638 |
| Outpatient attendances | 583 (0–2745) | 356 (0–3931) | 0.0068 |
| Visits to specialist | 1577 (0–7709) | 16 (0–6069) | <0.0001 |
| GP visits | 147 (0–645) | 165 (0–1660) | 0.3722 |
| Prescriptions | 41 (0–5170) | 26 (0–8513) | 0.0294 |
| Total cost | 3054 (48–10097) | 950 (5–18929) | <0.0001 |
| Years 0–4 inclusive | | | |
| Total cost | 10683 (1367–84350) | 4044 (277–87285) | <0.0001 |

Data are given per child and shown as median (range).
GP, General practitioner.

### Patients

Screening of 1581 case records showed that 459 infants fulfilled the eligibility criteria. In 205 cases, the detailed hospital (n = 200) or primary care (n = 5) records could not be retrieved, and in 19 cases written parental consent was not obtained. The original study sample therefore was 235 infants with a median gestational age of 27 weeks (range 22–31) and birth weight of 934 g (range 510–3000).[7] Written informed consent for participation in the preschool study[5] was obtained from 190 of the 235 sets of parents. Reasons for failure to recruit were lack of consent (n = 35), not registered with a GP (n = 5), no contact address (n = 4), and child in care (n = 1). The children who were and were not recruited into the preschool study did not differ significantly (data not shown). In all four centres, infants were discharged home in supplementary oxygen if they had no other ongoing medical needs, their parents were agreeable, and the home conditions were appropriate. In two of the centres, infants who were also nasogastrically tube fed were considered for home oxygen therapy.[3] In all four centres, when at home, infants received intermittent monitoring of oxygen saturation. A minimum oxygen saturation of 95% was recommended for infants receiving home oxygen therapy in all four centres. No dedicated staff were available to care for infants receiving home oxygen therapy, but the centres that also considered tube fed babies for home oxygen had staff designated as home oxygen specialists (these staff undertook other duties and were not employed solely to look after infants receiving home oxygen therapy). Children were followed after 2 years of age according to their medical needs, regardless of whether they had had supplementary oxygen at home.

## RESULTS

Seventy of the cohort received supplementary oxygen on discharge from the neonatal unit (home oxygen group). Only one child remained chronically oxygen dependent beyond 2 years of age, although five others (three in the home oxygen group) required supplementary oxygen at some time during the preschool years.

The home oxygen group differed from the rest of the cohort in that more of their mothers had received corticosteroids antenatally (p = 0.033) and fewer had required continuous positive airway pressure in addition to mechanical ventilation (p<0.0001) (table 1). In addition, the home oxygen group required a significantly longer duration of supplementary oxygen (p = 0.027) and were discharged at an older postnatal (p = 0.0435) and postmenstrual (p = 0.0147) age.

The children in the home oxygen group had significantly more outpatient attendances (p = 0.0021) and visits to a specialist (p = 0.0023) in years 2–4 inclusive (table 2). When only respiratory problems are considered, the home oxygen group had significantly more outpatient attendances (median 1 (range 0–11) *v* median 0 (range 0–7); p = 0.0144), visits to the GP (median 6 (range 0–29) *v* median 4 (range 0–55); p = 0.0363), and more prescriptions (median 5.5 (range 0–46) *v* median 4 (range 0–29); p<0.0001).

The cost of care for the home oxygen group was greater for outpatient attendances (p = 0.0068), visits to specialists (p<0.0001), and total care (p<0.0001) (table 3). If only respiratory problems were considered, the cost of care was greater in the home oxygen group for outpatient visits (p = 0.0175), visits to the GP (p = 0.0348), prescriptions (p<0.0001), and total care (p = 0.0023). The total cost of care of the home oxygen compared with the no home oxygen group from birth to year 4 inclusive was significantly greater (p<0.0001).

Analysis of the respiratory questionnaire for risk factors for respiratory morbidity showed that the only significant difference between the two groups was that a greater proportion of the home oxygen group had a family history of hay fever (p = 0.0204) (table 4).

**Table 4** Risk factors for ongoing respiratory morbidity

| | Home oxygen (n = 70) | No home oxygen (n = 120) | p Value |
|---|---|---|---|
| Siblings | 55.6 | 52.8 | 0.7252 |
| FH asthma | 41.0 | 36.8 | 0.6039 |
| FH eczema | 32.1 | 29.2 | 0.7196 |
| FH hay fever | 58.3 | 39.1 | 0.0204 |
| FH atopy | 70.8 | 61.8 | 0.2334 |
| Smoking during pregnancy | 23.1 | 27.6 | 0.5068 |
| Maternal smoking | 27.6 | 27.8 | 0.9790 |
| Father smoking | 27.3 | 27.1 | 0.9816 |
| Household smoking | 36.0 | 24.2 | 0.1320 |
| Long haired pets | 27.0 | 19.8 | 0.2723 |
| House owner | 70.3 | 69.8 | 0.9458 |

Data are percentages.
FH, Family history.

**Table 5** Respiratory morbidity according to home oxygen status

| | Home oxygen | No home oxygen | p Value |
|---|---|---|---|
| Number | 70 | 120 | |
| Cough more than once a week | 23 (33) | 24 (20) | 0.7394 |
| Wheeze more than once a week | 9 (13) | 3 (3) | 0.0486 |
| Used an inhaler | 57 (81) | 69 (57) | <0.0001 |

Values in parentheses are percentages.

A greater proportion of the home oxygen group had wheezed (p = 0.0197), wheezed more than once a week (p = 0.0486), and had used an inhaler (p<0.0001) (table 5).

## DISCUSSION

We have shown that healthcare utilisation in prematurely born children who had had home oxygen therapy was significantly greater in the preschool years—that is, years 2–4 inclusive—than in those who had never received home oxygen therapy, even though only one of the 70 home oxygen group had home oxygen continuously beyond 2 years of age. There were no significant differences in the number or duration of hospital admissions between the two groups, but very few of either group required hospital admission in years 2–4 inclusive (table 2). The increase in healthcare utilisation in the home oxygen group was due to significantly more outpatient and specialist attendances and a tendency to receive more prescriptions. The latter became significant when prescriptions for respiratory problems were considered, suggesting that this group had greater respiratory morbidity. The results of the questionnaire support this hypothesis, as it showed that the home oxygen group were more likely to wheeze and use an inhaler (table 5).

The greater morbidity in years 2–4 suffered by the home oxygen group was not predicted by their ''neonatal'' data (table 1). The two groups had similar gestational age and birth weight, and similar proportions required mechanical ventilation and developed such complications as an air leak or a patent ductus arteriosus, suggesting that their initial disease may not have been more severe. Indeed, a greater proportion of the home oxygen group had received antenatal steroids and a smaller proportion had required continuous positive airway pressure support in addition to mechanical ventilation. There was also no significant difference in the proportions of the two groups who received postnatal dexamethasone (table 1). This is important, as in animal models postnatal dexamethasone has been shown to adversely influence lung growth[8] and hence may result in chronic respiratory morbidity. We did not collect information as to whether the mothers of our children had had chorioamnionitis. Chorioamnionitis has been associated with an increased risk of BPD[9] and intra-amniotic endotoxin exposure associated with disrupted alveolar development,[10] although there are conflicting results.[11] Whether chorioamnionitis increases the likelihood of respiratory morbidity associated with home oxygen therapy has not been reported and merits prospective investigation. Analysis of the respiratory questionnaire revealed that most risk factors for respiratory morbidity did not differ significantly between the two groups (table 4). The home oxygen group, however, had a significant excess of a family history of hay fever, but not eczema, asthma, or atopy. Whether the significant difference in the family history of atopy contributed to the differences in respiratory morbidity found between our groups is uncertain; even the role of a family history of atopy in BPD development remains controversial.[12 13]

### What is already known on this topic

- Infants with BPD discharged home on supplementary oxygen have high healthcare utilisation due to ongoing respiratory morbidity in the first two years after birth

### What this study adds

- Respiratory morbidity, healthcare utilisation, and total cost of care is significantly higher during the preschool years in those who used supplementary oxygen at home after discharge compared with those who did not, even though most were no longer dependent on supplementary oxygen
- These results have implications for the planning of health care and for counselling of parents

There are no standard criteria for administering home oxygen therapy. In this study, however, the practices of the four centres differed only with respect to feeding practices on discharge home for infants who were to receive supplementary oxygen.[3] Two of the four centres sent babies home in oxygen when they still required tube feeding and, as a consequence, were able to discharge them on average two weeks earlier than the other two centres.[3] Despite these variations, the home oxygen group had greater morbidity in the preschool years.

A limitation of this study is that it does not have a randomised intervention. As a consequence, it is possible that uninvestigated differences between our groups explain the increased morbidity of the home oxygen group—for example, co-existing neuromorbidity. Not surprisingly, the home oxygen group had a significantly longer use of supplementary oxygen than the rest of the cohort. Thus it seems likely that very prolonged use of supplementary oxygen rather than use of supplementary oxygen at home per se explains the increased morbidity. It is, however, possible that the parents of the home oxygen group were more anxious about their children and hence sought more GP consultations and reported more wheeze. The home oxygen group, however, did require more outpatient attendances and prescriptions, particularly respiratory prescriptions, and significantly more had used an inhaler. Regardless of the mechanism, use of home oxygen clearly defined a group with increased healthcare utilisation and respiratory morbidity in the pre-school years, which has resource implications.

In conclusion, prematurely born children who had had BPD and received supplementary oxygen at home had greater healthcare utilisation in the preschool years than similar patients who had not received home oxygen. To our knowledge this is the first study to examine morbidity outside the first two years of life in premature children who had home oxygen. Whether this increased healthcare utilisation persists into school age merits further investigation.

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