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ORIGINAL ARTICLE

Low readmission rates during neonatal homecare: Gestational age and bronchopulmonary dysplasia as key predictors

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Abstract

Aim: Homecare for neonates has advanced, but combative analysis of contact methods remains unexplored. The aim was to identify predictors of readmission during homecare and to compare home visit, telemedicine or outpatient visit.

Methods: This retrospective study included infants receiving homecare from 1 January 2015 to 31 December 2022. Data were obtained from local databases from six neonatal units in Denmark. The medical records of readmitted infants were reviewed. The main outcome were causes and predictors of readmission during homecare. The secondary outcome was exclusive breastfeeding at discharge.

Results: The cohort consisted of 4827 infants (boys = 54.0%). The rate of unplanned readmissions was 4.6%. A gestational age (GA) <32 weeks (p-value <0.01) or bronchopulmonary dysplasia (BPD) (p-value <0.01) were predictors of readmission. There was no difference in unplanned readmissions based on contact method (p-value = 0.46 for telemedicine, p-value = 0.11 for outpatient visit). The overall exclusive breastfeeding rate at discharge from homecare was 64.1%.

Conclusion: Homecare can be provided for preterm and term infants while establishing oral feeding, with caution on infants with a GA < 32 or BPD. All types of contact methods during homecare investigated can be provided equally in relation to readmission and exclusive breastfeeding.

KEYWORDS
breastfeeding, homecare, neonatal unit, preterm infants, readmission

1 | INTRODUCTION

The last weeks of admission at the neonatal intensive care unit (NICU) mainly focus on ensuring growth and establishment of oral feeding.[1] This period in the NICU can be emotionally exhausting for parents, and they start longing for home.[2] To bring parents and infants together at home as soon as possible, neonatal homecare has been developed. During homecare, the parents manage tube feeding and

Abbreviations: BPD, bronchopulmonary dysplasia; CPR, cardiopulmonary resuscitation; GA, gestational age; HR, hazard ratio; NICU, neonatal intensive care unit; OR, odds ratio; PMA, post menstrual age; SD, standard deviations; SGA, small for gestational age.

establish oral feeding of clinically stable infants at home. Although the infants are clinically stable at discharge, they remain high-risk infants requiring specialised neonatal care.

Homecare originated in the early nineties as an early discharge followed by domiciliary nursing care and home visits.[1] It has later been implemented in several countries worldwide, with home visits from NICU nurses as the primary type of contact.[3]

During homecare, parents have close contact with nurses and if necessary neonatologists for support to monitor infant growth and progression of oral feedings.[3,4] The parents can contact the NICU around the clock. Studies have shown that homecare facilitates a close bond between parents and their infant and does not increase parental anxiety.[5,6]

A study has shown a correlation between homecare and a longer duration of breastfeeding among preterm infants.[7] The calmer home environment is believed to be beneficial for the establishment of breastfeeding.[5] For moderate preterm infants, homecare can contribute to increasing rates of exclusively breastfeeding without compromising growth.[8] Furthermore, homecare is considered safe for most infants, and readmissions are rare.[9]

Over time, telemedicine has been implemented as a contact method during homecare instead of home visits.[10,11] A study has shown that telemedicine reduces the number of hospital visits compared to home visits.[11] Parents report telemedicine as a useful method of communication.[12]

Most studies on readmission and breastfeeding rates during homecare have focused on home visits, with no prior comparisons made between home visits, telemedicine and outpatient visits.

This study had three key aims. The first aim was to identify predictors of unplanned readmission during homecare among preterm and term infants and present the causes of unplanned readmissions. The second aim was to compare baseline characteristics, characteristics at homecare start and at discharge from homecare between readmitted and non-readmitted infants.

The third aim was to compare type of contact during homecare in relation to unplanned readmissions and rates of exclusive breastfeeding at discharge.

Key Notes

- Contact during homecare has traditionally been facilitated through home visits, but telemedicine has been introduced as an alternative.
- Neonatal homecare is a safe model of care for clinically stable neonates, with a low unplanned readmission rate of 4.6%, with 75% being non-acute causes, while acute readmissions were attributed to apnoea and aspiration.
- There was no significant difference in breastfeeding and unplanned readmission rates when comparing home visits, telemedicine or outpatient visits.

2 | METHODS

2.1 | Setting and participants

The study was conducted as a retrospective cohort study. It included two level II NICUs at Herlev Hospital and Hvidovre Hospital. In addition, three level III NICUs at Aarhus University Hospital, Aalborg University Hospital and Odense University Hospital. Finally, one level IV NICU at Rigshospitalet in Denmark.

All infants enrolled in homecare from 1 January 2015 to 31 December 2022 were included in the study.

The criteria for receiving homecare in Denmark are specified in a national guideline published in 2020 by the Danish Paediatric Society.[13] Infants are eligible for homecare when they are clinically stable, do not require vital signs monitoring, have normal thermoregulation and are 34 ± 0 weeks/days of postmenstrual age (PMA). It is the responsibility of a neonatologist to decide when an infant can start homecare. The clinical decision is supported by the recommendations in the national clinical guideline.[13]

Some of the participating NICUs have local additions to the national guideline, with some units not providing homecare before 35 weeks of PMA and/or infant weight of minimum 1500 grams.

The criteria for starting homecare varied between the contact methods. In the home visit group the criteria was 34 or 35 weeks of PMA, and no weight limit or a minimum weight of 1500 grams. In the telemedicine group the criteria was 34 or 35 weeks of PMA and a minimum weight of 1500 g. In the outpatient group, the criteria was 35 weeks of PMA and a minimum weight of 1500 g.

Before enrollment to homecare, the parents are trained in handling the nasogastric feeding tube and informed about early symptoms of sickness. Further, the parents are trained in cardiopulmonary resuscitation (CPR) using a training doll.

The type of contact between the NICU and the parents at home during Homecare differed between home visits, telemedicine and outpatient visits between the NICUs. The home visit group and the telemedicine group had two contacts per week, while the outpatient group had three contacts per week. If required, medical examination, blood test, ultrasound of cerebrum or screening for retinopathy of prematurity was scheduled as outpatient visits at all the NICUs. The criteria for discharge from homecare for all participating NICUs was infant weight gain without supplemental tube feeding.

2.2 | Data collection

The first author collected data from each NICU from January to September 2023. Each NICU had either electronic or paper registration of infants who had received homecare. The electronic files were imported to a database in REDCap (Open Patient data Explorative Network, Region of Southern Denmark, Denmark) developed for the purpose. The paper registrations were manually entered into the database.

TABLE 1 Baseline characteristics on all infants enrolled to NH from 2015 to 2022 according to type of NH.

	Home visit group ($n=3719$)	Telemedicine group ($n=636$)	Outpatient group ($n=461$)	p-value
Baseline				
Male, n (%)[c]	1371 (53.8)	294 (56.0)	246 (53.4)	0.63
Twin, n (%)[c]	1027 (29.0)	133 (21.0)	85 (18.4)	<0.01
Gestational age (weeks)[a]	34.0 (24–42.9)	33.9 (23.6–41.7)	34.1 (24.4–41.9)	<0.01
Birth weight (grams)	2032 (410–4925)	2020 (440–4540)	2172.5 (540–4900)	<0.01
NH start				
Post menstrual age at NH start[a,c]	36.3 (33.3–51.3)	36.0 (33.9–49.6)	36.4 (34.9–45.6)	<0.01
Weight at NH start (grams)[c]	2340 (1280–6080)	2323 (1500–4618)	2495 (1585–4454)	<0.01
NH discharge				
Post menstrual age at NH discharge[a,c]	39.1 (34.4–62.7)	39.0 (35.4–57.6)	38.3 (35.7–53)	<0.01
Weight at NH discharge (grams)[c]	3000 (1950–6840)	2960 (1615–5400)	2865 (1795–5321)	<0.01
Days at NH[a,b]	18 (1–100)	19 (2–93)	11 (1–46)	<0.01

[a]Variables presented as median (min-max).

[b]Excluding days readmitted.

[c]Missing data: sex ($n=1286$), multiple birth ($n=185$), PMA NH start ($n=115$), weight NH start ($n=111$), type of NH ($n=11$), PMA NH discharge ($n=122$), weight NH discharge ($n=109$).

Local registrations for all infants receiving homecare included variables such as gestational age (GA), birth weight, sex and information on singleton or multiple pregnancy.

All participating NICUs documented the type of contact during homecare. At enrolment to homecare and at discharge, PMA, weight and type of nutrition were registered. Exclusive breastfeeding was defined as feeding solely from the mother's breast.

The medical record of each readmitted infant was systemically reviewed from the hospital where the infant was admitted. Data on PMA, weight and type of nutrition by time of readmission were registered.

The cause of readmission, diagnoses, time since respiratory support and caffeine, and duration without vital sign monitoring before starting homecare were recorded. Aspiration and apnoea were defined as acute readmissions.

2.3 | Statistical analyses

Data analyses were performed using STATA 17 (Stata Corporation, College Station, Texas, USA).

Normality tests were conducted through histograms. Continuous variables with non-normal distribution were presented in median, minimum and maximum values. Comparison between non-normal distributed continuous variables were preformed using the Mann–Whitney U-test or the Kruskall-Wallis test.

Categorial variables were presented as numbers and percentages. The categorical variables were compared using a chi-square test and Fisher's exact test. Weights were converted to standard deviation (SD) weight-for-age z-score using a growth reference.[14]

Predictors for unplanned readmission were analysed using Cox regression and presented as hazard ratios (HR) with 95% confidence intervals. HR were interpreted as risk of readmission per day. Infants readmitted from homecare in the study period were identified and grouped as cases in further analyses. Breastfeeding rates were analysed using logistic regressions and presented as odds ratio (OR) with 95% confidence intervals.

Results were considered statistically significant at p-values ≤0.05.

3 | RESULTS

The study cohort comprised 4827 infants who received homecare during the study period, with 92.8% were born preterm. The most common type of contact method during homecare was home visits, followed by telemedicine, and outpatient visits (Table 1). The outpatient group had a shorter duration of homecare, resulting in lower PMA and weight at discharge from homecare (Table 1). There was no significant difference in the number of unplanned readmissions in the home visit or telemedicine group. However, significantly fewer infants were readmitted in the outpatient group ($p<0.01$) (Table 2).

TABLE 2 Baseline characteristics on all infants enrolled to NH from 2015 to 2022, and baseline characteristics on readmitted and non-readmitted infants in the same period.

	All ($n=4827$) (Missing data on +/− readmission for 145 infants)	Readmitted ($n=262$)	Non-readmitted ($n=4420$[e])	*p*-value
Characteristics at birth				
Sex, male, *n* (%)[d]	1913/3541 (54.0)	139 (53.1)	1708 (54.0)	0.88
Multiple birth, *n* (%)[d]				
Twin	1245 (26.8)	79 (30.2)	1131 (25.7)	0.27
Triplets	18 (0.4)	0 (0.0)	18 (0.4)	-
Gestational age (weeks)[a]	34.0 (23.6–42.9)	32.9 (24.1–40.9)	34 (23.6–42.9)	<0.01
<28, *n* (%)	234 (4.8)	37 (14.1)	182 (4.2)	<0.01
28–32, *n* (%)	847 (17.6)	78 (29.8)	748 (16.9)	<0.01
32–36, *n* (%)	3397 (70.4)	135 (51.5)	3164 (71.6)	<0.01
≥37, *n* (%)	349 (7.2)	12 (4.6)	326 (7.4)	0.09
Birthweight (grams)[a]	2044 (410–4925)	1700 (410–4210)	2060 (440–4925)	<0.01
<1000, *n* (%)	228 (4.7)	34 (13.0)	180 (4.1)	<0.01
1000–1500, *n* (%)	671 (13.9)	75 (28.6)	565 (12.8)	<0.01
1500–2000, *n* (%)	1321 (27.4)	58 (22.1)	1234 (27.9)	0.02
2000–2500, *n* (%)	1652 (34.2)	65 (24.8)	1543 (34.9)	<0.01
2500–3000, *n* (%)	700 (14.5)	20 (7.6)	667 (15.1)	<0.01
≥3000, *n* (%)	255 (5.3)	10 (3.8)	231 (5.2)	0.32
z-score <−2SD, *n* (%)	1003 (20.8)	59 (22.6)	897 (20.3)	0.38
Characteristics at NH start				
Post menstrual age (weeks)[a,d]	36.3 (33.3–51.3)	36.4 (34–51.3)	36.3 (33.3–49.6)	0.10
Weight (grams)[a,d]	2360 (1280–6080)	2360 (1395–5970)	2355 (1280–6080)	0.69
z-score <−2SD, *n* (%)	1338 (27.8)	72 (27.5)	1231 (27.9)	0.88
Diagnosis				
Bronchopulmonary dysplasia, *n* (%)	18 (0.4)	15 (5.7)	3 (0.07)	<0.01
Necrotising enterocolitis, *n* (%)	11 (0.2)	10 (3.8)	1 (0.02)	<0.01
Patent ductus arteriosus, *n* (%)	49 (1.0)	37 (14.1)	12 (0.3)	<0.01
Retinopathy of prematurity, *n* (%)	19 (0.4)	18 (6.9)	1 (0.02)	<0.01
Intraventricular haemorrhage ≥3, *n* (%)	11 (0.2)	1 (0.4)	10 (0.2)	0.61
Periventricular leukomalacia, *n* (%)	3 (0.06)	2 (0.8)	1 (0.02)	<0.01
Ventricular septal defect, *n* (%)	11 (0.2)	6 (2.3)	5 (0.1)	<0.01
Syndrome, *n* (%)	36 (0.8)	7 (2.7)	28 (0.6)	<0.01
Oxygen treatment, *n* (%)	11 (0.3)	8 (3.1)	3 (0.07)	<0.01
Type of NH, *n* (%)[d]				
Home visits	3719 (77.2)	207 (79.6)	3378 (76.5)	0.26
Telemedicine	636 (13.2)	43 (16.5)	586 (13.3)	0.13
Outpatient visit	461 (9.6)	10 (3.8)	451 (10.2)	<0.01
Days receiving NH[a,b]	17 (0–100)[f]	24 (0–67)	17 (1–100)	<0.01
Characteristics at NH discharge				
Post menstrual age (weeks)[a,d]	39.0 (34.4–62.7)	40.3 (34.7–55.3)	38.9 (34.4–57.6)	<0.01

(Continues)

TABLE 2 (Continued)

	All ($n=4827$) (Missing data on +/− readmission for 145 infants)	Readmitted ($n=262$)	Non-readmitted ($n=4420$[e])	p-value
Weight (grams)[a,d]	2980 (1615–6840)	3220 (2120–6840)	2980 (1615–6580)	<0.01
Weight gain per day during NH (gram)[a]	33 ((−25)–60)	29 (3–58)	33 ((−14)–60)	<0.01
z-score <−2SD, n (%)	876 (18.2)	45 (17.2)	808 (18.3)	0.66
Exclusive breastfeeding[c], n (%)	2921 (64.1)	132 (50.4)	2769 (65.0)	<0.01
Exclusive breastfeeding twins[c], n (%)	567 (50.4)	31 (39.2)	532 (51.3)	0.04

[a]Variables presented as median (min-max).

[b]Excluding days readmitted.

[c]Defined as feeding solely from the mother's breast.

[d]Missing data: Sex ($n=1286$), multiple birth ($n=185$), PMA NH start ($n=115$), weight NH start ($n=111$), type of NH ($n=11$), PMA NH discharge ($n=122$), weight NH discharge ($n=109$).

[e]Missing information on readmission (yes/no) for 145 infants. These infants are not included in the non-readmitted group.

[f]Infants receiving NH in zero days were readmitted the same day as starting NH. Infants receiving NH in 1 day started NH while almost establishing full oral feeding.

3.1 | Baseline

The baseline characteristics of all infants, including readmitted infants and non-readmitted infants, are presented in Table 2. In total 36 of the infants were diagnosed with a syndrome, with 7 of them having Down syndrome.

Readmitted infants had a significant lower GA and birthweight ($p<0.01$) compared to the non-readmitted infants (Table 2). More of the readmitted infants had diagnoses related to prematurity compared to non-readmitted infants.

Readmitted infants received homecare for a longer period of time resulting in significantly higher PMA and weight at discharge from homecare, compared to the non-readmitted infants ($p<0.01$) (Table 2).

3.2 | Readmissions

Among 4827 infants, 262 infants (5.4%) were readmitted during homecare, of which 40 (15.3%) were planned readmissions, resulting in 222 (4.6%) unplanned readmissions. Of the readmitted infants 95.4% of them were born preterm (Table 2). The planned readmissions included surgery of retinopathy of prematurity, hernia or anastomosis after stoma, monitoring of vital signs for 48 hours after vaccination or readmission as a healthy companion to a twin. Infants with planned readmissions during homecare were excluded from the analysis of predictors of readmission. Infants who were not readmitted during homecare served as a control group for further analysis ($n=4420$, due to missing data on readmission or not for 145 infants, Table 2). The 145 infants missing readmission data had a median gestational age of 33.8 weeks (min-max: 24.3–41.7) and median birthweight of 1930 grams (min-max: 560–3832). Two infants died during homecare, not related to homecare, resulting in a mortality rate of 0.04%. Causes and data from the unplanned readmissions are presented in Table 3. Most infants were readmitted once, while 19 infants (8.6%) experienced more than one unplanned readmission during homecare. Of all unplanned readmissions, only 93 infants (41.9%) received a diagnose. The most frequent diagnoses were upper respiratory tract infection, affecting 23 infants, and icterus, affecting 25 infants. No infants received more than one diagnosis.

The number of days since respiratory support at primary admission varied from zero to 62 days (Table 3). Infants who were readmitted on the same day as receiving respiratory support were those receiving home oxygen.

3.3 | Predictors for infants at risk of unplanned readmission

GA <32+0 at birth was associated with an increased risk of unplanned readmission (Table 4). Most infants started homecare after 35±0 weeks/days of PMA, with only 10% of infants being ready to receive homecare before 35+0 weeks/days of PMA. Infants starting homecare before 34+6 weeks/days of PMA did not have significant more readmissions compared to infants starting homecare after 35±0 weeks/days of PMA (5% vs. 4%, $p=0.37$).

Sub-analyses were made for infants born before 32+0 weeks/days of gestation. A diagnosis of bronchopulmonary dysplasia (BPD) was a significant predictor of readmission ($p<0.01$) in both the crude and adjusted model (Table 4).

3.4 | Nutrition and breastfeeding

All infants had a nasogastric feeding tube when starting homecare. Nutritional information from 2360 infants was registered upon enrollment to homecare. Most infants were in the process of

TABLE 3 Characteristics of unplanned readmissions.

	$n = 222$[a]
Causes for unplanned readmission	
Apnoea, *n* (%)	47 (21.2)
Stimulation at home, *n* (%)	38 (80.9)
CPR at home, *n* (%)	22 (46.8)
Ambulance to hospital, *n* (%)	26 (55.3)
In relation to meal, *n* (%)	23 (48.9)
Aspiration, *n* (%)	9 (4.1)
Stimulation at home, *n* (%)	7 (77.8)
CPR at home, *n* (%)	2 (22.2)
Ambulance to hospital, *n* (%)	7 (77.8)
Impaired growth, *n* (%)	34 (15.3)
Gastrointestinal symptoms, *n* (%)	18 (8.1)
Obstipation, *n* (%)	4 (22.2)
Diarrhoea, *n* (%)	5 (27.8)
Vomiting, *n* (%)	9 (50.0)
Parents' request, *n* (%)	11 (5.0)
Icterus, *n* (%)	25 (11.3)
Respiratory symptoms, *n* (%)	67 (30.0)
Viral infections	68 (30.6)
Positive cultivation	35 (15.8)
Negative cultivation	33 (14.9)
Other, *n* (%)	33 (14.9)
Unplanned readmission data	
Days on NH before readmission[b]	8 (0–55)
Days of readmission[b]	2 (0–38)
Emergency call, *n* (%)	36 (18.2)
Transportation by ambulance, *n* (%)[c]	31 (15.5)
Days since[b]	
Respiratory support	21 (0–62)
Caffein	21 (3–61)
Monitoring	12 (0–56)
Season for readmission, *n* (%)	
Summer	89 (44.5)
Winter (October–March)	111 (55.5)
NH again after readmission, *n* (%)	165 (82.5)

[a]42 infants were readmitted with more than one symptom.
[b]Variables presented as median (min-max).
[c]Two infants were readmitted with both apnoea and aspiration as symptom. Consequently 31 infants were transported by ambulance and not 33 infants as listed under "Causes for readmission".

establishing breastfeeding rather than bottle feeding (65% vs. 35%) when starting homecare.

Nutritional information from 4557 infants was registered at discharge from homecare. Exclusive breastfeeding at discharge was obtained for 2921 infants (64.1%) (Table 2). A total of 685 infants were partially breastfed at discharge and received either mother's own milk, infant formula or a combination in a bottle as supplement to breastfeeding. Eighteen infants were unable to establish oral feeding and were discharged from homecare with continued tube feeding. If readmitted unplanned, the infant had a 38% lower chance of establishing breastfeeding (OR 0.62, 95% CI 0.48–0.82) (Table 5), also demonstrated by a significant lower rate of exclusive breastfeeding at discharge among the unplanned readmitted infants (65.0% vs. 50.4%, $p < 0.01$) (Table 2). Nutrition among unplanned readmitted infants is presented in Table 6.

When comparing type of contact during homecare, there was no significant difference in rates of exclusive breastfeeding at discharge from homecare (Table 5).

4 | DISCUSSION

To our knowledge, this is the largest study identifying predictors of unplanned readmission, readmission rates and breastfeeding outcomes according to type of contact method used during homecare. We identified a readmission rate of 4.6%, of which 75.0% were non-acute. Apnoea and aspiration were classified as acute readmissions. Previous studies have described unplanned readmissions rates of 5.2%[9] and 10.4%,[15] though these studies had smaller populations. To make further conclusions on the safety of homecare, comparisons should be made with infants not receiving homecare. Unfortunately, data from these infants were not available. It must also be considered that infants, who are not offered homecare, are often not clinically stable and are therefore at a higher risk of adverse events, making this comparison challenging.

Preterm birth has been associated with an increased risk of respiratory morbidity.[16] This can explain the main cause for readmission to be respiratory symptoms followed by apnoea. A total of 24 parents of infants with unplanned readmission provided CPR to their infant at home, which underlines the importance of thorough training of the parents prior to homecare.

The mortality rate of 0.04% was lower compared to other studies.[9,17] Preterm birth is known to increase infant mortality and the risk of sudden infant death syndrome (SIDS).[17–19] Most cases of SIDS happen after term age at which point the infants most likely already will be discharged from homecare.[17,18] No infants died of SIDS in this study.

The results indicates that the risk of unplanned readmission increased with decreased GA. Another study identified GA < 28 or GA ≥ 37 weeks as significant predictors of readmissions,[9] which differ from this study, probably due to population size.

For infants with born at less than 32 weeks of GA, BPD was also a significant predictor of unplanned readmission, which is similar to findings from Lundberg et al.[9] BPD is known to be associated with preterm birth and increased risk of readmission after discharge from the NICU.[16] These findings indicate that careful consideration should be given when offering homecare to infants with BPD.

We found no association between weight at start of homecare and unplanned readmission. Our national clinical guideline does not include a weight criteria for starting homecare.[13] Our data showed that

TABLE 4 Predictors for unplanned readmission during NH—crude and adjusted Cox regression.

	Number ($n = 4787$[a])	Hazard ratio (95%CI)	*p*-value	Adjusted Hazard ratio[b] (95% CI)	*p*-value
Gestational age (weeks)					
<28	220	2.56 (1.58–4.13)	<0.01	2.49 (1.48–4.19)	<0.01
28–31.9	838	2.19 (1.60–2.98)	<0.01	2.26 (1.62–3.14)	<0.01
32–36.9 (base)	3381	1 (Reference)		1 (Reference)	
≥37	348	0.63 (0.28–1.44)	0.27	0.51 (0.19–1.40)	0.19
SGA					
No (base)	3788	1 (Reference)		1 (Reference)	
Yes	999	1.00 (0.71–1.41)	1.00	0.93 (0.65–1.34)	0.71
Multiple birth[d]					
Single (base)	3356	1 (Reference)		1 (Reference)	
Twin	1228	1.10 (0.81–1.49)	0.56	1.11 (0.80–1.53)	0.53
Triplets	18	-	-	-	-
PMA at NH start (weeks)					
≤34.9 (base)	551	1 (Reference)		1 (Reference)	
≥35.0	4236	1.70 (1.05–2.76)	0.03	2.10 (1.20–3.66)	0.01
Weight at NH start (grams)					
≤1500	58	1.66 (0.52–5.26)	0.39	2.02 (0.63–6.45)	0.24
1500–2000	704	1.38 (0.95–2.03)	0.09	1.39 (0.93–2.09)	0.11
2000–2500 (base)	2275	1 (Reference)		1 (Reference)	
2500–3000	1295	1.23 (0.86–1.74)	0.25	1.05 (0.73–1.52)	0.79
≥3000	455	1.54 (0.96–2.51)	0.08	1.09 (0.63–1.88)	0.77
Type of NH[d]					
Home visit (base)	3688	1 (Reference)		1 (Reference)	
Telemedicine	628	1.15 (0.79–1.68)	0.46	1.10 (0.71–1.72)	0.66
Outpatient visit	460	0.56 (0.27–1.14)	0.11	0.63 (0.28–1.39)	0.25
Season readmission					
Summer	89	1 (Reference)		-	-
Winter (Oct–March)	111	1.05 (0.79–1.39)	0.73	-	-
BPD[c]					
No (base)	1044	1		1	
Yes	14	20.44 (10.74–38.89)	<0.01	17.83 (7.21–44.04)	<0.01
Oxygen at home[c]					
No (base)	1050	1		1	
Yes	8	22.12 (9.50–51.55)	<0.01	2.37 (0.75–7.56)	0.14

[a]Excluding planned readmission ($n = 40$).

[b]Adjusted for GA, SGA, multiple birth, PMA at NH start, weight at NH start and type of NH. Variables BPD and oxygen at home also adjusted for BPD and oxygen at home.

[c]Sub-analyses for infants with GA < 32.0 weeks. $N = 1058$, excluding infants with planned readmission.

[d]Missing data: multiple birth ($n = 185$), Type of NH ($n = 11$).

infants with weight down to 1280 grams were offered homecare, and weight was not a predictor for unplanned readmission. This indicates that a minimum infant weight should not be a criteria for homecare.

Only 41.9% of the infants with an unplanned readmission received a diagnose. This is likely due to missing registration of diagnosis or physician unable to make a diagnosis.

A longer duration of homecare among infants with unplanned readmission compared to non-readmitted infants was observed in this study and also found by Lundberg et al.[9] This may indicate that infants with unplanned readmissions were more complex from baseline in terms of diagnoses. Their homecare program was more affected by complications compared to non-readmitted infants.

TABLE 5 Exclusive breastfeeding according to type of NH and unplanned readmission.

	n (%)	OR (95% CI)	*p*-value
Exclusive breastfeeding			
Home visits (base)	2278 (63.7)	1 (Reference)	
Telemedicine	407 (65.4)	1.08 (0.90–1.29)	0.40
Outpatient visit	240 (65.9)	1.10 (0.88–1.39)	0.39
Exclusive breastfeeding, twin			
Home visits (base)	594 (51.3)	1 (Reference)	
Telemedicine	72 (53.7)	1.10 (0.77–1.58)	0.59
Outpatient visit	31 (50.0)	0.95 (0.57–1.58)	0.84
Exclusive breastfeeding, unplanned readmission			
No (base)	4420 (95.2)	1 (Reference)	
Yes	222 (4.8)	0.62 (0.47–0.81)	<0.01

TABLE 6 Nutritional information of unplanned readmitted infants.

	n (%)
At NH start	
Feeding type	
Breastfeeding	165 (85.1)
Bottle feeding	29 (15.0)
Bottle or gastric tube content	
Mother's milk only	144 (76.2)
Mixed feeding	31 (16.4)
Formula milk	14 (7.4)
At unplanned readmission	
Feeding type	
Breastfeeding	149 (78.4)
Bottle feeding	41 (21.6)
Bottle or gastric tube content	
Mother's milk only	145 (77.1)
Mixed feeding	20 (10.6)
Formula milk	23 (12.2)
At NH discharge	
Feeding type	
Exclusive breastfeeding	117 (53.7)
Breast- and bottle feeding	30 (13.8)
Bottle feeding	68 (31.2)
Gastric tube	3 (1.4)
Bottle or gastric tube content	
Mother's milk only	26 (28.3)
Mixed feeding	27 (29.4)
Formula milk	39 (42.4)

When comparing types of homecare, there was no difference in rates of unplanned readmissions and exclusive breastfeeding. A study comparing homecare with telemedicine or outpatient visits found no significant difference in breastfeeding (66.7% vs. 66%).[20] Other studies found breastfeeding rates of 78%[8] with telemedicine in infants with born at less than 32 weeks of GA and 65%[15] with home visits. This indicates that contact method during homecare does not affect establishment of breastfeeding. However, these studies defined exclusive breastfeeding as being fed solely with mother's own milk, and not solely from the mother's breast as in this study. One study has shown association with longer duration of breastfeeding after homecare.[7] Unfortunately, we did not have data on duration of breastfeeding, so we are unable to draw any conclusion on this.

Significantly fewer infants were unplanned readmitted in the outpatient group. This may be explained by more contacts per week and easier to observe and evaluate by a neonatologist due to physical attendance at the NICU. The outpatient group had a higher PMA and weight at start of homecare, and a shorter duration of homecare, which contributes to lower risk of readmission. The infants in the outpatient group also had a lower PMA at discharge. Having three contacts per week allow for faster weaning from tube feeding compared to two contacts per week, which might explain the lower PMA at discharge from homecare.

Most infants were offered home visits during homecare, which is the most traditional type of contact in Denmark. Studies have shown high satisfaction among parents when offered homecare using telemedicine.[11] Further, high rates of exclusive breastfeeding when using telemedicine in homecare has been demonstrated.[8] Combined with the results from this study, it suggests that telemedicine can be implemented in homecare without negatively affecting establishment of exclusive breastfeeding. We did not have nutritional information from all infants by the start of homecare. Thus we cannot determine if the type of homecare had any impact on the establishment of breastfeeding during homecare.

A significant decline in breastfeeding occurred among unplanned readmitted infants from start to end of homecare. This suggests the need for increased support for parents in establishing breastfeeding during and after unplanned readmissions, as the stress from readmission can negatively affect breastfeeding.

Homecare facilitates the possibility for infants in need of tube feeding to be at home while establishing oral feeding and is warranted by parents. Most parents wish to start homecare, as demonstrated in a study in which only 7 out of 103 parents declined to receive homecare.[8] It is unknown if there are differences in the characteristics of the infants offered homecare between the participating NICUs, and how the type of homecare affects the parents. Studies have shown parental satisfaction during homecare,[5,6] with parents feeling in control with a lifeline to the NICU.[21] Only 5.0% out of the 222 unplanned readmitted in our study were readmitted on parental request, which indicates that parents felt secure during homecare.

4.1 | Strengths and limitations

The strengths of this study were a large sample size, large number of variables, and a national perspective with multicentre data collection. Data were collected continuously during homecare, which minimised the risk of recall bias.

The limitations were differences in data due to the retrospective data from the six NICUs. The numbers of missing data are listed in Table 2. Data on nutrition and diagnosis at enrollment to homecare were only registered for some infants. The missing data for infants was not possible to recollect for those not readmitted during the study period. The study was only granted access to medical files of the readmitted infants, why missing data on diagnoses on some non-readmitted infants occurred. This may have led to misinterpretation when comparing diagnoses between unplanned readmitted and non-readmitted infants.

It should be noted that there were significant differences in infant characteristics when comparing the types of contact, which were attributed to the difference in group sizes (Table 1). While these results were statistically significant, the effect size is likely not clinically relevant. Telemedicine is relatively new, and outpatient visits as the primary type of contact were restricted to one, limiting the amount of available data.

5 | CONCLUSION

Our study demonstrated that neonatal homecare can be provided in the discharge process of preterm and term infants in need of tube feeding while transitioning to oral feeding. Unplanned readmissions were rare with predominantly non-acute causes. Extra caution on infants born extremely and very preterm is recommended due to increased risk of unplanned readmission. The type of contact method during neonatal homecare had no impact on infant outcomes, such as unplanned readmissions and breastfeeding rates.

AUTHOR CONTRIBUTIONS

Charlotte Hoeyer Rosenbaek: Conceptualization; data curation; investigation; writing – original draft; writing – review and editing. **Gitte Zachariassen:** Conceptualization; supervision; writing – original draft; writing – review and editing. **Bente Hoest:** Conceptualization; resources; writing – review and editing. **Gitte Holst Hahn:** Conceptualization; resources; writing – review and editing. **Joan Neergaard Larsen:** Conceptualization; resources; writing – review and editing. **Tenna Gladbo Salmonsen:** Conceptualization; resources; writing – review and editing. **Malene Horskjaer:** Conceptualization; resources; writing – review and editing. **Kristina Garne Holm:** Conceptualization; supervision; writing – original draft; writing – review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

ETHICS STATEMENT

The project was approved by the Head of Department of the participating NICUs. The Danish Data Protection Agency (Journal no. 22/47531) and the ethical committee (Journal no. 22/50236) in the Region of Southern Denmark approved the study. Due to the ethical approvals parental consent was not obtained for this study.

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