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Health Care and Societal Costs of Bronchopulmonary Dysplasia

Wannasiri Lapcharoensap, MD[*], **Henry C. Lee, MD MS**[†], **Amy Nyberg, BS**[‡], **Dmitry Dukhovny, MD MPH**[*]

[*]Department of Pediatrics, Oregon Health and Science University, Portland, OR

[†]Department of Pediatrics, Stanford University, Stanford, CA

[‡]March of Dimes NICU Family Support Coordinator, Helen DeVos Children's Hospital, Grand Rapids, MI

Abstract

Despite significant technological advances and increasing survival of premature infants, bronchopulmonary dysplasia (BPD) continues to be the most prevalent major morbidity in surviving very low-birthweight infants. Infants with BPD are often sicker, require longer stays in the NICU, and accumulate greater hospital costs. However, care of the infant with BPD extends beyond the time spent in the NICU. This article reviews the costs of BPD in the health-care setting, during the initial hospitalization and beyond, and the long-term neurodevelopmental impact of BPD, as well as the impact on a family caring for a child with BPD.

Education Gaps

Bronchopulmonary dysplasia (BPD) continues to affect a large portion of very low-birthweight infants; therefore, knowledge of the short- and long-term economic impact of BPD is necessary to gain a broader perspective of the disease.

INTRODUCTION

Approximately 1 in 10 infants is born prematurely in the United States. (1) In the year 2015 alone, there were more than 55,000 very low-birthweight (VLBW, <1,500 g) infant births. Although overall survival rates are improving, the number of VLBW infants with at least 1 major morbidity remains high. (2) Bronchopulmonary dysplasia (BPD) was initially described as a disease of premature infants by William Northway, Jr, in 1967, when potential ventilator injury and oxygen toxicity were recognized as modifiable factors in ameliorating the disease process. (3) Although we have gained considerable understanding of the pathophysiology of BPD since that time, it continues to be the most prevalent major morbidity affecting an estimated 22% to 45% of all VLBW infants in the United States. (2) (4) This article reviews the resource utilization and costs of BPD and the impact on the health-care system and family.

DIRECT MEDICAL COSTS AND HEALTH-CARE UTILIZATION

Birth Hospitalization

VLBW infants account for a large percentage of birth hospitalization costs. In a population-based study in California, VLBW infants comprised 0.9% of all birth hospitalizations but accounted for 35.7% of total costs. (5) As infants with BPD tend to be sicker and smaller, the costs for caring for these infants are comparatively increased. In low-birthweight infants (<2,500 g), Russell et al found that the single most expensive cause of morbidity based on average cost per discharge was BPD; infants with BPD had an initial hospitalization cost that was 16 times higher than the cost of infants without BPD. (6) The median cost for NICU hospitalization for infants with BPD was $102,000 (US dollars, 2001) per infant compared to a median of $36,800 for all infants less than 28 weeks' gestational age (GA) and $500 for uncomplicated newborns. Johnson et al found that in VLBW infants, BPD has the highest associated mean marginal costs compared to other significant morbidities (necrotizing enterocolitis, late-onset sepsis, brain injury). (7) The direct costs for those with BPD were 2.3 times higher than for those without BPD. Infants with BPD have significantly increased lengths of stay and hospitalization costs because of the greater number of procedures, greater duration of respiratory equipment use, and other advanced medical technologies in addition to increased risk of complications and comorbidities. (5)(8) These increased costs are reflected in prolonged hospitalization, with infants with BPD having an average length of stay 4 weeks longer, even after adjusting for birthweight and other risk factors. (9) Affected infants have an almost 6-fold increased risk of delayed discharge, defined as discharge after 42 weeks' postmenstrual age. (10) Although there is tremendous variability in what is included in the cost accounting studies (eg, facility fees, hospital fees, etc), infants with BPD consistently pose a significantly higher economic burden on the health-care system across times and multiple studies (Table).

The First 2 Years: Back to the Hospital and the Role of Respiratory Infections

Respiratory illnesses are the number 1 reason for hospital readmissions in premature infants. (11) As BPD is known to be an underlying cause of pulmonary dysfunction, infants with BPD are susceptible to respiratory infections as well as increased severity of illness; thus, they are at greater risk for hospital admissions during an illness. (11)(12) Many studies have demonstrated that infants with BPD, particularly those with moderate to severe BPD, have a significantly higher rate of rehospitalization for respiratory causes. (8) (11)(12)(13) In a population-based study of almost 1,600 infants at less than 33 weeks' GA, infants with BPD had increased rehospitalization rates during the first year of age (49%) compared with infants without BPD (23%). (8) Furthermore, there were significant differences in number of readmissions as well as length of stay during those subsequent hospitalizations.

A significant health-care burden for patients with BPD is respiratory syncytial virus (RSV). Although RSV often causes a self-limited respiratory infection for most infants, it is a leading cause of hospitalization in the first year for all infants, with rates of hospitalization reported at 16.9 per 1,000 infants of age 0 to 5 months and 5.1 per 1,000 infants of age 6 to 11 months. (14) It is recognized that BPD is a major independent risk factor for RSV disease leading to serious infections and hospitalizations. (15) Infants born preterm with BPD may

be particularly vulnerable to RSV because of their history of underdeveloped or injured alveoli, pulmonary vasculature, and respiratory epithelium, which predisposes them to pulmonary edema with infection. (16) RSV infection in the context of BPD has been shown to lead to increased likelihood of hospitalizations, hospital length of stay, ICU admission, and need for mechanical ventilation. (17)(18)(19) Patients with BPD with RSV infections also have increased outpatient visits and higher total cost of care for the first 2 years of age. (20) A history of RSV infection in patients with BPD has a downstream effect on patient morbidity, leading to continued increased health-care utilization (outpatient visits, cost of care) at 5 to 7 years of age and also significantly worse pulmonary function at 8 to 10 years of age. (21) Palivizumab, a mouse monoclonal antibody product directed against an RSV protein, has been shown to be effective in reducing the burden of hospitalization in preterm infants, with RSV-related hospitalizations in preterm infants with BPD decreasing from 12.8% to 7.9%. (22) However, palivizumab remains an expensive therapy to administer and cost-effectiveness for various populations remains in question, though a stronger case can be made for preterm infants with BPD. (23)

Beyond the Second Year: Rehospitalizations and Outpatient Visits

Rehospitalization rates in patients with BPD continue to be comparatively higher beyond the initial year with an increased risk for rehospitalization and more frequent outpatient visits. (13) Although most infants will not require oxygen beyond 2 years of age, indicating clinical improvement, up to 25% will continue to have respiratory complications into young adulthood. (12)(24) Children and adolescents with a history of BPD are more often diagnosed with asthma (26.9% vs 11.8%; $P<.0001$) and psychiatric illnesses (such as depression, anxiety, attention-deficit/hyperactivity disorder) leading to increased health-care utilization. (25) In a Quebec study comparing a preterm BPD cohort and a preterm respiratory distress syndrome cohort over 16 to 25 years, the costs of medical services and total health-care costs per person annually was significantly increased in the BPD cohort ($13,472 vs $10,719; $P=.02$; expressed in 2008 Canadian dollars). (25)

Durable Medical Equipment

In a multicenter study, approximately one-third of infants with BPD of any severity were sent home with oxygen supplementation. (24) Infants categorized with either moderate or severe BPD likely account for most of these cases, as they are discharged with oxygen supplementation 57% to 68% of the time. (31)(32) It is important to note that home oxygen use is largely institution dependent, with a large study of 117 centers finding that home oxygen use ranged from 7% to 95% in infants requiring respiratory support at 36 weeks' postmenstrual age. (32) Infants who were oxygen dependent had outpatient visits, specialist visits, and prescription costs approximately 3 times greater than infants sent home without oxygen from 2 to 4 years of age. (24) As most children no longer required continuous supplemental oxygen beyond the second birthday, this represents a continued increased health-care cost and respiratory morbidity beyond just receiving oxygen supplementation. These differences in health-care utilization continued through school age. (33)

Given that prolonged ventilation plays a significant role in the development of BPD, infants with severe BPD are at increased risk for tracheostomy placement with or without ventilator

dependence. Tracheostomy may be a result of pulmonary disease that is dependent on positive pressure ventilation, consequences of prolonged intubation (such as subglottic stenosis, vocal cord paralysis, granulation tissue), or airway anomalies (such as laryngotracheomalacia). A large multicenter study found that 0.1% of all NICU infants required a tracheostomy over a 16-year period, with BPD being the number 1 diagnosis associated with the procedure (45%). (34) Another study from 27 centers found that 13.5% of infants with severe BPD required a tracheostomy and 20.4% of infants with severe BPD required a tracheostomy or died before discharge. (35) Infants with tracheostomies are either discharged from the hospital or sent to a care facility after receiving extensive family education and multidisciplinary care coordination by the medical team to ensure safety. Once a tracheostomy is placed, the median time to decannulation was 436 to 479 days (range 48–1,611 days). (36) Furthermore, health-care utilization in the 5 years following tracheostomy placement in children is increased, including total time of hospitalization (mean±SD, 32.3±65.9 days) and risk of at least 1 readmission within 30 days (45.1%). (37) The use of technology can increase both direct medical costs (equipment, supplies, nursing care, outpatient visits, hospitalizations, prescriptions) and nondirect costs (electricity, water, family stress, loss of income).

BPD AND CHILD NEURODEVELOPMENT

Numerous studies have found that BPD is an independent risk factor for poor developmental outcomes, low IQ, and cerebral palsy. (12)(38) Children with moderate to severe BPD have a lower developmental quotient and more developmental disabilities (defined as developmental quotient less than 2 SD below mean, severe cerebral palsy, bilateral blindness, or severe hearing deficit) compared to those with or without mild BPD. (39) Infants with BPD often have more prolonged periods of hypoxemia, or apnea, associated with the need for increased ventilator days compared to peer infants without BPD. This severity of illness likely affects brain development of the premature infant. In cases of severe BPD, movement disorders similar to chorea and akathisia have been described as early as the third month of age with an autopsy in 1 patient demonstrating hallmarks of hypoxic brain injury. (40) Moreover, infants with BPD have poor physical growth compared to peers with lower mean weight and head circumference. (38)(41) Thus, the effects of BPD on neurodevelopment is likely multifactorial, related to underlying pathophysiology of BPD, growth failure, and environmental factors (such as socioeconomic status and parental education).

The delay in neurodevelopment can be detected early with a significantly increased number of infants with BPD having sensorineural conductive hearing loss compared to controls requiring tympanostomy tube placement (22.1% vs 7.7%). (42) Another study demonstrated that at 10 months of age, infants with BPD had poor hand-eye coordination and perception and intelligence compared to infants with mild BPD or without BPD. (43) These differences persisted at age 5.5 years with poor visual-spatial development along with deficits in cognition. (44) Deficits are also apparent in language development as infants with BPD have lower receptive language skills starting at 3 years of age with increased enrollment in speech and language therapy by 8 years of age compared to peers without BPD. (45) By school age, children with BPD were more likely to be enrolled in special education classes with deficits

in reading, mathematics, and gross motor skills, even after correcting for neurologic risk factors. (46) Greater severity of BPD was also associated with lower school achievement, lower IQ, increased therapy needs (occupational, physical, speech), and special education enrollment. In particular, those requiring a tracheostomy had significantly more adverse developmental outcomes. (47) With these complications, it is not surprising that adults with a history of preterm birth and BPD were less likely to have access to higher education and more likely to be unemployed. (48)

In an estimate by the Centers for Disease Control and Prevention, average lifetime costs for 4 different developmental disabilities (mental disabilities, cerebral palsy, hearing loss, and vision impairment) ranged from $417,000 to $1,014,000 (2003 US dollars) per person. (49) As individuals with BPD are at higher risk of being affected by these disabilities both through childhood and as adults, the economic costs continue to be comparatively increased throughout their lifetime. The report further specifies that lifetime indirect costs (ie, productivity losses, decreased functional participation) reflects up to 81% of total lifetime costs. When looking at direct medical expenditures alone, children who have more than 1 disability will have substantially higher associated costs. In a comparison of children with cerebral palsy, those who also had intellectual disability had 1-year mean medical expenditures 2.5 times the amount of those with a single diagnosis of intellectual disability or cerebral palsy. (50) Even with 1 diagnosis, the mean medical expenditure in 1 year was 10 times higher than the control population without cerebral palsy or intellectual disability.

FAMILY BURDEN

Studies have shown that there are increased parental stressors when an infant is born prematurely or with low birthweight. (51)(52) Psychological distress is mainly manifested as symptoms of depression, anxiety, and posttraumatic stress both during and after a NICU admission. (52) Up to 40% of mothers of very preterm infants report significant depression based on the Edinburgh Postpartum Depression Scale compared to 10% to 15% of postpartum women overall. (53) As BPD infants tend to have more complications and a prolonged hospitalization, mothers of infants with BPD often have more severe negative symptoms. Caregivers are also more likely to have negative symptoms during the first 2 years of age if the child is frequently ill, and requires more outpatient visits and health-care utilization. (54) Studies have shown that personal, family, and financial stressors are more pronounced when the school-age child has lower IQ scores and more severe neurodevelopmental outcomes. (55)(56) In a prospective longitudinal study Singer et al compared mothers of VLBW infants with BPD, VLBW infants without BPD, and term infants from birth through adolescence. (56-57) Overtime, mothers of VLBW infants with BPD had increased personal, family, and financial stress, as well as lower attainment of additional education, whereas mothers of VLBW infants without BPD had similar outcomes to term mothers in most categories. Financial stressors can be a direct result of loss of wages, with up to 42% of families of infants with BPD discharged with oxygen supplementation losing wages in order to provide home medical care to their child. (30) Financial strain directly affects parental stress, with familial socioeconomic status being a significant risk factor for greater stress for any family independent of the child’s health status or IQ. (56)

The impact on the family is best portrayed from the parents' own experience. As part of understanding the family burden of NICU parents, one of the coauthors (A.N.) led a video project to highlight the NICU parent perspective. Parents talked about what life is like with their children years after the NICU. In this 6-minute video (https://youtu.be/TRGKWm2DBbA), the impact of having a former premature infant with special health-care needs is communicated eloquently and clearly by the family (Fig).

CONCLUSIONS AND IMPLICATIONS

BPD is the most prevalent major morbidity in surviving VLBW infants. The economic burden stems from increased health-care costs starting with the birth admission and persists through childhood and into adulthood. The costs are increased both in a setting of relatively routine disease states (eg, RSV infection), as well as with disease severity (eg, patients with tracheostomies). In addition, there is a significant impact on the family unit of patients with BPD, with respect to both psychosocial and financial stressors. The burden of BPD that is imposed on the health-care system and the family, in combination with the association of BPD and worse neurodevelopmental outcomes, produces a substantial cumulative societal cost. When considering strategies in BPD reduction (ie, delivery room interventions, lung protective ventilation approaches, novel medications, quality improvement interventions), the return of investment calculus should take into account the annual economic impact of 12,100 infants diagnosed with BPD (22% of VLBWs, low estimate) per year in the United States and their lifetime "cost" to those individuals and their families, health-care system, and society.

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ABBREVIATIONS

BPD	bronchopulmonary dysplasia
GA	gestational age
RSV	respiratory syncytial virus
VLBW	very low-birthweight

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Objectives

1. Describe the short- and long-term costs for infants with bronchopulmonary dysplasic (BPD).
2. Describe the impact of BPD on the health-care system.
3. Compare the costs of infants and children with BPD to those without BPD.
4. Discuss the impact of BPD on the child's neurodevelopment.
5. Estimate the burden of BPD on the family unit.

Figure.
Chris and Denise Van Dis with their twins, Natalie and Caleb, who were born at 24 weeks' gestation and had bronchopulmonary dysplasia. Click this link (https://youtu.be/TRGKWm2DBbA) to watch a 6-minute video of the parents' account of their personal experience of bringing home 2 former preterm infants with BPD.

TABLE.

Selected Studies Outlining the Resource Utilization and/or Cost Associated With BPD

REFERENCE	YEAR PUBLISHED	POPULATION	TIME HORIZON	RESOURCES	COSTS/CHARGES	NOTES
Patel et al (26)	2016	N=254 VLBW Source: Prospective single center, admitted to the NICU 2008-2012 Country: USA	Birth hospitalization	Although the LOS is not directly reported, the authors do provide a cost per day and thus it could be calculated; additionally, there is a report on breakdown of different services used between the 2 groups (see Table 3 in Patel et al.)	Cost/charges: Costs Currency: US dollars, 2014 Median cost for BPD $269,004 (IQR:204,606-331,552) compared to $117,078 (IQR 90,496-162,017) (*P*<.001) In an adjusted analysis, BPD increased costs by $41,929 compared to non-BPD patients Source of costs: hospital data and cost accounting system includes direct and indirect hospital costs Facility fees: included Professional fees: included (based on physician payments) Parent costs: not included Other: N/A	Prospective cohort Table 3 of this article by Patel et al provides a detailed description of the total costs and the individual sub-costs (e.g. hospital direct costs, physician costs, and NICU cost per day) Adjustment: propensity score for BPD, race/ethnicity, gender, gestational age, and small for gestational age
Johnson et al (7)	2013	N=425 VLBW Source: Single center Country: USA	Birth hospitalization	LOS: BPD: Mean 94±31 days compared to 46±19 days w/o BPD (*P*<.001)	Cost/charges: Costs Currency: US dollars, 2009 Mean 103,151±43,482 compared to 44,465±23,300 (*P*<.001) BPD cost is $31,565 higher compared to no morbidity when adjusted for GA, sex, birthweight, race/ethnicity, and primary payer (*P*<.001) Source of costs: Hospital data and cost accounting system using direct hospital costs for each billable item Facility fees: included Professional fees: Not included Parent costs: Not included Other: N/A	Adjusted for birthweight, GA, and sociodemographic characteristics
Landry et al (25)	2012	N=3,442 (with BPD=773; RDS without BPD=2,669) Source: Provincial health administrative databases from Quebec (infants born with RDS and/or BPD between 1983-1992) Data was extracted through March 2008 for follow-up Country: Canada	16- to 25-year follow-up (mean duration 19.3 y for BPD and 17.6 y without BPD)	Health-care utilization and costs Table 2 in the article by Landry et al represents the health-care utilization data Hospitalizations: (mean±SD) BPD: 5±7.3 w/o BPD: 2.9±3.3 (*P*<.0001) ED visits (per subject; mean±SD): BPD: 15.4±18.9 w/o BPD: 12±14.5 (*P*=.0002)	Cost/charges: Costs Currency: Canadian dollars, 2008 Total cost per person-year (mean±SD): BPD: $13,472±527 w/o BPD: $10,719±625 (*P*=.02) Pharmaceutical costs (from 1997 only): BPD: $175±88 w/o BPD: $101±23 (*P*=.06) Source of costs: Administrative data Facility fees: Included Professional fees: Included Parent costs: Not included Other: Pharmaceutical costs	Infants were identified using ICD-9 codes for BPD, RDS, and prematurity. Hospitalization costs were based on estimates from the Canadian Institute of Health Information and Health Canada Higher diagnosis of asthma (11.13 vs 4.55 diagnosis per patient-year; *P*<.0001) There is no term equivalent comparison group (just former preterm infants with and without BPD) There was also an increased use of respiratory and neurologic/

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						psychiatric drugs in a subset of the cohort with BPD compared to those w/o BPD)
Stroustrup et al (27)	2010	N=9,542,032 hospitalizations (1.53% of which were <1,500 g at birth) Source: NIS HCUP, 1993–2006 Country: USA	Birth hospitalization	LOS and charges	Cost/charges: Charges Currency: US dollars, year of currency not stated There are no exact cost and LOS estimates in the published article, but the authors give % changes over time: 3.9% annual increase (1993–2006) in LOS for patients with BPD; only 2% when adjusted for VLBW incidence (*P*<.0001) 4.9% annual increase (1993–2006) in charges for patients with BPD; only 2.9% when adjusted for VLBW incidence (*P*<.0001) Facility fees: Included Professional fees: Not included Parent costs: Not included Other: N/A	NIS samples 20% of US hospital discharges and is weighted to approximate population BPD identified using the ICD-9 code 770.7 Limited to patients <1,500 g birthweight and those who received non-invasive mechanical ventilation or continuous invasive mechanical ventilation ≥96 hours based on procedure codes Both univariate and multivariable analyses performed (4 different model adjustments were done) Goal of the study was to assess trends over time for incidence of BPD, LOS, and charges
Russell et al (6)	2007	N=9,400 (7,100–11,700) with BPD and 204,600 (186,800–222,300) without BPD Source: NIS HCUP, 2001 Country: USA	Birth hospitalization	LOS was determined in this study, but not directly comparing those with BPD to those without (however, there is LOS comparing normal newborns to preterm/low birthweight)	Cost/charges: Costs (charges were converted to costs using cost-to-charge ratios) Currency: US dollars, 2001 (presumed year, not explicitly stated) Mean 116,000 (95% CI=102,200–129,900; median=102,000) for BPD compared to 16,900 (95% CI=15,200–18,600; median=6,300) without BPD Source of costs: Administrative data Facility fees: Included Professional fees: Not included Parent costs: Not included Other: N/A	NIS samples 20% of US hospital discharges and is weighted to approximate population Attempted to minimize the overlap from inter-hospital transfers during the birth admission (80% of births involved no hospital transfer) BPD identified using the ICD-9 code 770.7 All patients who were defined as preterm/low birthweight (<2,500 g) were included in this analysis likely decreasing the mean/median cost of hospitalization in the non-BPD group
Smith et al (8)	2004	N=1,597 (14.9% with BPD) Source: Northern California Kaiser Permanente Medical Care Program, 6 level III facilities (Neonatal Minimal Dataset linked to California birth certificates and Kaiser follow-up); 1995–1999 Country: USA	Rehospitalization in the first year after birth among infants with BPD (born <33 weeks)	Rehospitalization rates LOS is included for the birth hospitalization	Cost/charges: N/A (resources only) Currency: N/A 49% rehospitalization rate in patients with BPD compared to 23% in patients without BPD (*P*<.0001) Mean number of rehospitalizations per infant was 2.2±1.9 (BPD) vs 1.6±1.1 (w/o BPD) (*P*=.0012) Mean LOS of 12.7±27.5 days (BPD) vs 6.4±9.4 days (w/o BPD) (*P*=.0036) Birth hospitalization LOS: 92.8±37.3 days (BPD) vs 38.4±20.6 days (w/o BPD) Source of costs: Administrative data Facility fees: N/A Professional fees: N/A Parent costs: N/A Other: N/A	Limited to those who survived to first birthday, had follow-up care at Kaiser, and did not have any major anomalies Table 1 of the study provides additional information on resource utilization during the birth hospitalization (eg, duration of ventilator and oxygen use; % of comorbidities such as NEC, ROP, and IVH) No risk factors identified among patients with BPD who were and were not readmitted

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Greenough et al[a] (28)	2002	N=235 (88 received supplemental oxygen) Source: Born in 1 of 4 NICUs between July 1994 and July 1997 Country: United Kingdom	Readmissions and primary care use in the first 2 years after birth in infants with BPD (born <32 weeks) discharged with oxygen compared to infants with BPD with no support BPD defined as oxygen dependence beyond 28 days after birth in this study	Outpatient visits, community care, readmissions (resources and costs) Routine health-care visits were not recorded	Cost/charges: Costs, using the NHS website 1999 reference costs) Currency: British pounds, 1999 Readmissions per infant/LOS per infant: Median (range) Home oxygen group (n=88) −2 (0-20)/7 days (0-131) w/o home oxygen group (n=147) −1 (0-20)/3 days (0-282) *P*<.05, *P*<.01 Total costs in the 2 years postdischarge: Mean (range) Home oxygen group (n=88) – 6,802 (896–85,831) w/o home oxygen group (n=147) – 4,881 (95–58,444) *P*<.001 Facility fees: Included Professional fees: Included Parent costs: Not included Other: N/A	Detailed review was performed of postdischarge records in the first 2 years after birth The costs are broken down into the following categories: Primary care total Primary care respiratory related Primary care drugs Hospital drugs Hospital stay Outpatient attendance Of note, these investigators have published 2 other analyses on this cohort: 1)@Pre-school healthcare utilization by home oxygen status (n=190) – Greenough et al, 2006 (24) 2)@School age outcomes by admission status with RSV – Greenough et al, 2009 (29)
Greenough et al[a] (20)	2001	N= 235 Source: Born in 1 of 4 NICUs between July 1994 and July 1997 Country: United Kingdom	Readmission with proven RSV infection in the first 2 years after birth in infants with BPD (born <32 weeks) BPD defined as oxygen dependence beyond 28 days after birth in this study	Outpatient visits, community care, readmissions (resources and costs) Routine health-care visits were not recorded	Cost/charges: Costs, using the NHS website (1999 reference costs) Currency: British pounds, 1999 Readmission rate per infant: RSV group (n=45) – 5.4 Probably bronchiolitis (n=24) – 2.8 Other respiratory (n=60) – 3.1 Nonrespiratory (n=106) – 0.6 (*P*<.001 for between-group comparison) Total costs in the 2 years postdischarge: mean (95% CI) RSV group (n=45) – 12,638 (8,041; 17,235) Probably bronchiolitis (n=24) – 6,059 (3,427; 8,690) Other respiratory (n=60) – 5,683 (3427; 6775) Nonrespiratory (n=106) −2,461 (2,074; 2,849) (*P*<0.001 for between-group comparison) Facility fees: Included Professional fees: Included Parent costs: Not included Other: N/A	Detailed review was performed of postdischarge records in the first 2 years after birth The costs are broken down into the following categories: Primary care total Primary care respiratory related Primary care drugs Hospital drugs Hospital stay Outpatient attendance
McAleese et al (30)	1993	N=59 Source: Dartmouth-Hitchcock Medical Center, 1981–1989; infants with BPD who were discharged with oxygen; data obtained	Birth hospitalization and home oxygen therapy	Birth hospitalization (LOS and cost) Home oxygen therapy cost Financial and emotional stress on the family	Cost/charges: The article is not clear as it appears to use the words ‘charges’ and ‘costs’ interchangeably Currency: US dollars, 1989–1990 Birth hospitalization: Median birth hospitalization duration 120 days (range: 30–772 days)	Combination of hospital records as well as parental records and regional charges were used Distribution of costs 82% – hospital charges 12% – physician fees 5% – community hospital charges

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		from hospital billing office Country: USA			Mean birth hospitalization cost per patient: $197,668 (median $172,817, range $43,364–$864,594) Mean self-pay for hospital bill $14,103 Median out of pocket expenses $1,624 (range $267–$8,017) (travel, lodging, phone bill) Postdischarge: Home oxygen duration median 92 days (range: 9–577 days) Cost of oxygen and related equipment median $2,250 (range: $475–$9,000) Facility fees: Included Professional fees: Included Parent costs: Included (using parent interviews; parental wage losses were included) Other: N/A	1% – parental expenses Interviews of parents provided parental expenses during infant hospitalization Financial and emotional impact of home care was assessed via a questionnaire Home oxygen therapy costs were obtained as average charges from suppliers in the region

The table breaks down some of the elements of costs and summarizes the economic burden. BPD=bronchopulmonary dysplasia; ED=emergency department; GA=gestational age; HCUP=Healthcare Cost and Utilization Project; ICD-9=International Classification of Diseases, Ninth Revision; IQR=interquart11e range; IVH=intraventricular hemorrhage; LOS=length of stay; N/A=not available; NEC=necrotizing enterocolitis; NHS= National Health Service; NIS=National Inpatient Sample; RDS=respiratory distress syndrome; ROP=retinopathy of prematurity; RSV=respiratory syncytial virus; VLBW= very low birthweight.

[a]Represents the same cohort of patients with different focus and period of anaiysis.