This is the post print version of the article, which has been published in Acta Paediatrica. 2017, 106(12), 1998–2003. http://dx.doi.org/10.1111/apa.13964.

National high-flow nasal cannula and bronchiolitis survey highlights need for further research and evidence-based guidelines

Paula Sokuri[1], Paula Heikkilä[1], Matti Korppi[1]

[1]Centre for Child Health Research, University of Tampere and Tampere University Hospital, Tampere, Finland

Short Title: High-flow nasal cannulas and bronchiolitis

Correspondence: Matti Korppi, Centre for Child Health Research, 33014 University of Tampere, Finland. Tel: +358503186316. Email: matti.korppi@uta.fi

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

FUNDING

PS and PH received funding from The Research Foundation of the Pulmonary Diseases to carry out this study.

Abstract

Aim: High-flow nasal cannula (HFNC) therapy provides non-invasive respiratory support for infant bronchiolitis and its use has increased following good clinical experiences. This national study describes HFNC use in Finland during a severe respiratory syncytial virus (RSV) epidemic.
Methods: A questionnaire on using HFNC for infant bronchiolitis during the 2015-2016 RSV epidemic was sent to the head physicians of 18 Finnish children`s hospitals providing inpatient care for infants: 17 hospitals answered, covering 77.5% of the infants born in Finland in 2015.
Results: Most (85%) HFNC was given on paediatric wards. The mean incidence for bronchiolitis treated with HFNC in infants under the age of one in 15/17 hospitals was 3.8 per 1,000 per year (range 1.4-8.1). One excluded hospital did not supply the relevant data and one supplied a figure of 34.1 due to different treatment policy. Instructions on how to start and wean HFNC therapy were present in 71% and 61% of the hospitals, respectively, weighted to the population. Providing weaning instructions was associated with shorter weaning times.
Conclusion: HFNC was actively used for infants with bronchiolitis, with no substantial over-use. Randomised controlled studies are needed before any evidence-based guidelines can be constructed for using HFNC in infant bronchiolitis.

Key notes:

- This questionnaire-based study evaluated high-flow nasal cannula treatment for infant bronchiolitis in Finland during the 2015-2016 respiratory syncytial virus epidemic.
- Responses were received from 17 children's hospitals and the mean incidence of HFNC treatments was 3.8 per 1,000 per year.

- Instructions on how to start HFNC were provided more often (71%) than how to wean (61%) and providing weaning advice was associated with shorter weaning times.

Key words: Bronchiolitis, High-flow nasal cannula, Respiratory syncytial virus epidemic, Treatment instructions, Weaning instructions

Abbreviations: HFNC, high-flow nasal cannula; PICU, paediatric intensive care unit; RCT, randomised controlled trial; RSV, respiratory syncytial virus; SpO_2, oxygen saturation; FiO_2, fraction of inspired oxygen

INTRODUCTION

Bronchiolitis is the leading infectious cause of hospitalisation in infancy (1). In European countries it is usually defined as an acute respiratory infection with breathing difficulties in infants under 12 months of age (2) and the diagnosis is clinical, based on typical signs and symptoms (3). As there is no widely accepted consensus on the treatment of infants with bronchiolitis, the therapy tends to focus on maintaining oxygenation and hydration (4).

High-flow nasal cannula (HFNC) therapy is a relatively new approach to treating, and even preventing, hypoxia in respiratory diseases (5). It involves administering a heated and humidified mixture of oxygen and air via a nasal cannula at a flow rate of more than three litres a minute, which reduces the dead space and causes continuous distending pressure in the airways (5,6).

Physiological studies have shown that when bronchiolitis patients were treated with HFNC, oxygen saturation improved and the work of breathing, respiratory rate and heart rate decreased (6,7). HFNC seems to be well tolerated in infants with bronchiolitis (8), but the research-based clinical evidence on its effectiveness is insufficient (5, 8). Some studies have compared infants with bronchiolitis who were treated with HFNC to historical controls who were treated in the same hospital with standard low-flow oxygen administration. The results of these studies were positive, in line with subjective clinical experience (9,10).

In an Italian semi-randomised pilot study, infants hospitalised for bronchiolitis at less than 12 months of age, and treated with HFNC, presented with lower clinical severity scores, shorter oxygen administration times and shorter hospitalisation stays than controls treated with standard

low-flow oxygen (11). An Australian randomised controlled trial (RCT) published in 2017 comprised 202 infants with moderate bronchiolitis who were less than 24 months of age and had oxygen saturation (SpO_2) levels of 90-94%. Half were randomised to HFNC and the other half to standard low-flow therapy. The groups did not differ in terms of weaning time or the need for intensive care, but treatment failures were less common in the HFNC group (14%) than in the controls (33%) and 60% of the controls that failed to respond were successfully treated with HFNC (12). Thus, HFNC therapy may have a role to play as rescue therapy for infant bronchiolitis in order to avoid high-cost intensive care.

Five RCT studies are currently being carried out on HFNC therapy in bronchiolitis to our knowledge: one large study in Australia and New Zealand (13) and four other studies that have recorded their protocols in the Clinical Trials Register.

Until now, no evidence-based guidelines have been constructed for HFNC in infant bronchiolitis, simply due to the lack of such evidence. There is a risk that the non-controlled use of HFNC will expand, with varying indications and protocols that are only based on the experiences of single teams or even single doctors. The aim of this national questionnaire study was to evaluate the use of HFNC for infant bronchiolitis in children's hospitals in Finland and the period we chose was during the 2015-2016 respiratory syncytial virus (RSV) epidemic.

MATERIAL AND METHODS

In this descriptive study, the data were collected by a questionnaire that was specially written for this study and included both quantitative and open qualitative questions. The questionnaire, which covered the indications and practices of HFNC treatment in infants with bronchiolitis, was sent to the head physicians of the paediatric departments of 18 Finnish hospitals that provided inpatient care for young children. Of those, three were university hospitals, 13 were central hospitals and two were large regional hospitals working in close connection with a tertiary university hospital. We received completed questionnaires from 17 hospitals that were primarily responsible for 43,202 (77.5%) of the 55,759 infants born in Finland 2015, according to official Government statistics. The hospital that did not respond was one of the 13 central hospitals.

The questionnaire consisted of questions on the HFNC treatment provided for infants hopitalised for bronchiolitis below the age of 12 months between 1 November 2015 to 31 May 2016, when there was severe nationwide epidemic caused by the RSV. The collected data included the numbers of bronchiolitis patients treated with HFNC and whether the hospital provided its staff with instructions on how to initiate, wean and to cease HFNC therapy. We also asked respondents about the indications for HFNC treatment, including the SpO_2 threshold, the starting, maximum and end settings for gas flows and the SpO_2 oxygen saturations during HFNC. There were also questions about whether nasogastric tubes were routinely used, and about the indications and practices for fluid therapy. The questionnaire also requested details on how many HFNC treatments were carried out in the paediatric intensive care unit (PICU) or other intensive care units and how many were carried out on the paediatric ward. The attending doctors were asked to describe, in their own words, what indications they used to start, wean and cease HFNC

treatment, including the gas flows they used, the fractions of inspired oxygen (FiO_2) and the starting and target SpO_2 levels of the patients. Answers to the open qualitative questions were catogorised by the authors as quantitative variables in the analyses.

We did not send the questionnaires to two university hospitals, Tampere University Hospital and Oulu University Hospital, because both these hospitals were involved in an ongoing RCT on the HFNC treatment of infants with bronchiolitis, which started in 2016 during the RSV epidemic (Clinical Trials Register, No NCT02737280). These two hospitals treated bronchiolitis patients according to the RCT study protocol. In short, infants who were less than six months old and had been hospitalised for bronchiolitis were eligible to be included in the study and the indication for enrollment was an SpO_2 below or equal to 91% with room air without the need for mechanical ventilation. The starting flow for HFNC treatment depended on the child's weight: 5L/min for 3-4kg, 6L/min for 4-7kg and 8L/min for 8-10kg. The FiO_2 was adjusted to keep the SpO_2 at 92-95%. HFNC treatment was ceased when the FiO_2 had been 21% for two hours and the flow had been 5-8L/min for the same amount of time.

The analyses were performed with SPSS version 24 (SPSS Inc, Chicago, Illinois, USA). We used descriptive statistics and the results were presented as unweighted and weighted means and medians and ranges. Each hospital was given a weighted index, depending on the number of infants born in the catchment area of the hospital in 2015. The Mann-Whitney U test was used in the statistical analyses. The surveillance period was seven months, including the RSV epidemic, and we did not make any corrections when we calculated the incidences, which were expressed as per year.

RESULTS

The age-specific mean incidence of bronchiolitis treated with HFNC between 1 November 2015 and 31 May 2016 in infants under the age of one in 15/17 hospitals was 3.8 per 1,000 per year, with a range of 1.3-8.7 and 95% confidence interval (95% CI) of 2.4-5.2. We excluded one central hospital that did not supply the relevant data and one small central hospital that supplied an age-specific incidence of 34.1 per 1,000 due to long distances to intensive care facilities as this outlier would have artificially skewed the overall mean (Table S1). In the latter hospital, all infants with bronchiolitis who needed oxygen were treated with HFNC. Most (86.5%) of the HFNC treatments were given on the paediatric wards and only 13.5% were provided in the PICU or other intensive care units.

We found that 10 hospitals provided instructions on how to start HFNC, which equated to a weighted percentage of 71.1%, and seven of those hospitals told staff how to wean patients off and cease HFNC, which was a weighted percentage of 60.6%. The other seven hospitals (28.9%) did not provide instructions on starting or weaning HFNC (Table 1). Nasogastric tubes were routinely inserted in nine hospitals, which equated to a weighted percentage 40.1% and short-term fluids were admistered intravenously in five hospitals, which was a weighted percentage of 30.2% (Table 1). The comparison of crude and weighted percentages suggests that instructions, especially those for weaning off and ceasing HFNC, were more likely to be present in large hospitals, but the routine insertion of nasogastric tubes was more common in small hospitals (Table 1).

The presence of instructions for starting HFNC was not significantly associated with the number of infants in the area or the number of HFNC treatments provided by the hospital (Data not shown). However, the presence of instructions for weaning off HFNC were significantly associated with the number of infants in the area (medians, 2,580 if present *versus* 2,257 if not present, p=0.019) and the number of HFNC treatments provided by the hospital (medians, 17 if present *versus* 11 if not present, p=0.012). This meant that large hospitals treated more patients with HFNC were more likely to also provide instructions for weaning off and ceasing HFNC.

The most important indication for HFNC was reduced SpO_2 and the limit varied between 90% or less and 95% or less, with a weighted median of 91%. The target SpO_2 during HFNC varied between 90% or more and 95% or more, with a weighted median of 91%. The starting FiO_2 varied from 21% to 50%, with a weighted median of 21%. The starting flow and maximum flow during HFNC were expressed as interpolated for an infant weighing 10kg and the weighted medians were 10 L/min (4-20 L/min) and 20 L/min (7-50 L/min), respectively.

The weaning protocols varied substantially (Table 2). The minimum weaning time, expressed as a weighted median, ranged from 8 to 20 hours. The minimum flow rate when the clinical staff were ready to end HFNC ranged from 4L/min to 5L/min and the FiO_2 was 30%, with all figures expressed as weighted medians. The weaning times of HFNC were shorter, and the flow rates and FiO_2 were higher if the hospital provided weaning instructions (Table 2).

DISCUSSION

There were three main results to emerge from the present questionnaire-based study on clinical practices for HFNC treatment of infants with bronchiolitis in Finnish children`s hospitals during the RSV epidemic in winter 2015-2016. First, the mean incidence of HFNC treatments was 3.8 per 1,000 per year in infants under 12 month old in the general population, which means that around 0.4% of the age cohort was treated with HFNC in hospital during that epidemic. Second, the instructions on when and how to start HFNC therapy for bronchiolitis were present in 71% of the hospitals, but only 61% of the hospitals provided instructions on when and how to wean the bronchiolitis patients off HFNC therapy. These percentages were weighted, and were higher than the crude percentages, which means that large hospitals were more likely to provide instructions than small hospitals. The presence of weaning instructions were associated with a shorter weaning time. Third, the great majority (85%) of HFNC treatments were successfully given on the paediatric wards.

A 2014 paper, published before the RSV epidemic covered by this study, quantified the incidence of bronchiolitis in infants admitted to the emergency room at less than six months of age as 37 per 1,000 in Finland and 70% of cases were treated in hospital, which means that the incidence of hospitalisations was 26 per 1,000 per year (14). In the present study, the mean incidence of bronchiolitis treated with HFNC at less than 12 months of age was 3.8 per 1,000 per year. No data are available on the incidence of bronchiolitis hospitalisations during the winter 2015-2016 epidemic, which the present study covers. If we apply the incidence figures presented above, we can estimate that around 15% of infants hospitalised for bronchiolitis were treated with HFNC, which does not suggest any substantial overuse of HFNC. In one hospital, all bronchiolitis patients

who needed oxygen support were treated with HFNC if there was a device free. That hospital was small, had limited paediatric intensive care facilities and was situated a long way from the tertiary hospital. As it was an obvious statistical outlier, it was not included in the mean incidence quoted above as that would have artifically skewed the figure.

The indications for starting HFNC treatment did not substantially differ between the Finnish children`s hospitals, despite the fact that some did not provide formal instructions. The limits of hypoxia that were treated with oxygen support varied between an SpO_2 of 90% to 95%, but similar variations can be seen in the international bronchiolitis guidelines (3). In the Finnish bronchiolitis guidelines, the lowest SpO_2 that did not require oxygen administration was set at 92% (15), which was close to the weighted median (91%) observed in the present study.

The starting flow rates were in accordance with the instructions given by the manufacturers of the devices, but during HFNC treatment the hospitals reported surprisingly high maximal flows of 20L or even higher. Distending airway pressure depended on the size of the patient, the flow rate and the diameter of the nasal cannula compared to the nares (8,16). There have not been any studies that compared flows above 10L/min and distending airway pressure in infants (5), but higher flows up to 50L/min have been used in older children and adults (17,18). The lack of studies, together with the case reports on serious air leakage in children treated with HFNC (19), indicate that caution is needed with flows that are higher than 10L/min in infants.

The average weaning time varied from three to 48 hours in those 12 children`s hospitals, which reported it. The detailed instructions for weaning were present in seven of them. The weaning time was shorter and the flow and FiO_2 just before the HFNC ended was higher, if the instruction for weaning were available. It was evident that there was a risk of using unnecessarily slow

weaning protocols, since most of the paediatric experience has been using HFNC with neonates, who need to be weaned slowly, for example by reducing the flow rate by 0.5L/min per hour, when the maximum rates are not needed anymore (5). In contrast, in infants with bronchiolitis, the reduction rate can be 1.0L/min per hour or even a more rapid reduction (5).

The recommended flow when doctors were ready to end HFNC treatment varied between 2L/min and 8L/min. When the flow is 2L/min or less it is not defined as high-flow treatment anymore and the use of the HFNC device does not offer any benefits over standard oxygen administration (20). A flow of 2-3L/min is needed to produce distending pressure (21,22). In addition, there is evidence that the high flow itself, without any additional oxygen administration, improves oxygen uptake and reduces respiratory work (15). HFNC use may be harmful if the flow is less than 2L/min and there is no air leak through the nares (22).

Increasing evidence from retrospective studies suggests that HFNC treatment is safe with no substantial risk of complications (8) and prospective pilot studies have reported that treatment can be carried out on the pediatric ward (10,23). In the only RCT study published so far on the effectiveness of HFNC treatment, Kepreotes et al reported that only four minor adverse events occurred in 101 infants with bronchiolitis and none of them led to them being withdrawn from the trial (12). On the other hand, the risk of adverse effects can be higher, if there is bronchial obstruction caused by smooth muscle contraction, as in wheezy bronchitis or asthma (19,24).

The main impact of HFNC therapy may the reduction of PICU treatment, which is much more expensive than treatment on the ward (9,10,25). As seen in the only RCT study, HFNC may have a a special role as rescue therapy to prevent or shorten intensive care (12) or to reduce the need to

transfer patients to tertiary hospitals (13). We found that 85% of the HFNC treatments in the present study were carried out on paediatric wards and the doctors did not report any substantial complications.

Nasogastric tubes were routinely used for HFNC treated infants in more than half of the hospitals we surveyed. Interestingly, the weighted percentage was lower than the crude percentage, which means that this routine was common in small hospitals. Nasogastric tubes were not routinely used in the only RCT on HFNC in infants with bronchiolitis and the authors did not report cases with substantial abdominal distension (12).

The present study had some limitations. It is difficult to say how well the answers given by the head doctors, or by the senior doctors who were responsible for bronchiolitis treatment in the hospitals, reflected the real practices in the departments. On the other hand, our aim was to evaluate whether there were instructions on HFNC treatment for bronchiolitis and, if present, what those recommendations were. Our aim was not to evaluate how the patients were actually treated. The strength of the study is that we received completed questionnaires from all but one of the eligible hospitals and the answers covered more than 77% of all infants born in Finland in 2015 when expressed as a weighted percentage.

Conclusions

The mean incidence of HFNC treatment was 3.8 per 1,000 in infants who were less than 12 months of age, which suggests that HFNC was actively used, but not overused, in bronchiolitis treatment in Finland. We found that 71% of hospitals provided instructions how to start treatment, but only

61% provided instructions for weaning. Instructions are particularly needed for weaning to avoid unnecessary long treatment times. Well-designed randomised controlled studies on HFNC treatment in bronchiolitis are needed before any evidence-based guidelines can be constructed.

Acknowledgements

The authors are grateful to the 17 paediatricians responsible for bronchiolitis treatment, who completed and returned the questionnaires.

References

1. Smyth R, Openshaw P. Bronchiolitis. Review. *Lancet* 2006; 368: 312-22.
2. Mecklin M, Hesselmar B, Qvist E, Wennergren G, Korppi M. Diagnosis and treatment of bronchiolitis in Finnish and Swedish children's hospitals. *Acta Paediatr* 2014;103:946-50.
3. Florin TA, Plint AC, Zorc JJ. Viral bronchiolitis. *Lancet* 2017;389:211-24.
4. Ralston SL, Lieberthal AS, Meissner HC, Alverson BK, Baley JE, Gadomski AM, et al. American Academy of Pediatrics. Clinical practice guideline: the diagnosis, management, and prevention of bronchiolitis. *Pediatrics* 2014;134: e1474-502 .
5. Hutchings FA, Hilliard TN, Davis PJ. Heated humidified high-flow nasal cannula therapy in children. *Arch Dis Cild* 2015;100:571-5.
6. Hough JL, Pham TM, Schibler A. Physiologic effect of high-flow nasal cannula in infants with bronchiolitis. *Pediatr Crit Care Med* 2014;15:e214-9.

7. Sinha IP, McBride AK, Smith R, Fernandes RM. CPAP and high-flow nasal cannula oxygen in bronchiolitis. *Chest* 2015;148:810-23.
8. Mikalsen IB, Davis P, Øymar K. High flow nasal cannula in children: a literature review. *Scand J Trauma Resusc Emerg Med* 2016;24:93.
9. Riese J, Fierce J, Riese A, Alverson B. Effect of hospital-wide high-flow nasal cannula protocol on clinical outcomes and resource utilisation of bronchiolitis patients admitted to the PICU. *Hosp Pediatr* 2015;5:613-7.
10. Heikkilä P, Forma L, Korppi M. High-flow oxygen therapy is more cost-effective for bronchiolitis than standard treatment-A decision-tree analysis *Pediatr Pulmonol* 2016;51:1393-402.
11. Milani GP, Plebani AM, Arturi E, Brusa D, Esposito S, Dell'Era L, et al. Using a high-flow nasal cannula provided superior results to low-flow oxygen delivery in moderate to severe bronchiolitis. *Acta Paediatr* 2016;105:e368-72.
12. Kepreotes E, Whitehead B, Attia J, Oldmeadow C, Collison A, Searles A, Goddard B, et al. High-flow warm humidified oxygen versus standard low-flow nasal cannula oxygen for moderate bronchiolitis (HFWHO RCT): an open, phase 4, randomised controlled trial. *Lancet* 2017; 389:930-39.
13. Franklin D, Dalziel S, Schlapbach LJ, Babl FE, Oakley E, Craig SS, et al. Early high flow nasal cannula therapy in bronchiolitis, a prospective randomised control trial (protocol): A Paediatric Acute Respiratory Intervention Study (PARIS). *BMC Pediatr* 2015;15:183.
14. Pruikkonen H, Uhari M, Dunder T, Pokka T, Renko M. Infants under 6 months with bronchiolitis are most likely to need major medical interventions in the 5 days after onset. *Acta Paediatr* 2014;103:1089-93.

15. Tapiainen T, Aittoniemi J, Immonen J, Jylkkä H, Meinander T, Nuolivirta K, et al. Finnish guidelines for the treatment of laryngitis, wheezing bronchitis and bronchiolitis in children. *Acta Paediatr* 2016;105:44-9.
16. Dysart K, Miller TL, Wolfson MR, Shaffer TH. Research in high flow therapy: mechanisms of action. *Respir Med* 2009;103:1400-5.
17. Frat JP, Thille AW, Mercat A, Girault C, Ragot S, Perbet S, et al. High-flow oxygen through nasal cannula in acute hypoxemic respiratory failure. *N Engl J Med* 2015;372:2185–96.
18. Wing R, James C, Maranda LS, Armsby CC. Use of high-flow nasal cannula support in the emergency department reduces the need for intubation in pediatric acute respiratory insufficiency. Pediatr Emerg Care 2012;28:1117–23.
19. Hegde S, Prodhan P. Serious air leak syndrome complicating high-flow nasal cannula therapy: a report of 3 cases. *Pediatrics* 2013;131:e939-44.
20. Rubin S, Ghuman A, Deakers T, Khemani R, Ross P, Newth CJ. Effort of breathing in children receiving high-flow nasal cannula. *Pediatr Crit Care Med* 2014;15:1–6.
21. Spence KL, Murphy D, Kilian C, McGonigle R, Kilani RA. High-flow nasal cannula as a device to provide continuous positive airway pressure in infants. *J Perinatol* 2007;27:772-5.
22. Milési C, Baleine J, Matecki S, Durand S, Combes C, Novais AR, et al. Is treatment with a high flow nasal cannula effective in acute viral bronchiolitis? A physiologic study. *Intensive Care Med* 2013;39:1088-94.
23. Mayfield S, Bogossian F, O'Malley L, Schibler A. High-flow nasal cannula oxygen therapy for infants with bronciolitis: pilot study. *J Paediatr Child Health* 2014;50:373-8.
24. Long E, Babl FE, Duke T. Is there a role for humidified heated high-flow nasal cannula therapy in paediatric emergency departments? *Emerg Med J* 2016;33:386–9.

25. Heikkilä P, Forma L, Korppi M. Hospitalisation costs for infant bronchiolitis are up to 20 times higher if intensive care is needed. *Acta Paediatr* 2015;104:269-73.

Table 1. Presence of instructions for starting HFNC, for weaning off HFNC, and on the use of nasogastric tubes and intravenous routes, presented as weighted percentages with 95% confidence intervals.

Instructions	Number of hospitals	Percentage	Weighted percentage*
Instructions present for starting HFNC	10	58.8 %	71.1 %
Instructions present for weaning off HFNC	7	41.2 %	60.6 %
Nasogastric tube routinely used during HFNC	9	52.9 %	40.1 %
Short-term fluids given intravenously during HFNC	6	35.3%	30.2 %

*Weighted for the number of infants in the catchment area of the hospital.

Table 2. Weaning time, gas flow and inspired oxygen fraction limits for ending HFNC in infants with bronchiolitis.

Weaning times, gas flows and inspired oxygen fractions (n = number of hospitals)	Medians weighted for numbers of infants in the area (range)
Weaning time (hours), minimum (n=12)	8 (3 – 48) [1]
Weaning time (hours), maximum (n=12)	20 (5 – 48) [2]
Ready to end flow (L/min) minimum (n=13)	4 (2 – 6) [3]
Ready to end flow (L/min) maximum (n=13)	5 (2 – 8) [4]
Ready to end FiO_2 (%) (n=16)	30 (21 – 40) [5]

FiO_2 inspared oxygen fraction

[1] 6(3-12) if instructions present *versus* 24(4-48) if not present ($p<0.001$)

[2] 8(5-24) if instructions present *versus* 24(4-48) if not present ($p<0.001$)

[3] 5(2-6) if instructions present *versus* 3(2-5) if not present ($p<0.001$)

[4] 5(3-6) if instructions present *versus* 4(2-6) if not present ($p<0.001$)

[5] 40(21-40) if instructions present *versus* 21(21-25) if not present ($p<0.001$)

SUPPLEMENTARY MATERIAL

Table S1. Basic data on the hospital districts included in the study, including the incidence of HFNC treatments per 1,000 infants aged less than 12 months in the hospital district.

Hospital district	Number of newborn infants in 2015	Weighted proportion of newborn infants	Number of infants with bronchiolitis treatedwith HFNC (1 November 2015 to 31 May 2016)	Incidence of HFNC treatments per 1,000 infants aged less than 12 months
Southern Ostrobothnia Central Hospital	2,058	0.048	5	2.43
Mikkeli Central Hospital	1,063	0.025	5	4.70
Children's Hospital Helsinki (plus Porvoo hospital)	11,329	0.257	40	3.53
Jorvi Hospital (plus Lohja hospital)	4,889	0.112	28	5.73
Hyvinkää Hospital	1,858	0.043	5	2.69
Central Hospital of Kainuu	586	0.014	20	34.13

Central Hospital of Tavastia	1,560	0.036	2	1.28
Central Hospital of Keski-Pohjanmaa	876	0.020	-	-
Central Finland Central Hospital	2,583	0.060	14	5.42
Kymenlaakso Central Hospital	1,431	0.033	5	3.49
Lapland Central Hospital	1,058	0.024	8	7.56
North Karelia Central Hospital	1,507	0.035	3	1.99
Kuopio University Hospital	2,294	0.053	20	8.71
Päijänne-Tavastia Central Hospital	1,887	0.044	6	3.18
Satakunta Central Hospital	2,012	0.047	8	43.98
Vaasa Central Hospital	1,889	0.044	4	2.12
Turku University Hospital (plus Salo hospital)	4,615	0.107	25	5.42

The annual incidences are calculated from the numbers of bronchiolitis patients hospitalised during the study period without any corrections.The mean age-specific incidence was 3.8 per 1,000 per year. The central hospital of Kainuu was not included in the calculation, because the indications for HFNC treatment differed from other hospitals. The data were not received from the Central Hospital of Keski-Pohjanmaa.