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ORIGINAL ARTICLE

Association of early discharge with increased likelihood of hospital readmission in first four weeks for vaginally delivered neonates

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Abstract

Aim: The main aim was to determine whether hospital readmission rates by 28 days of age are elevated with early discharge (ED) in Finland. We sought to identify the causes and predictors of ED, readmission rates, admissions to the intensive care unit (ICU) and death.

Methods: The data of 333,321 infants were retrieved from nationwide registers. Vaginally delivered single infants at gestational ages (GAs) of $\geq 37^{+0}$, born in 2008–2015 and treated in any maternity ward in Finland, were included. ED was defined as discharge on the day of birth or after one night stay on the maternity ward.

Results: During the study period, the ED and hospital readmission rates increased. Low-risk infants and those born in high population-density areas were more likely to be discharged early. ED predicted hospital readmission but not ICU admission or death. The most common reason for readmission was jaundice, followed by infection. ED seemed not to predict severe cardiologic problems. Rather than ED, being born at 38^{+0}–38^{+6} weeks' GA significantly predicted ICU admission or death.

Conclusion: Early discharge seems to be associated with increased hospital readmission. Birth at 38^{+0}–38^{+6} weeks' GA was a significant predictor of ICU admission or death, as opposed to early discharged infants.

KEYWORDS
early discharge, full-term, hospital readmission, newborn discharge timing

1 | INTRODUCTION

Since the 1970s, the lengths of the hospital stay (LOSs) for newborns and their mothers after uncomplicated vaginal deliveries have steadily shortened, especially in developed countries, for example, in the United States, Canada and Sweden.[1–3] Early discharge (ED) has several advantages, including reduced costs, reduced risk of iatrogenic infection and the opportunity for the mother and infant to

Abbreviations: AGA, appropriate for gestational age; CCHD, critical congenital heart defect; CI, confidence interval; CRHC, care register for health care; ED, early discharge; GA, gestational age; ICU, intensive care unit; IQR, interquartile range; LGA, large for gestational age; LOS, length of hospital stay; MBR, Medical Birth Register; Md, median; OR, odds ratios; SD, standard deviation; SF, Statistics Finland; SGA, small for gestational age; THL, Finnish institute for health and welfare.

recover in a familiar, home environment.[3,4] However, ED may hold potential risks. As an example, critical congenital heart defects (CCHDs), jaundice and gastrointestinal obstructions may not appear within one to two days after birth.[5–9] ED may also lead to fewer opportunities for healthcare practitioners to guide breastfeeding and parenting.[10]

Reduced LOSs have been associated with increased readmission rates, especially due to jaundice.[10] According to a report from California (1992–1995), discharging a neonate on the day of birth increased the risk of infant readmission.[4] However, no significant risk was detected if the newborn was discharged one day after birth. In Finland, the average LOS for newborns decreased from 3.7 days in 2006 to 2.9 days in 2015.[11,12] In total, 5.7% of neonates were discharged at 0–1 days' age and 27.4% at 2 days' age in 2015.[12] There are many recent studies concerning early postpartum discharge, but sparse information is available in the Nordic countries concerning the outcomes of healthy term neonates discharged early from delivery hospitals. Therefore, the aim of this study was to investigate whether ED after uncomplicated vaginal delivery is associated with increased hospital readmission rates by the time infants reach 28 days old. The authors also aimed to establish the causes and predictors of ED, along with readmission rates, admissions to the intensive care unit (ICU) and death.

Key Notes

- The early discharge (less than two nights' stay) and hospital readmission rates increased among low-risk newborns born in Finland.
- Infants discharged early had an increased risk of readmission to hospital but not of admission to the intensive care unit (ICU) or death, by 28 days' age.
- Being born at 38^{+0}–38^{+6} weeks' gestational age predicted admission to the ICU or death by 28 days' age.

2 | PATIENTS AND METHODS

2.1 | Selection of the study population

The number of live births in Finland from 2008 to 2015 was 471,232.[13] A national register study included 333,321 vaginally delivered, liveborn single babies at gestational ages (GAs) of $\geq 37^{+0}$ weeks treated on a maternity ward. Infants born via caesarean section were excluded since they usually stay in the hospital longer given their mothers' indications. Also, infants born out of the hospital, admitted after birth to the neonatal ICU, or admitted after birth to another paediatric ward at the same or another hospital, were excluded. Infants with chromosomal anomalies were included only if those anomalies were detected after the perinatal period. Finally, 412 infants and mothers with missing information on the date of discharge, or who were discharged when the infant's age was more than 28 days, and 13,230 newborns with discrepant data across the registers, were excluded.

In Finland, paediatricians examine all newborns before discharge. If the check-up occurs when the infant is <24 h old, newborns are invited to a prescheduled re-examination by the paediatrician, usually at three to five days of age. Infants discharged at the age of <48 h and infants with risk factors will be referred to check-up to outpatient clinic run by a midwife at the hospital. In the remaining cases, a public healthcare nurse checks the newborn at 3–7 days of age.

Data on infants and mothers were collected from the Medical Birth Register (MBR), run by the Finnish Institute for Health and Welfare (THL). This register includes data on livebirths and stillbirths at birthweights of at least 500 g or GAs of at least 22^{+0} weeks. The MBR's data sources are maternity hospitals and the Population Information System headed by the Digital and Population Data Services Agency and Cause-of-Death Register, Statistics Finland (SF). The validity of the MBR has been proven reliable.[14,15]

Data on readmissions and hospital stays were collected from the Care Register for Health Care (CRHC), also maintained by the THL. The CRHC contains information on admissions, discharges, diagnoses, procedures and interventions. The dates and causes of death were obtained from SF. The information from the MBR, CRHC and SF was linked individually via each infant's anonymised personal identity code made by recordkeeping authorities.

2.2 | Exposure

Neonates were analysed in three groups according to their discharge days: (1) discharged on the day of birth (1st day), (2) discharged one day after birth (2nd day) and (3) discharged beyond day after birth (after 2nd day). Infants discharged on the 1st or 2nd day were defined as discharged early.

The covariates included can be seen in Tables 1 and 2. Regions were divided according to five university hospital areas: southern (population density ~87/km^2), eastern (~13/km^2), northern (~5/km^2), western (~27/km^2) and southwestern (~34/km^2). GAs were categorised as 37^{+0}–38^{+6} (early term), 39^{+0}–40^{+6}, 41^{+0}–41^{+6} and $\geq 42^{+0}$ (post-term). Small for gestational age (SGA) and large for gestational age (LGA) were defined as a birthweight of ≤−2 or ≥+2 standard deviations (SDs), respectively, according to the national sex-specific standard.[16]

Causes of readmission were categorised into 11 groups according to the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10), as follows: lower respiratory infectious diseases (J09–J18, J20–J22 and A37); other infectious diseases (A02.1, A40, A41, P36, A04.3, A39, A85, A87 and B00) including inflammatory diseases of the central nervous system (G00–G09), soft tissue infections (A46, H00.03, L03, H05.0 and P38), bone and joint infections (M00, M86) and urinary tract infections (N10, N12, N39.0 and P39.3); and gastrointestinal problems including congenital lactase deficiency (E73.0), gastrointestinal obstruction and acute

TABLE 1 Characteristics of infants and their mothers

Day of discharge	1st day (*n* = 2,089; 0.6%)		2nd day (*n* = 24,296; 7.3%)		After 2nd day (n=306,936; 92.1%)		*p*-Value* 1st day vs. after 2nd day	2nd day vs. after 2nd day
Mother								
Age (years), *n* (%)							<0.001	<0.001
<20	11	(0.5)	120	(0.5)	7,056	(2.3)		
20–24	238	(11.4)	2,904	(12.0)	48,680	(15.9)		
25–29	665	(31.8)	7,626	(31.4)	98,087	(32.0)		
30–34	723	(34.6)	8,973	(36.9)	99,394	(32.4)		
35–39	379	(18.1)	3,969	(16.3)	44,095	(14.4)		
≥40	73	(3.5)	704	(2.9)	9,624	(3.1)		
Marital status, *n* (%)								
Married	1,305	(62.5)	15,089	(62.1)	17,7209	(57.7)	<0.001	<0.001
Cohabiting	1,905	(91.4)	22,560	(92.9)	278,246	(90.8)	0.601	<0.001
Socioeconomic group, *n* (%)							<0.001	<0.001
Upper-level employees	727	(34.8)	9,514	(39.2)	135,694	(44.2)		
Lower-level employees	3	(0.1)	50	(0.2)	1,071	(0.3)		
Entrepreneurs	59	(2.8)	626	(2.6)	7,031	(2.3)		
Manual workers	230	(11.0)	2,377	(9.8)	34,446	(11.2)		
Students	149	(7.1)	1,915	(7.9)	28,800	(9.4)		
Pensioners	0	(0.0)	2	(0.0)	91	(0.0)		
Others[1]	107	(5.1)	975	(4.0)	11,160	(3.6)		
BMI, *n* (%)							<0.001	<0.001
<18.5	84	(4.0)	915	(3.8)	11,411	(3.7)		
18.5–24.9	1,326	(63.6)	15,644	(64.5)	192,102	(62.8)		
25–29.9	395	(18.9)	4,770	(19.7)	63,680	(20.8)		
≥30	184	(8.8)	2,280	(9.4)	33,058	(10.8)		
Pregnancy								
Primipara, *n* (%)	37	(1.8)	580	(2.4)	97,739	(31.8)	<0.001	<0.001
Previous miscarriages, *n* (%)	521	(24.9)	5,887	(24.2)	64,780	(21.1)	<0.001	<0.001
Smoking, *n* (%)							<0.001	<0.001
Stopped smoking during 1st trimester	90	(4.3)	1,214	(5.0)	18,119	(5.9)		
Smoked after 1st trimester	298	(14.3.)	2,626	(10.8)	26,385	(8.6)		
Prenatal visits								
Median (IQR)	13	(11–16)	14	(12–16)	15	(13–18)	<0.001	<0.001
At the hospital clinic, median (IQR)	2	(1–3)	2	(1–3)	3	(1–4)	<0.001	<0.001
Insulin treatment started during pregnancy, *n* (%)	10	(0.5)	212	(0.9)	4,530	(1.5)	<0.001	<0.001
Gestational diabetes[2], *n* (%)	18	(0.9)	921	(3.8)	29,862	(9.7)	<0.001	<0.001
Delivery								
Birth hospital level, *n* (%)							<0.001	<0.001
University	566	(27.1)	8,625	(35.5)	102,229	(33.3)		

(Continues)

TABLE 1 (Continued)

Day of discharge	1st day (n = 2,089; 0.6%)		2nd day (n = 24,296; 7.3%)		After 2nd day (n=306,936; 92.1%)		p-Value* 1st day vs. after 2nd day	p-Value* 2nd day vs. after 2nd day
Central	1,030	(49.3)	10,500	(43.2)	149,333	(48.7)		
Other[3]	493	(23.6)	5,171	(21.3)	55,374	(18.0)		
Gestational age, n (%)							<0.001	<0.001
37^{+0}–37^{+6}	31	(1.5)	341	(1.4)	12,265	(4.0)		
38^{+0}–38^{+6}	159	(7.6)	2389	(9.8)	37,759	(12.3)		
39^{+0}–40^{+6}	1,371	(65.6)	15,242	(62.7)	178,741	(58.2)		
41^{+0}–41^{+6}	452	(21.6)	5,427	(22.3)	64,645	(21.1)		
$\geq 42^{+0}$	76	(3.6)	897	(3.7)	13,525	(4.4)		
Mode of vaginal delivery, n (%)							<0.001	<0.001
Normal vaginal	2,062	(98.7)	23,644	(97.3)	273,409	(89.1)		
Breech delivery	9	(0.4)	117	(0.5)	1,983	(0.6)		
Instrumental delivery[4]	18	(0.9)	535	(2.2)	31,544	(10.3)		
Time of birth, n (%)							<0.001	<0.001
Morning (8:00 AM–3:00 PM)	474	(22.7)	6,211	(25.6)	85,293	(27.8)		
Evening (3:00 PM–10:00 PM)	55	(2.6)	3,470	(14.3)	99,241	(32.3)		
Night (10:00 PM–8:00 AM)	1,559	(74.6)	14,612	(60.1)	122,195	(39.8)		
Day of birth, n (%)							0.752	0.924
Weekday	1,544	(73.9)	17,890	(73.6)	225,922	(73.6)		
Weekend	545	(26.1)	6,406	(26.4)	81,014	(26.4)		
Newborn								
Sex, male, n (%)	1,045	(50.0)	11,965	(49.2)	153,822	(50.1)	0.934	0.009
Birthweight, mean (IQR)[5]	3,612	(3,350–3,865)	3,626	(3,350–3,880)	3,566	(3,260–3,860)	<0.001	<0.001
SGA	2	(0.1)	34	(0.1)	3,889	(1.3)		
AGA	2,079	(99.5)	24,067	(99.1)	297,598	(97.0)		
LGA	8	(0.4)	195	(0.8)	5,431	(1.8)		
Resuscitation, n (%)	1	(0.0)	22	(0.1)	424	(0.1)	0.267	0.052
One-min Apgar 0–6, n (%)	13	(0.6)	267	(1.1)	9,708	(3.2)	<0.001	<0.001
Phototherapy, n (%)	19	(0.9)	246	(1.0)	12,836	(4.2)	<0.001	<0.001

Note: *p-values were tested via Pearson's chi-squared test or Kruskal–Wallis test. IQR= interquartile range.

[1]Others include, for example, unemployed and full-time mothers.

[2]Mothers' diabetes: gestational diabetes= O24; DM1= E10; DM2= E11.

[3]Other include regional hospitals and healthcare centres.

[4]Instrumental delivery includes, for example, forceps and vacuum extraction. [5]Birthweight.

Abbreviations: AGA, appropriate for gestational age; LGA, large for gestational age; SGA, small for gestational age.

abdomen (K31.1, Q40.0, K40.3, K56, P76, Q41, Q42, Q43.1, R10.0, K63.1 and K65), hepatic failure (K72), gastrointestinal haemorrhage (K92, P54.0 and P54.1) and biliary atresia (Q44.29). Diagnoses P57–P59 and R17 were categorized as jaundice. Haematologic problems included haemolytic anaemia (D59), coagulation disorder (D65, D66) and haemolytic disease of the foetus and newborn (P55 and P56). Hypoglycaemia and inadequate nutrition included hypoglycaemia (P70.4), dehydration (P74.1 and E86), insufficient feeding (P92.3, P98.2 and E40–E46) and abnormal weight loss (R63.4). Cardiologic problems included hypertension (I15), endocarditis and myocarditis (I38 and I51.4), cardiac arrest (I46), paroxysmal tachycardia (I47), heart failure (I50), persistent foetal circulation (P29.31) and cardiac defects (Q20, Q21.30, Q25.1, Q25.21, Q25.6, I35.0 and I37.0). Neurologic problems included convulsions (G40, G41, P90 and G47.3), intracranial

TABLE 2 Predictors of early discharge after birth

	All	Early discharge (ED) (*N* = 26,385)				
		ED (*n* = 26,385)		Multivariable adjusted for ED*		
	(*N* = 333,321)	*n*	(%)	*p*	OR	(95% CI)
Mother						
Primipara						
No	234,965	25,768	(11.0)		1	
Yes	98,356	617	(0.6)	<0.001	0.05	(0.04, 0.05)
BMI						
18.5–30	278,593	22,184	(8.0)	<0.001	1	
<18.5	12,410	999	(8.0)	0.007	1.10	(1.02, 1.18)
≥30	35,732	2,477	(6.9)	<0.001	0.82	(0.78, 0.86)
Age						
25–29 years	106,378	8,291	(7.8)	<0.001	1	
<25 years	59,009	3,272	(5.5)	<0.001	0.91	(0.87, 0.95)
30–34 years	123,684	11,084	(9.0)	<0.001	0.91	(0.88, 0.93)
≥35 years	44,250	3,737	(8.4)	<0.001	0.75	(0.72, 0.78)
Smoking						
No	277,189	21,469	(7.7)	<0.001	1	
Yes	48,732	4,228	(8.7)	<0.001	1.27	(1.23, 1.32)
Gestational age						
39+0–40+6	195,354	16,613	(8.5)	<0.001	1	
37+0–37+6	12,637	372	(2.9)	<0.001	0.36	(0.33, 0.41)
38+0–38+6	40,307	2,548	(6.3)	<0.001	0.77	(0.74, 0.81)
41+0–41+6	70,524	5,879	(8.3)	0.10	1.02	(1.00, 1.06)
≥42+0	14,498	973	(6.7)	0.007	0.91	(0.85, 0.97)
Mode of vaginal delivery						
Normal vaginal	29,915	25,706	(8.6)	<0.001	1	
Breech delivery	2,109	126	(6.0)	0.09	0.84	(0.70, 1.03)
Instrumental delivery[1]	32,097	553	(1.7)	<0.001	0.30	(0.27, 0.33)
Time of birth						
Morning (8:00 AM–3:00 PM)	91,978	6,685	(7.3)	<0.001	1	
Evening (3:00 PM–10:00 PM)	102,766	3,525	(3.4)	<0.001	0.46	(0.44, 0.48)
Night (10:00 PM–8:00 AM)	138,366	16,171	(11.7)	<0.001	1.76	(1.70, 1.81)
Place of birth						
University hospital	111,420	9,191	(8.2)	<0.001	1	
Central hospital	160,863	11,53	(7.2)	<0.001	0.65	(0.63, 0.68)
Other[2]	61,038	5,664	(9.3)	<0.001	0.68	(0.64, 0.70)
University hospital's catchment area						
Southern	131,202	14,260	(10.9)	<0.001	1	
Eastern	45,158	2,301	(5.1)	<0.001	0.35	(0.34, 0.37)
Northern	53,673	1,029	(1.9)	<0.001	0.12	(0.11, 0.13)
Western	54,030	5,154	(9.5)	<0.001	0.69	(0.66, 0.71)
Southwestern	48,634	3,580	(7.4)	<0.001	0.53	(0.51–0.56)

(Continues)

TABLE 2 (Continued)

	All (N = 333,321)	Early discharge (ED) (N = 26,385) ED (n = 26,385) n	(%)	Multivariable adjusted for ED* p	OR	(95% CI)
Newborn						
Sex						
Female	166,489	13,375	(8.0)		1	
Male	166,832	13,010	(7.8)	0.15	0.98	(0.96, 1.01)
One-min Apgar						
7–10	323,121	26,093	(8.1)		1	
0–6	9,988	280	(2.8)	<0.001	0.51	(0.45, 0.58)
Birthweight[3]						
AGA	323,744	26,146	(8.1)	<0.001	1	
SGA	3,925	36	(0.9)	<0.001	0.13	(0.09, 0.18)
LGA	5,634	203	(3.6)	<0.001	0.38	(0.33, 0.44)
Phototherapy						
No	320,220	26,120	(8.2)		1	
Yes	13,101	265	(2.0)	<0.001	0.39	(0.34, 0.43)
Year of birth						
2008–2009	85,714	4,986	(5.8)	<0.001	1	
2010–2012	127,082	9,935	(7.8)	<0.001	1.40	(1.35, 1.46)
2013–2015	120,525	11,464	(9.5)	<0.001	1.87	(1.81, 1.94)

Note: *Multivariable-adjusted logistic regressions were used, and results are shown by odds ratios (ORs) with 95% confidence intervals (CIs).
1: Instrumental delivery including, for example, forceps and vacuum extraction.
2: Other includes regional hospitals and healthcare centres. 3: Birthweight.
Abbreviations: AGA, appropriate for gestational age; LGA, large for gestational age; SGA, small for gestational age.

haemorrhages (P52.0 and I60–169) and malformations of the central nervous system (Q00–Q07). Injuries were categorised as S00–T74. The category of other included social problems (Z59, Z63, Z75 and Z81) and neonatal withdrawal symptoms (P96.1 and P04). Mild conditions, which could not be included in any category, were defined as 'miscellaneous, minor causes'—for example, medical observations and suspicions of diseases or conditions.

2.3 | Outcomes

The main endpoint was infant readmission to any hospital ward after discharge by the age of 28 days. The secondary measures were the causes and predictors of ED, ICU admissions or death by the time infants were 28 days old. The causes of ICU admissions and detailed factors of deaths were clarified.

2.4 | Statistical analyses

Either Pearson's chi-squared test, the Kruskal–Wallis test or Cochran–Armitage trend test was used in group comparisons, as appropriate. Potential predictors of ED, readmission, ICU admission and/or death were analysed via multivariable logistic regression analysis. The covariates used can be seen in Table 3. Risk factors of readmission were analysed by dividing the groups into three categories (1st, 2nd and after 2nd day discharge) and into two categories (ED and discharge after the 2nd day). The results were presented as odds ratios (ORs) and 95% confidence intervals (CIs).

Statistical analyses were performed with IBM SPSS Statistics for Windows, versions 24 and 25 (IBM Corp., released 2013). A *p*-value of < 0.05 was considered statistically significant.

2.5 | Missing data

The date of hospital discharge was missing for 1.4% of the newborns. In case of a missing date, the mother's date of hospital discharge was used in healthy newborns. The missing data for other variables were as follows: cohabitation (4.4%), socioeconomic group (29.5%), smoking (2.2%), prenatal visits (2.1%) and prenatal visits at the hospital clinic (4.2%). The proportions of all other variables were less than 1%.

TABLE 3 Predictors of readmission, admission to ICU or death (age ≤28 days)

	N	Readmission (N = 10,443)					ICU or Died (N = 87)				
		Yes		Multivariable*			Yes		Multivariable *		
	(333,321)	n	(%)	p	OR	(95% CI)	n	(%)	p	OR	(95% CI)
Mother											
Primipara											
No	234,965	7,749	(3.3)		1		63	(<0.1)		1	
Yes	98,356	2,694	(2.7)	**<0.001**	**0.77**	**(0.73, 0.80)**	24	(<0.1)	0.63	0.88	(0.53, 1.47)
BMI								(<0.1)			
18.5–29.9	278,593	8,504	(3.1)	0.02	1		70	(<0.1)	0.89	1	
<18.5	12,410	406	(3.3)	0.29	1.06	(0.95, 1.17)	3	(<0.1)	0.91	0.93	(0.29, 2.98)
≥30	35,732	1,327	(3.7)	**0.002**	**1.10**	**(1.03, 1.17)**	14	(<0.1)	0.44	1.26	(0.70, 2.24)
Age											
25–29 years	106,378	3,188	(3.0)	<0.001	1		27	(<0.1)	0.16	1	
<25 years	59,009	1,905	(3.2)	**<0.001**	**1.15**	**(1.08, 1.22)**	23	(<0.1)	0.12	1.58	(0.89, 2.79)
30–34 years	123,684	3,918	(3.2)	0.68	1.01	(0.96, 1.06)	25	(<0.1)	0.41	0.80	(0.46, 1.38)
≥35 years	44,250	1,432	(3.2)	0.44	0.98	(0.91, 1.04)	12	(<0.1)	0.82	1.08	(0.54, 2.17)
Smoking											
No	277,189	8,690	(3.1)	0.88	1		67	(<0.1)	0.65	1	
Yes	48,732	1,521	(3.1)	0.68	0.99	(0.93, 1.05)	18	(<0.1)	0.36	1.29	(0.75, 2.21)
Gestational age											
39^{+0}–40^{+6}	195,354	5,525	(2.8)	<0.001	1		47	(<0.1)	0.01	1	
37^{+0}–37^{+6}	12,637	939	(7.4)	**<0.001**	**1.97**	**(1.83, 2.12)**	6	(<0.1)	0.33	1.54	(0.64, 3.68)
38^{+0}–38^{+6}	40,307	2,119	(5.3)	**<0.001**	**1.67**	**(1.58, 1.76)**	21	(<0.1)	**0.02**	**1.89**	**(1.12, 3.18)**
41^{+0}–41^{+6}	70,524	1,549	(2.2)	**<0.001**	**0.80**	**(0.76, 0.85)**	8	(<0.1)	0.08	0.51	(0.24, 1.07)
≥42^{+0}	14,498	311	(2.1)	**<0.001**	**0.79**	**(0.71, 0.89)**	5	(<0.1)	0.20	1.82	(0.72, 4.62)
Mode of vaginal delivery											
Normal vaginal	29,915	9,318	(3.1)	0.25	1		82	(<0.1)	0.07	1	
Breech delivery	2,109	71	(3.4)	0.59	0.94	(0.73, 1.19)	2	(<0.1)	0.22	2.44	(0.58, 10.20)
Instrumental delivery[1]	32,097	1,054	(3.3)	0.12	1.06	(0.99, 1.13)	3	(<0.1)	0.06	0.32	(0.10, 1.03)
Time of birth											
Morning (8:00 AM–3:00 PM)	91,978	2,851	(3.1)	0.04	1		24	(<0.1)	0.93	1	

(Continues)

TABLE 3 (Continued)

	N	Readmission (N = 10,443)					ICU or Died (N = 87)				
		Yes		Multivariable*			Yes		Multivariable *		
	(333,321)	n	(%)	p	OR	(95% CI)	n	(%)	p	OR	(95% CI)
Evening (3:00 PM–10:00 PM)	102,766	3,348	(3.3)	0.17	1.04	(0.99, 1.09)	30	(<0.1)	0.71	1.11	(0.65, 1.90)
Night (10:00 PM–8:00 AM)	138,366	4,233	(3.1)	0.50	0.98	(0.94, 1.03)	33	(<0.1)	0.80	0.93	(0.55, 1.58)
Place of birth											
University hospital	111,420	3,421	(3.1)	<0.001	1		42	(<0.1)	0.49	1	
Central hospital	160,863	4,920	(3.1)	**<0.001**	**1.10**	**(1.05, 1.15)**	41	(<0.1)	0.73	1.09	(0.69, 1.71)
Other[2]	61,038	2,102	(3.4)	**<0.001**	**1.23**	**(1.16, 1.31)**	4	(<0.1)	0.307	0.57	(0.19, 1.68)
University hospital's catchment area											
Southern	131,202	4,102	(3.1)	<0.001	1		7	(<0.1)	<0.001	1	
Eastern	45,158	1,383	(3.1)	0.23	1.04	(0.98, 1.11)	11	(0.1)	**0.009**	**3.74**	**(1.40, 10.01)**
Northern	53,673	1,649	(3.3)	**<0.001**	**0.80**	**(0.76, 0.86)**	5	(<0.1)	0.65	1.31	(0.40, 4.27)
Western	54,030	1,680	(3.1)	0.28	0.97	(0.91, 1.03)	41	(<0.1)	**<0.001**	**11.58**	**(4.92, 27.30)**
Southwestern	48,634	1,614	(3.1)	0.21	1.04	(0.98, 1.11)	23	(<0.1)	**<0.001**	**7.61**	**(3.15, 18.34)**
Newborn											
Sex											
Female	166,489	4,795	(2.9)		1		43	(<0.1)		1	
Male	166,832	5,648	(3.4)	**<0.001**	**1.12**	**(1.08, 1.17)**	44	(<0.1)	0.89	0.97	(0.64, 1.48)
One-min Apgar											
7–10	323,121	10,137	(3.1)		1		82	(<0.1)		1	
0–6	9,988	302	(3.0)	0.10	0.90	(0.80, 1.02)	5	(0.1)	0.09	2.26	(0.89, 5.72)
Birthweight[3]											
AGA	323,744	10,043	(3.1)	0.001	1		86	(<0.1)	1.00	1	
SGA	3,925	122	(3.1)	0.33	0.91	(0.76, 1.10)	1	(<0.1)	1.00	0.96	(0.13, 6.96)
LGA	5,634	276	(4.9)	**<0.001**	**1.27**	**(1.12, 1.44)**	0	(<0.1)	0.98	-	-
Phototherapy											
No	320,220	8,602	(2.7)		1		76	(<0.1)		1	
Yes	13,101	1,841	(14.1)	**<0.001**	**5.33**	**(5.02, 5.64)**	11	(0.1)	**0.002**	**2.92**	**(1.49, 5.72)**
Year of birth											

TABLE 3 (Continued)

	N	Readmission (N = 10,443)					ICU or Died (N = 87)				
		Yes		Multivariable*			Yes		Multivariable *		
	(333,321)	*n*	(%)	*p*	OR	(95% CI)	*n*	(%)	*p*	OR	(95% CI)
2008–2009	85,714	2,206	(2.6)	<0.001	1		5	(<0.1)	<0.001	1	
2010–2012	127,082	4,100	(3.2)	**<0.001**	**1.28**	**(1.22, 1.35)**	12	(<0.1)	0.37	1.62	(0.57, 4.60)
2013–2015	120,525	4,137	(3.4)	**<0.001**	**1.30**	**(1.23, 1.37)**	70	(<0.1)	**<0.001**	**10.10**	**(4.07, 25.06)**
Discharging group											
Discharge after 2nd day	306,936	9,563	(3.1)		1		78	(<0.1)		1	
Early discharge	26,385	880	(3.3)	**<0.001**	**1.15**	**(1.07, 1.24)**	**9**	(<0.1)	0.54	1.25	(0.61, 2.58)

Note: *Multivariable-adjusted logistic regressions were used, and results are shown by odds ratios (ORs) with 95% confidence intervals (CIs).
[1]Instrumental delivery includes, for example, forceps and vacuum extraction.
[2]Other include regional hospitals and healthcare centres.
[3]Birthweight.
Abbreviations: AGA, appropriate for gestational age; LGA, large for gestational age; SGA, small for gestational age.
The Bold values are statistically significant.

2.6 | Ethics approval

This study was approved by the Ethics Committee of the Pirkanmaa Hospital District, THL and SF.

3 | RESULTS

3.1 | Timing and predictors of early discharge

In total, 7.9% ($n = 26{,}385$) of newborns were discharged early, that is, on the 1st or 2nd day, and this percentage increased over time (Figure 1). According to Cochran–Armitage trend test, the yearly change was statistically significant between 1st or 2nd and after 2nd day (<0.0001) but not between 1st and 2nd day ($p = 0.107$). In this ED group, most of the mothers were ≥30 years old or upper-level employees, and most of the newborns were born at the central hospital (Table 1). The predictors of ED are presented in Table 2.

3.2 | Readmission

Of all neonates, 3.1% ($n = 10{,}443$) were readmitted to the hospital by the time they reached 28 days of age. The infants discharged after the 2nd day were readmitted less often than those discharged earlier (Table 3). Readmission rates increased over time, especially among infants discharged early (Figure 2). According to Cochrane–Armitage trend test, the proportion of early discharged increased during time period from 2008 to 2015 ($p = 0.0005$).

In all university hospital areas, the readmission rates were similar: 3.1%–3.3%. The time between hospital discharge and readmission was the shortest among infants discharged on the 1st day (1st day median (Md): 5.0, interquartile range (IQR): 2.0–13.5; 2nd day Md: 7.0, IQR 3.0–16.0; after 2nd day Md: 7.0, IQR: 2.0–15.0). The overall difference between groups was $p = 0.039$, and the pairwise comparisons were as follows: 1st versus 2nd day: $p = 0.049$; 2nd veresus after 2nd day: $p = 0.034$; 1st versus after 2nd day: $p = 0.174$.

Of the infants readmitted, most initial readmissions occurred at the age of <7 days (32.5%, $n = 3{,}398$). Following this, 29.7% ($n = 3{,}097$) were initially readmitted at 7–13 days old, 19.2% ($n = 2{,}008$) at 14–20 days old and 18.6% ($n = 1{,}940$) at 21–27 days old ($p < 0.001$). The number of readmissions ranged from one to five, but 94.0% ($n = 9{,}817$) were readmitted only once.

3.3 | Causes of readmission

The most common reasons for readmission were 'miscellaneous, minor causes', especially among infants discharged on the 1st day. The most common single cause for readmission was jaundice (30.9%), followed by infection (20.6%). Readmission because of hypoglycaemia and inadequate nutrition affected 0.3% of newborns

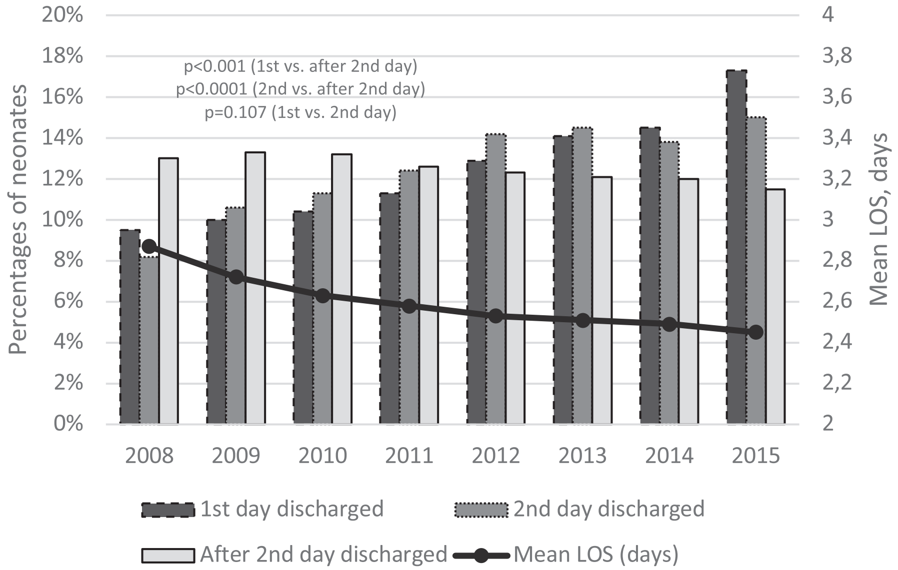

FIGURE 1 Mean length of stay at the hospital and percentages of neonates discharged on the 1st day, 2nd day and after 2nd day post-birth

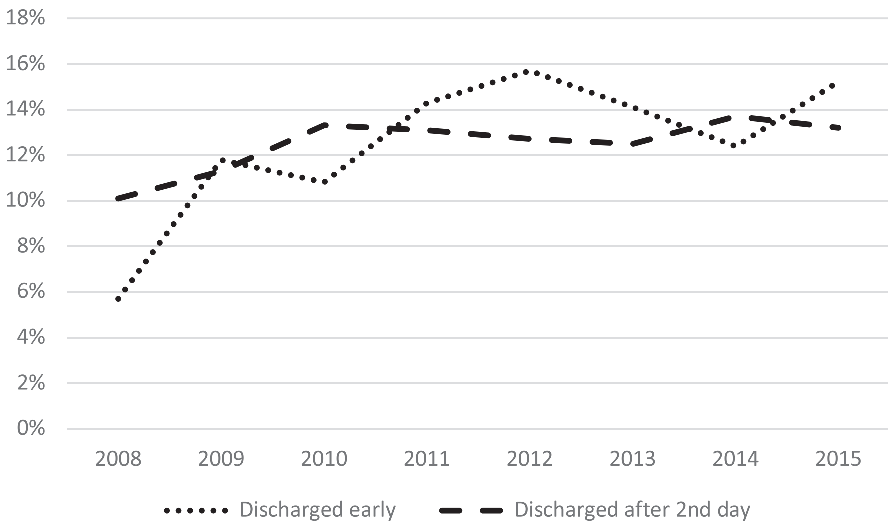

FIGURE 2 Percentages of neonates readmitted to the hospital by the age of 28 days

discharged on the 1st day, and 0.1% of newborns discharged on the 2nd day and after the 2nd day (p = 0.003) (Table S1). Other categories contained no statistical differences between neonates discharged on the 1st or 2nd day or after the 2nd day. Some infants had more than one diagnosis code registered as the reason for readmission.

3.4 | Risk factors for readmission

The risk factors of readmission were analysed in two different ways, by dividing the groups into two (ED and discharge after the 2nd day) or three (1st, 2nd and after 2nd day discharge) categories. ED was a significant risk factor for readmission in the analysis divided into two discharge groups (Table 3). Additionally, infants of mothers with BMIs ≥30 or aged <25 years, as well as infants born at 38^{+0}–38^{+6} weeks' GA, in central or other hospitals, who were male, were LGA, with a history of phototherapy or born after the year 2009, were statistically significantly more likely to be readmitted. Infants of primiparae, with GAs of ≥41^{+0} weeks, or born in the northern university hospital area had a decreased risk of readmission (Table 3).

The multivariable analysis in which three discharge groups were included detected the same significant risk factors as the first analysis with minor, insignificant differences in p-values, ORs and CIs. An 'after 2nd day' discharge was associated with decreased risk of readmission (OR 0.88 (95% CI 0.82, 0.95) p < 0.001), while 1st day discharge was not a statistically significant risk factor for readmission (OR 1.21 (95% CI 0.96, 1.53) p = 0.114).

3.5 | Admission to ICU and mortality

Table 3 presents risk factors for ICU admission or death; early discharge was not a significant predictor of either.

In total, 75 newborns were admitted to the ICU. Nine (12.0%) of these infants were discharged on the 2nd day and 66 (88.0%) after the 2nd day; none were discharged on the 1st day. Of the infants

TABLE 4 Definitions of early discharge of neonates according to earlier publications

Publication	Year of publication	Country	Definition of early discharge
Danielsen, et al.[4]	2000	United States	≤48 h (very early ≤24 h)
Zimmerman, et al.[6]	2003	Israel	≤24 h or less
Isayama, et al.[9]	2020	Canada	<48 h
Farhat, et al.[10]	2011	Lebanon	≤48 h
Nilsson, et al.[19]	2017	Denmark	13–50 h (very early ≤12 h)
Meara, et al.[29]	2004	Unites States	Within 1 day
Our definition		Finland	≤2nd day

admitted to the ICU, 24 (32.0%) were born at $37–38^{+6}$ and 20 (27.0%) at $38^{+0}–38^{+6}$ weeks' GA. Considering their ages, 34 (45.3%) neonates were admitted to the ICU at <7 days old.

The proportions of infants admitted to the ICU increased over time. In 2008, 2/100,000 neonates were admitted to the ICU; in 2011, 7/100,000; in 2012, 12/100,000; in 2013, 54/100,000; in 2014, 47/100,000; and in 2015, 64/100,000 ($p < 0.001$). No neonates were admitted to the ICU in 2009 or 2010. ICU admission rates differed notably among the university hospital areas. In the southern area, 2/100,000 neonates were admitted to the ICU; in the eastern area, 18/100,000; in the northern area, 7/100,000; in the western area, 74/100,000; and in the southwestern area, 43/100,000 ($p < 0.001$).

The causes of ICU admission included infections ($n = 25$), gastrointestinal problems ($n = 25$), neurologic problems ($n = 9$), respiratory problems ($n = 6$) and cardiologic problems ($n = 2$), and a further eight infants were admitted for observation. Jaundice was the most common single cause, followed by respiratory tract infections. In nine of the latter cases, respiratory syncytial virus was diagnosed. Nine other neonates were readmitted because of sepsis—two early onset and the remaining late onset. In the early-onset cases, no specific organisms were detected. Among the late onset cases, one was caused by streptococci, one by staphylococci and one by a gram-negative organism.

All 12 newborns who died had been discharged at ≥2 days old. The causes of death were sudden infant death syndrome in five, cardiologic problems in four (including oneCCHD, hypoplastic left heart syndrome) and infections in two cases.

4 | DISCUSSION

4.1 | Principal findings

Post-birth LOS for healthy, vaginally delivered single babies was shortened, and hospital readmission rates increased over time. Neonates discharged early were more likely to be low-risk infants born in areas with high population densities. History of phototherapy before discharge was the most common risk factor, and jaundice was the most common single cause of hospital readmission. ED, including infants discharged on the 1st or 2nd day, predicted readmission. Nevertheless, the 1st day discharge did not seem to be a significant, independent risk factor for readmission. The rates of ICU admission and mortality were extremely low, and ED seemed not to be associated with these outcomes. However, birth at 38 weeks' GA was a significant predictor of ICU admission or death.

4.2 | Strengths of the study

A strength of this study was that it involved a population-based, complete, national cohort with a large number of cases. Using linked data from several national health registers served as a valid method.[17] It was possible to obtain information about diagnoses, complications and causes of death from the registers—providing comprehensive, reliable data.

4.3 | Limitations of the data

The MBR and hospital record data do not contain time labels, and thus, the authors were unable to analyse exactly how many hours old the newborns were when examined by the paediatrician and when discharged. Information on breastfeeding would also have been helpful for establishing factors behind jaundice, hypoglycaemia and inadequate nutrition.

4.4 | Interpretation

The increasing global trend of ED was seen in this population. The mean LOS has, in many countries, become much shorter than that in Finland. In California[4] 12%—and in England,[18] up to 90%—of newborns are discharged within 2 days of vaginal birth. ED is a concept that has no standardised definition, and it varies markedly between different countries and hospitals, as well as between publications (Table 4).

The discharge time is associated with parity of birth, infant and psychosocial factors.[1,2,19] As predictive, factors necessitating longer follow-up periods for either the mother or the neonate, for example, primiparous or older mothers and early or post-term infant or infants required phototherapy were less likely to be discharged early. As found in previous research,[19] mothers' smoking was associated with ED. It is possible, that the smokers do not feel comfortable in the hospitals, where smoking is prohibited and are therefore eager to get discharged as soon as possible.

The readmission rate and significant predictors (ED and male sex) of readmission, coincided with earlier research (e.g., readmission rate 25–30/1,000 in California and 32/1,000 in Canada).[3,4,10] However, in our study, the difference in readmission was slight between ED newborns and those who were not discharged early.

Jaundice was the most common single cause of readmission and ICU admission, but no kernicterus cases were found. In our study, infants born at 38^{+0}–38^{+6} weeks' GA were at an increased risk of readmission, in contrast to infants born at 37^{+0}–37^{+6} weeks' GA. The healthcare professionals tend probably to be more cautious with the infants born at <38 weeks GA, and thus, smaller proportions of these less mature infants are discharged early.

Infants of primiparous mothers have, in earlier research, been found to be at an increased risk of readmission.[4] The present findings, in contrast, might be explained by the fact that infants of primiparous mothers were less likely to be discharged early.

The incidence of early-onset sepsis was also low as since 2013, in Finland, the THL has recommended routine antenatal screening for vaginal carriage of group B streptococcus and antepartum antibiotic prophylaxis.[20] Newborns with increased risk of neonatal sepsis are monitored more closely than they were before, and they now have a longer LOS.[21]

Births in lower than tertiary-level hospitals were associated with increased risk of readmission, but births in northern Finland were associated with decreased risk of readmission. Inside Finland, there were also significant geographical differences concerning ICU admission. These findings could be explained, at least partly, by differences between travelling distances from the hospital to home in the north and south, discharge practices and registration procedures in hospitals.

Sudden infant death syndrome, as well as cardiologic and circulatory issues, including one CCHD, were the most common causes of death in the present sample. CCHDs have occurred in 19.1/10,000 births across 12 countries and approximately 8.85 million births.[22] On average, the prenatal detection rate has been 50%, ranging between 13% and 87% among centres.[22] After 2006, pulse oximetry screens were distributed to most delivery hospitals in Finland.[23,24] Both high-quality prenatal diagnostics and nationwide neonatal pulse oximetry screening may explain the low rate of adverse events related to CCHDs in the sample.

Birth at 38 weeks seemed associated with increased risk of readmission to the ICU or death. A previous Finnish register study[25] also reported that being born early term was associated with low Apgar scores, perinatal mortality and adverse neurologic outcomes.

A correlation between ED and mortality has been previously established in a few single-unit studies. Yet, among 7,009 infants in one study, there were no deaths in the ED group by the time the infants were 30 days old.[26] Furthermore, no correlation between a shorter LOS and death by the age of 14 days was found among 920,554 neonates in another.[27] Accordingly, none of the twelve newborns who died in the present study population were discharged early.

Many studies indicate that ED is safe for neonates if certain criteria are followed and if early follow-up visits are arranged.[28,29] This, combined with appropriate prenatal and early postnatal diagnostics and screening systems in Finland, has created a structure in which well-selected neonates can be discharged early after birth without increased risk of adverse events.

5 | CONCLUSION

The ED and hospital readmission rates among low-risk newborns increased over the study period. This study shows that ED is marginally associated with the risk of readmission to the hospital. Yet, ED did not seem to predict ICU admission or death. Instead, infants born at 38^{+0}–38^{+6} weeks' GA had an increased risk of admission to the ICU or death within four weeks after birth.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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