

Promotion of Early and Exclusive Breastfeeding in Neonatal Care Units in Rural Rwanda: a Quasi-experimental Study

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Keywords: neonatal nutrition, small and sick newborns, Rwanda, exclusive breastfeeding, nurturing care, baby-friendly

Posted Date: December 8th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-119415/v1>

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Abstract

Background: Early initiation of breastfeeding after birth and ongoing exclusive breastfeeding for the first 6 months improves child survival, nutrition and health outcomes. However, only 42% of newborns worldwide are breastfed within the first hour of life. Small and sick newborns are at greater risk of not receiving breastmilk and often require additional support for feeding. This study compares breastfeeding practices in Rwandan neonatal care units (NCUs) before and after the implementation of a package of interventions aimed to improve breastfeeding, aligned with the Baby Friendly Hospital Initiative for small and sick newborns.

Methods: A pre-post quasi experimental study was conducted at two District hospital NCUs in rural Rwanda from October 2017–December 2017 (pre-intervention) and September 2018–March 2019 (post-intervention). Only newborns admitted before their second day of life (DOL) were included. Data was extracted from patient charts for clinical and demographic characteristics, feeding throughout admission, and patient outcomes. Bivariate analyses were conducted using Fisher's exact and Wilcoxon rank sum tests. Logistic regression was used to evaluate factors associated with exclusive breastfeeding at discharge following a backwards stepwise procedure.

Results: Pre-intervention, 255 newborns were admitted in the NCUs and 793 were admitted in the post-intervention period. The percentage of infants who were exclusively breastfed on their day of birth, or day-of-life zero (DOL0) increased from 5.4% to 35.9% ($p < 0.001$). For newborns discharged alive, the proportion exclusively breastfeeding increased from 69.6% to 87.0% ($p < 0.001$). The mortality rate for all admitted newborns decreased from 16.1% to 10.5% ($p < 0.019$). Factors associated with greater odds of exclusive breastfeeding at discharge included post-intervention time point (Odds Ratio (OR): 4.91, 95% Confidence Interval (CI) 1.99-12.11, $p < 0.001$), and admission for infection (OR 2.99, 95%CI 1.13-7.93, $p = 0.027$). Home deliveries (OR 0.15, 95%CI 0.05-0.47, $p = 0.001$), preterm delivery (OR 0.36, 95%CI 0.15-0.87, $p = 0.0260$) and delayed first breastmilk feed (OR=0.04 for DOL3 vs. DOL0, 95%CI 0.01, 0.35, $p = 0.004$) reduced odds of exclusive breastfeeding at discharge.

Conclusion: Expansion and adoption of evidenced-based guidelines, using innovative approaches, aimed at the unique needs of small and sick newborns should be expanded and adapted in similar settings to improve outcomes for these infants.

Background

Breastfeeding plays a paramount role in child survival, development and maternal health[1]. Early initiation of breastfeeding within one hour after birth and exclusive breastfeeding for the first six months is recommended by WHO[2]. Immediate and early initiation of breastfeeding after birth is associated with better neonatal outcomes such as reduction of neonatal deaths, length of stay for sick infants and neonatal infections[3, 4]. A meta-analysis showed that non-breastfed infants under 6 months of age have a 14 times higher risk of death, and partially breastfed infants have a 4.8-fold higher risk of death compared to predominantly breastfed infants[5].

Even though the majority of deliveries globally are attended by skilled health care providers, only 42% of newborns are breastfed within the first hour of life worldwide[6]. Small and sick newborns requiring inpatient care after birth face unique challenges since the neonatal unit environment is not always conducive for initiation of early and exclusive breastfeeding, such as an infant requiring mechanical ventilation or being separated from the mother[7]. In addition, small and sick newborns may experience difficulties breastfeeding, or are too immature or unstable to breastfeed immediately after birth, so mothers require specialized support to establish and maintain their milk supply[8, 9]. Despite the strong recommendation from WHO that maternity and newborn services have trained and competent staff who can provide successful breastfeeding support to lactating mothers[10], they have noted that early breastfeeding is compromised by inappropriate procedures, such as infant-mother separation, performed by health care providers and outdated policies[6].

Many interventions exist at community and facility levels worldwide to promote early and exclusive breastfeeding. UNICEF and WHO launched the Baby-Friendly Hospital Initiative (BFHI) in 2009 to integrate breastfeeding with maternal and newborn care in hospitals. Through this multi-level approach, hospitals must implement the “Ten Steps to Successful Breastfeeding” to attain BFHI status, including having a breastfeeding policy, allowing rooming-in, and providing adequate training to staff[10, 11]. Specific recommendations for expanding BFHI to include the unique needs of small and sick newborns have also been developed[8, 12]. Additionally, utilizing lactation consultants for breastfeeding support and lactation education has shown to increase rates of initiation, duration of any breastfeeding and exclusive breastfeeding compared to usual practices[13]. Peer counseling approaches have also demonstrated improved early and continuous exclusive breastfeeding[14].

In Rwanda, 81% of newborns are breastfed within one hour of life and 87% are exclusively breastfed up to six months[15], however little is known about rates among small and sick newborns. Data from a neonatal care unit (NCU) in rural Rwanda found a large proportion of children had breastfeeding difficulties after discharge leading to use of infant formula and poor growth[16]. To address this, Partners In Health/Inshuti Mu Buzima (PIH/IMB) in collaboration with the Ministry of Health, implemented interventions for breastfeeding support for newborns and infants with feeding difficulties in neonatal care units, which included training of health care providers, breastfeeding counselling for mothers and health system strengthening to promote early and exclusive breastfeeding. This study aims to compare breastfeeding rates of newborns admitted to district hospital neonatal special care units before and after the implementation of a package of interventions aimed to improve breastfeeding practices.

Methods

Study setting

We conducted this study in the Rwinkwavu District Hospital (RDH) and Kirehe District Hospital (KDH) neonatal care units (NCUs). RDH and KDH are Rwandan Ministry of Health public hospitals located in Kayonza and Kirehe Districts in the Eastern province of rural Rwanda. Both RDH and KDH have been

supported by PIH/IMB, an international non-governmental organization, since 2005 and 2007, respectively. RDH supervises 8 health centers in its catchment area with a population of 215,555 and KDH supervises 16 health centers in its catchment area with a population of 384,776[17], in addition to 2 health centers and over 60,000 people in a refugee camp in the catchment area[18]. The NCUs provide care for small and sick newborns and are equipped with incubators, radiant warmers, syringe pumps, phototherapy, oxygen and continuous positive airway pressure machines for the management of common neonatal conditions. They are staffed by nurses – with an average nurse to patient ratio of 1 to 8.5[19] – and general practitioners, with mentorship by a pediatrician and midwife.

Intervention

Several inputs were introduced into the hospital neonatal care units to promote exclusive breastfeeding, including porridge for mothers and water filters to provide a high calorie, high protein supplement and ensure adequate hydration; pillows for more comfortable breastfeeding positioning; screens for mothers to breastfeed or express breastmilk privately; refrigerator and materials for storage of expressed breastmilk, and educational posters promoting exclusive breastfeeding and Kangaroo Mother Care (KMC). In addition to these inputs, a training was conducted in February 2018 called Working with Infants with Feeding Difficulties delivered by two Speech and Language Therapists who are experts in infant feeding. A description of that training package and a case study from its implementation in Rwanda has been described elsewhere[20]. As a result of the training and in an effort to ensure sustainability of the skills learned during the training, each hospital hired two Expert Mothers to serve as peer counsellors to support mothers in assessing breastfeeding readiness, improve positioning and attachment, and create a breastfeeding-friendly, caring environment for mothers with a focus on one-to-one as well as group counselling. The Expert Mothers were chosen based on criteria including previously having an infant in the neonatal unit and commitment to sharing her experience with other mothers. The Expert Mothers are trained on the Working with Infants with Feeding Difficulties package, provided with a job aid and tablet loaded with Global Health Media videos in Kinyarwanda which are culturally and linguistically relevant for counselling of mothers.

Study Design and Population

We conducted a pre-post quasi-experimental study. We included all newborns admitted to the RDH and KDH neonatology units in two periods including pre-intervention from October 2017 to December 2017 and post-intervention from September 2018 to March 2019 who were admitted before their second day of life.

Data Collection

Data from standardized neonatology patient charts is routinely collected by trained data collectors on a structured paper form and then entered in a Microsoft Access database. Types of data collected included infant's reason for admission, day of life on admission, relevant perinatal history, feeding data, weight gain, length of stay, and discharge outcomes.

Definition of Variables

Our primary outcome was exclusive intake of breast milk at the time of discharge among infants discharged alive. Day of life 0 (DOL0) referred to the child's day of birth. Newborns exclusively fed breastmilk was defined as the feeding type recorded in the patient's chart as 'only breast milk', regardless of the method of feeding (i.e. via breast, via naso-gastric tube, etc.). Fed on breast was defined as the method of feeding recorded in the patient's chart as 'only on the mother's breast' (i.e. not via cup, not via naso-gastric tube, etc.). Low birth weight (LBW) was defined as any birth below 2,500 grams and premature births are births before 37 weeks gestation.

Data Analysis

We described socio-demographic characteristics of infants and their mothers, and clinical and feeding characteristics of infants using frequencies and percentages for categorical data and median and interquartile ranges for continuous data. We conducted bivariate analysis using Fisher exact test to compare the pre- and post-intervention periods for all categorical socio-demographic, clinical and feeding characteristics described for infants with data recorded. Wilcoxon Ranksum test was used for bivariate analysis of continuous variables for infants with data recorded. Then, we used multivariable logistic regression models to identify predictors associated with the outcome 'exclusive breastfeeding on discharge', built using backward stepwise procedures for all variables significant at $\alpha = 0.20$ in bivariate analyses. All factors significant at the $\alpha = 0.05$ significance level were retained in the final model. The data were analyzed using Stata v.15.1 (Stata Corp, College Station, TX, USA).

Ethics

The study received ethical approval from the Rwanda National Ethics Committee.

Results

In total, 255 newborns were admitted in the neonatology units during the pre-intervention and 793 were admitted in the post-intervention periods (Table 1). There were no significant differences in admissions for prematurity at pre-intervention compared to post-intervention (40.0% vs. 40.6%, $p = 0.940$), maternal age (50.0% age 25–34 years vs. 43.7%, $p = 0.25$) maternal gravidity (27.1% primigravida vs 31.5%, $p = 0.396$), and age on admission (83.1% admitted on DOL0 vs. 85.4%, $p = 0.422$). Overall, in both time periods, infants delivered in health facilities was greater than 88%; however, there were slightly more non-facility births in the post-intervention period (11.6%) compared to pre-intervention (7.1%, $p = 0.024$). Compared to the pre-intervention period, infants were also more likely than in the post-intervention period to be delivered by caesarean section (31.5% vs. 41.1%, $p = 0.007$), be male (39.5% vs. 58.9%, $p < 0.001$), weigh more than 1,500 grams (86.6% vs. 91.9%, $p = 0.023$), be born at 32 or more weeks of gestation (86.7% vs. 92.5%, $p = 0.048$) and be born to a primiparous mother (32.4% vs. 43.6%, $p = 0.007$).

Table 1

Demographic and clinical characteristics of newborns admitted to Rwinkwavu and Kirehe District Hospital neonatal care units from October – December 2017 (pre-intervention) and September 2018 – March 2019 (post-intervention)

	Pre-intervention (N = 255)		Post-intervention (N = 793)		p-value
	n	%	n	%	
Hospital of admission					0.004
Kirehe	141	55.3%	521	65.8%	
Rwinkwavu	114	44.7%	272	34.3%	
Place of child's birth	(n = 253)		(n = 779)		0.024
Hospital	165	65.2%	531	68.2%	
Health Center	70	27.7%	158	20.3%	
Home	16	6.3%	69	8.9%	
Other	2	0.8%	21	2.7%	
Type of delivery	(n = 251)		(n = 767)		0.007
Vaginal	172	68.5%	452	58.9%	
C-section	79	31.5%	315	41.1%	
Sex of child	(n = 210)		(n = 781)		< 0.001
Male	83	39.5%	429	54.9%	
Female	127	60.5%	352	45.1%	
Birthweight category	(n = 254)		(n = 786)		0.023
Extremely low birth weight, < 1000 g	13	5.1%	16	2.0%	
Very low birth weight, < 1500 g	21	8.3%	48	6.1%	
Low birth weight, < 2500 g	94	37.0%	342	43.5%	
Normal birth weight, ≥ 2500 g	126	49.6%	380	48.4%	
Prematurity category recorded in hospital register	(n = 240)		(n = 762)		0.940
Term	144	60.0%	453	59.5%	
Preterm	96	40.0%	309	40.6%	
Gestational age category (if gestational age in weeks reported)	(n = 225)		(n = 683)		0.048

	Pre-intervention (N = 255)		Post-intervention (N = 793)		p-value
	n	%	n	%	
Extremely preterm < 28 weeks	9	4.0%	12	1.8%	
Very preterm 28–31 weeks	21	9.3%	39	5.7%	
Moderate/late 32–36 weeks	51	22.7%	179	26.2%	
Term 37 + weeks	144	64.0%	453	66.3%	
Mother's Age	(n = 240)		(n = 759)		0.25
<20 years	19	7.9%	79	10.4%	
20–24 years	52	21.7%	198	26.1%	
25–34 years	120	50.0%	332	43.7%	
35 + years	49	20.4%	150	19.8%	
Gravidity (# pregnancies) of mother	(n = 244)		(n = 755)		0.396
1 pregnancy	66	27.1%	238	31.5%	
2–4 pregnancies	121	49.6%	358	47.4%	
5 + pregnancies (grand multigravida)	57	23.4%	159	21.1%	
Parity (# viable deliveries) of mother	(n = 244)		(n = 757)		0.007
1 delivery	79	32.4%	330	43.6%	
2–4 deliveries	127	52.1%	323	42.7%	
5 + deliveries (grand multiparous)	38	15.6%	104	13.7%	
Day of life (DOL) on admission					0.422
DOL 0	212	83.1%	677	85.4%	
DOL 1	43	16.9%	116	14.6%	
Diagnosis (not mutually exclusive)					
Preterm, or gestational age < 37 weeks	102	40.0%	308	38.8%	0.768
LBW, or birthweight < 2500 g	123	48.2%	406	51.2%	0.429
Infection	141	55.3%	328	41.4%	< 0.001
HIE/asphyxia	29	11.4%	70	8.8%	0.221

	Pre-intervention (N = 255)		Post-intervention (N = 793)		p-value
	n	%	n	%	
Other	23	9.0%	145	18.3%	< 0.001

The percentage of infants who were fed on the breast on DOL0 increased from 5.8–35.6% ($p < 0.001$) and exclusively breastfed on DOL0 increased from 5.4–35.9% ($p < 0.001$, Table 2). On DOL1, feeding on the breast increased from 30.5–68.6% ($p < 0.001$) and exclusive feeding on breastmilk increased from 37.4–70.2% ($p < 0.001$). For newborns discharged alive, the proportion fed on the breast increased from 59.8–84.7% ($p < 0.001$) and the proportion exclusively feeding on breastmilk increased from 69.6–87.0% ($p < 0.001$). Introduction of first breast milk feeding on DOL0 increased from 7.1% pre-intervention to 31.9% in post-intervention ($p < 0.001$).

Table 2

Breastfeeding timing and breastfeeding discharge status of newborns admitted to Rwinkwavu and Kirehe District Hospital neonatal care units between a pre- and post- breastfeeding intervention

	Pre-intervention (n = 255)		Post-intervention (n = 793)		p-value*
	n	%	n	%	
Newborn fed on breast day of life (DOL) 0	(n = 223)		(n = 694)		< 0.001
Yes	13	5.8%	247	35.6%	
No	158	70.9%	381	54.9%	
Not documented	52	23.3%	66	9.5%	
Newborn exclusively fed breastmilk on DOL 0					< 0.001
Yes	12	5.4%	249	35.9%	
No	159	71.3%	379	54.6%	
Not documented	52	23.3%	66	9.5%	
Newborn fed on breast on DOL 1	(n = 246)		(n = 776)		< 0.001
Yes	75	30.5%	532	68.6%	
No	156	63.4%	205	26.4%	
Not documented	15	6.1%	39	5.0%	
Newborn exclusively fed breastmilk on DOL 1					< 0.001
Yes	92	37.4%	545	70.2%	
No	137	55.7%	191	24.6%	
Not documented	17	6.9%	40	5.2%	
Newborn fed on breast on DOL 2	(n = 238)		(n = 736)		< 0.001
Yes	107	45.0%	568	77.2%	
No	114	47.9%	133	18.1%	
Not documented	17	7.1%	35	4.8%	
Newborn exclusively fed breastmilk on DOL 2					< 0.001
Yes	135	56.7%	600	81.5%	

	Pre-intervention (n = 255)		Post-intervention (n = 793)		p-value*
	n	%	n	%	
No	87	36.6%	100	13.6%	
Not documented	16	6.7%	36	4.9%	
Newborn fed on breast DOL 7	(n = 195)		(n = 441)		< 0.001
Yes	106	54.4%	331	75.1%	
No	68	34.9%	66	15.0%	
Not documented	21	10.8%	44	10.0%	
Newborn exclusively fed breastmilk on DOL 7					< 0.001
Yes	124	63.6%	351	79.6%	
No	48	24.6%	43	9.8%	
Not documented	23	11.8%	47	10.7%	
Newborn fed on breast on discharge day if discharged alive					< 0.001
Yes	128	59.8%	601	84.7%	
No	41	19.2%	38	5.4%	
Not documented	45	21.0%	71	10.0%	
Newborn fed breastmilk on discharge day if discharged alive					< 0.001
Yes	149	69.6%	618	87.0%	
No	19	8.9%	12	1.7%	
Not documented	46	21.5%	80	11.3%	
DOL of first documented breastmilk feed					< 0.001
DOL0	18	7.1%	253	31.9%	
DOL1	99	38.8%	330	41.6%	
DOL2	66	25.9%	105	13.2%	
DOL3 or later	72	28.2%	105	13.2%	

	Pre-intervention (n = 255)		Post-intervention (n = 793)		p-value*
	n	%	n	%	
*P-value compares only non-missing data values; "Not documented" is not included in the fisher's exact test.					

The median length of stay among infants admitted to the neonatal unit was reduced from 8 days in the pre- to 7 days in the post-intervention periods ($p < 0.001$) (Table 3). The overall mortality rate for all newborns admitted decreased from 16.1% in pre- to 10.5% in post-intervention periods ($p < 0.019$). Mortality rate for LBW newborns reduced from the pre-intervention to post-intervention period (23.6% vs. 15.0%, $p = 0.039$), but remained similar among babies diagnosed with other conditions.

Table 3

Difference in mortality and length of stay among newborns admitted to Rwinkwavu and Kirehe District Hospital neonatal care units before and after breastfeeding interventions

	Pre-intervention		Post-intervention		p-value
	n	%	n	%	
Length of stay (LOS), median [IQR]	8	[6, 8]	7	[3, 9]	< 0.001
Mortality					
Yes	41	16.1%	83	10.5%	0.019
No	214	83.9%	710	89.5%	
Mortality by condition					
Preterm					0.155
Died	26	25.5%	57	18.5%	
Discharged alive	76	74.5%	251	81.5%	
Low birth weight (LBW)					0.039
Died	29	23.6%	61	15.0%	
Discharged alive	94	76.4%	345	85.0%	
Hypoxic ischemic encephalopathy (HIE)					0.805
Died	7	24.1%	20	28.6%	
Discharged alive	22	75.9%	50	71.4%	
Neonatal infection					0.284
Died	15	10.6%	25	7.6%	
Discharged alive	126	89.4%	303	92.4%	
Mortality by birth weight					
Extremely low birth weight (ELBW), < 1000 g					0.183
Died	12	92.3%	11	68.8%	
Discharged alive	1	7.7%	5	31.3%	
Very low birth weight (VLBW), < 1500 g					0.068
Died	6	28.6%	26	54.2%	
Discharged alive	15	71.4%	22	45.8%	
Low birth weight (LBW), < 2500 g					0.128

	Pre-intervention		Post-intervention		p-value
	n	%	n	%	
Died	11	11.7%	23	6.7%	
Discharged alive	83	88.3%	319	93.3%	
Normal birth weight \geq 2500 g					0.208
Died	11	8.7%	21	5.5%	
Discharged alive	115	91.3%	359	94.5%	

In the final model (Table 4), there was a significant increase in exclusive feeding of breastmilk at discharge if admitted in the post-intervention period (odds ratio (OR): 4.91; 95% confidence interval (CI): 1.99–12.11, $p = 0.001$). Factors associated with increased odds of exclusive breastfeeding at discharge included diagnosis of infection or infection risk (OR: 2.99; 95% CI: 1.13–7.93). Factors associated with reduced odds of exclusive breastfeeding at discharge included home birth (OR: 0.15; 95% CI: 0.05–0.47, $p = 0.001$), prematurity (OR: 0.36; 95% CI: 0.15–0.87, 0.026), and later timing of first breastmilk feed (DOL2 OR: 0.11; 95% CI: 0.01–0.995, $p = 0.049$; DOL3 or later OR: 0.04; 95% CI: 0.005–0.35, $p = 0.004$).

Table 4

Multivariable analysis of demographic and clinical predictors of exclusively feeding on breastmilk at discharge for newborns discharged alive from Rwinkwavu and Kirehe District Hospital neonatal care units from October – December 2017 and September 2018 – March 2019

	Model 1 (Full)			Model 2 (Reduced)		
	OR	95% CI	p-value	OR	95% CI	p-value
Breastfeeding intervention time point						
Pre-intervention	ref			ref		
Post-intervention	3.53	1.17, 10.72	0.025	4.91	1.99, 12.11	0.001
Hospital of admission						
Kirehe	ref					
Rwinkwavu	0.40	0.14, 1.12	0.080			
Place of child's birth						
Hospital	ref			ref		
Health center	0.40	0.09, 1.73	0.218	0.44	0.17, 1.15	0.093
Home	0.22	0.04, 1.16	0.074	0.15	0.05, 0.47	0.001
Type of delivery						
Vaginal	ref					
C-section	0.83	0.19, 3.77	0.814			
Sex of child						
Male	ref					
Female	0.63	0.22, 1.83	0.400			
Birthweight category						
Extremely low birth weight (ELBW), < 1000 g	ref					
Very low birth weight (VLBW), < 1500 g	1.76	0.06, 56.25	0.749			
Low birth weight (LBW), < 2500 g	3.46	0.14, 83.08	0.444			

	Model 1 (Full)			Model 2 (Reduced)		
	OR	95% CI	p-value	OR	95% CI	p-value
Normal birth weight \geq 2500 g	1.60	0.05, 52.78	0.793			
Prematurity category recorded in hospital register						
Term	ref			ref		
Preterm	0.31	0.07, 1.34	0.117	0.36	0.15, 0.87	0.026
Mother's age						
<20 years	ref					
20–24 years	0.89	0.07, 11.24	0.927			
25–34 years	0.45	0.03, 6.06	0.548			
35+ years	0.58	0.03, 9.87	0.705			
Parity (# viable deliveries) of mother						
1 delivery	ref					
2–4 deliveries	0.76	0.18, 3.21	0.705			
5+ deliveries (grand multiparous)	0.59	0.09, 3.71	0.574			
Diagnosed with infection or infection risk						
No	ref			ref		
Yes	3.09	0.97, 9.83	0.056	2.99	1.13, 7.93	0.027
Diagnosed with HIE/asphyxia						
No	ref					
Yes	0.79	0.12, 5.09	0.802			
Day of life (DOL) of first breastmilk feed						
DOL0	ref			ref		

	Model 1 (Full)			Model 2 (Reduced)		
	OR	95% CI	p-value	OR	95% CI	p-value
DOL1	0.24	0.03, 2.03	0.188	0.24	0.03, 2.00	0.187
DOL2	0.12	0.01, 1.19	0.071	0.11	0.01, 0.995	0.049
DOL3 or later	0.05	0.01, 0.51	0.011	0.04	0.005, 0.35	0.004

Discussion

Our study showed that a multi-level intervention, aimed at improving rates of exclusive breastfeeding in a hospital neonatology unit in rural Rwanda, increased early and exclusive breastmilk feeding, and also reduced length of stay and decreased mortality among small and sick newborns.

We found that from the pre- to post-intervention period, significantly more infants were fed exclusively on the breast and were exclusively fed breastmilk. We also observed earlier initiation of breastfeeding in the post-intervention and this earlier initiation increased the odds that an infant was discharged exclusively feeding on breastmilk. This is consistent with other studies as it is well known that if milk removal does not occur either by infant suckling or expression by hand or pump, milk secretion will start to decline around day 3 postpartum[21, 22]. A study comparing milk expression within 1 hour after delivery to within 1–6 hours after delivery showed that the earlier expression group had earlier lactogenesis stage II (transition from colostrum to copious breast milk production) and resulted in higher milk volume[23]. Another study showed that milk volume on postpartum day 4 is predictive of having an adequate milk supply at 6 weeks[24]. These studies demonstrate the critical need for early expression of breast milk after delivery, whether the infant is able to breastfeed on the breast or if the mother expresses breastmilk and the infant receives breastmilk through other enteral feeding routes (i.e., cup, naso-gastric tube).

Mortality among newborns decreased from the pre- to post-intervention period, particularly among infants born LBW. The association between decreased mortality and exclusive breastfeeding has been well established in the literature and is often promoted as strong support for initiation of early and exclusive breastfeeding[1, 3–6, 25].

Overall length of stay showed a significant reduction from the pre- to post-intervention period. While hospital neonatology units are meant to be an environment for infants to improve from various illnesses or conditions, long length of stay in hospitals also increases an infant's chance of contracting hospital acquired infections[26]. Therefore, the ability to reduce the length of stay for newborns may have an impact on the overall morbidity of the infant. While we did not measure morbidity in this study, early initiation of breastfeeding has been shown to reduce morbidity in newborns[3], which likely has a positive impact on the total length of hospitalization. Reducing the time families, particularly mothers, spend in

hospitals can also have a significant impact on the mother's stress, and the family's economic situation[27, 28]. Reduced length of stay was likely a secondary outcome of improved breastfeeding rates in the post-intervention period. The overall larger number of admissions with a birthweight greater than 1,500 grams and gestational age over 32 weeks in the post-intervention period may have also contributed to lower mortality and shorter length of stay.

We found that the location of where the infant is born was associated with whether they are discharged from the hospital exclusively breastfeeding or not. Infants born at health centers or in the home were less likely to be discharged exclusively breastfeeding, compared to those born in the hospital which has also been seen in other studies[29, 30]. There may be many reasons for this. Infants born at home need to first be transferred to the health center, and subsequently to the hospital which may delay the introduction of breastmilk for those infants, and subsequently impact whether the infant is discharged exclusively breastfeeding. The clinical staff at health centers may also be less experienced in caring for high-risk newborns, and may not follow essential newborn care practices and delay introduction of breastmilk since the infant needs to be clinically stabilized and then transferred to the hospital.

Infants born preterm were less likely to be discharged exclusively breastfeeding compared to infants born at term. Infants born preterm have unique feeding needs that require specialized interventions and management, and other studies have demonstrated similar findings of reduced exclusive breastfeeding rates even among moderate to late preterm newborns compared to term newborns[31]. Similarly, infants admitted for infection risk or neonatal infection in our study had much higher odds of exclusive breastfeeding. These findings are not surprising, as these infants are often term and feed easily. But notably, even when considering all of these factors in multivariate analysis, admission during the post-intervention period was the strongest predictor of exclusive breastfeeding at the time of discharge with nearly double the odds of exclusive breastfeeding compared to the pre-intervention period. Other factors in the neonatal care unit environment may also interfere with early and exclusive breastfeeding, including delayed initiation of KMC, or skin-to-skin contact, especially for sick newborns[32]. We were unable to measure timing or duration of KMC but this is an area that warrants further attention to reduce breastfeeding barriers.

Our study has some limitations. First, we used routinely collected data for the study, which results in some missing data and reliance on clinician skills in completion of medical files. In addition, precise measurement of gestational age is a challenge in Rwanda like in other low- and middle-income countries where availability of ultrasound dating is limited. Due to the use of routine data, it was not possible to reliably discriminate between newborns with infection or those with risk of infection and so we included all of these newborns in our sample. We also had a small sample size of patients born with HIE and those born with extremely low birth weight, which prevented measurement of the impact of interventions on these subsets.

Conclusions

A multi-level breastfeeding intervention improves earlier initiation of breastmilk feeding, exclusive breastfeeding on discharge, reduced length of stay, and decreased mortality among infants admitted to hospital neonatal units in a rural African setting. Adoption of evidenced-based guidelines such as the Baby Friendly Hospital Initiative aimed at the unique needs of small and sick newborns and innovative interventions should be expanded and adapted in similar settings to improve outcomes for these infants.

Abbreviations

BFHI: Baby-Friendly Hospital Initiative

DOL: Day of life

HIE: Hypoxic ischemic encephalopathy

LBW: Low birth weight

KMC: Kangaroo Mother Care

KDH: Kirehe District Hospital

NCU: Neonatal Care Unit

PIH/IMB: Partners In Health/Inshuti Mu Buzima

RDH: Rwinkwavu District Hospital

Declarations

Ethics approval and consent to participate

This study was approved by the Rwanda National Ethics Committee. Data was captured through review of routine records and so informed consent was not required.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

This study was funded by the Primates World Relief and Development Fund and Global Affairs Canada, who provided the funding for the interventions and evaluations. MAITS provided funding for the Infants with Feeding Difficulties trainers.

Acknowledgements

We would like to acknowledge the contributions of the neonatal unit nurses and the Expert Mothers for their commitment to the care of small and sick newborns. The manuscript was developed as part of a research-capacity building training in maternal and child health research at Partners In Health/Inshuti Mu Buzima led by Alphonse Nshimiyiryo, Catherine M. Kirk, and Kathryn Beck and based on the Intermediate Operational Research Training developed by Bethany Hedt-Gauthier at Harvard Medical School.

Authors' contributions

GS, AM, and FB led the study design, literature search, data cleaning and analysis, results interpretation, and writing manuscript. HH, CMK, and KB provided input in the study design, literature search, data cleaning and analysis, results interpretation, and critically reviewed the writing manuscript. CPDS, MA, HDS, AN, MLM, EK, and TA contributed to the interpretation of results and review of final manuscript. All authors reviewed and approved the final manuscript and had access to the data.

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