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Original Article

Breastfeeding pattern and the risk of neonatal illnesses among urban poor in Lucknow, Northern India: A prospective follow-up study

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ARTICLE INFO

Article history:

Received 24 May 2016

Accepted 27 June 2016

Available online 12 July 2016

Keywords:

Breastfeeding

Neonatal illnesses

Urban poor

Prospective study

India

ABSTRACT

Background: Exclusive breastfeeding has been shown to be protective against infants' illnesses. Evidence is sparse about the association of different breastfeeding patterns on neonatal illnesses.

Methods: The study was conducted at two urban public hospitals at Lucknow. Neonates who did not have any morbidity or congenital malformation and were residents of Lucknow were enrolled within 48 h of birth and followed up once at 6 weeks of age, at the outpatients clinic or home to assess neonatal illnesses and established (voluntary) breastfeeding pattern (exclusive, predominant, partial, never breastfed). Association of established breastfeeding patterns with neonatal illnesses was studied using multivariate logistic regression, adjusting for potential confounders.

Results: A total of 1020 neonates were enrolled. Follow-up information on occurrence of neonatal illnesses (if any) as well as established breastfeeding pattern was available for 937 (91.8%) enrolled neonates. Among these, 46% (431/937) presented with any illness, with 20.2% (189/937) reported with at least one danger sign of severe illnesses as mentioned in Integrated Management of Neonatal and Childhood Illnesses (IMNCI).

Partially breastfed neonates were significantly more likely to develop any illness (Adj. OR = 6.6; 95% CI: 4.0–10.8, $p < 0.001$) as well as IMNCI illnesses (Adj. OR = 5.8; 95% CI: 2.9–11.8, $p < 0.001$) as compared to exclusively breastfed neonates. Similarly, predominantly breastfed neonates were also significantly more likely to develop any illness (Adj. OR = 3.4; 95% CI: 2.0–5.8, $p < 0.001$) as well as IMNCI illnesses (Adj. OR = 2.9; 95% CI: 1.3–6.4, $p < 0.01$) as compared to exclusively breastfed neonates. The strength and consistency of these associations remained similar on refitting the model with term, singleton, and normal birth weight neonates.

Conclusions: Exclusive breastfeeding during the neonatal period was significantly protective against the occurrence of any illness as well as illnesses mentioned in the IMNCI program, as compared to predominant or partial breastfeeding.

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<http://dx.doi.org/10.1016/j.cegh.2016.06.004>

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1. Background

In 2015, an estimated 5.9 million childhood deaths occurred; among which 2.7 million (46%) occurred in the neonatal period.¹ India contributed to around 26%¹ of all neonatal deaths in the world. In low-resource settings in India, infections contribute to around half of the neonatal deaths.²

Throughout the world, evidence suggests that due to several biological reasons exclusive breastfeeding is protective against infectious diseases among infants and children. Immune complexes in breastmilk help to initiate and stimulate an infant's immune system.³ Oligosaccharides, Immunoglobulins (IgA, IgM, IgG), lactoferrin, B lymphocytes, T lymphocytes, eosinophils, and neutrophils provided from the mother's milk have been shown to have a protective effect against infections.^{3–5} Having breastmilk as the single source for feeding, further, protects infants from contracting infections from the external environment such as contaminated top milk, water or bottle feeding.⁶

Neonatal period is a time in which the newborn could be at highest risk of infection than within any time period during infancy and childhood.⁷ The risk of contracting infections through external sources of nutrition gradually decreases with age, and though there is a body of evidence demonstrating significant protective effect of breastfeeding (particularly exclusive breastfeeding) against infant/childhood morbidity and mortality,^{7–9} there is sparse literature on the strength of this protection within the neonatal period.¹⁰ A recent systematic review found only 6 studies (all observational) that had studied the effect of breastfeeding on neonatal morbidity; among which only two studies presented an adjusted analysis for potential confounding.¹¹ The present study assesses the association between the established neonatal breastfeeding pattern (exclusive, predominant, partial, never breastfed) with neonatal illnesses among urban poor in Lucknow, northern India.

2. Methods

2.1. Study design

This was a prospective follow-up study of neonates delivered at two public hospitals in urban Lucknow.

2.2. Setting

Lucknow is the capital city of Uttar Pradesh, a state in Northern India and has a native population of 4.5 million.¹² United Nations Centre for Human Settlements (UNCHS) estimates that more than half of Lucknow urban population live in slums.¹³ Total literacy rate in Lucknow is 79%, and sex ratio is 900 females per thousand males.¹² Institutional delivery rate is 76.3% and antenatal care coverage is 64.6%.¹⁴

The study was conducted in two public hospitals, an urban Reproductive and Child Health (RCH) center and the district hospital, after obtaining institutional ethical clearance from King George's Medical University and permission from relevant district authorities. The RCH center is a 12-bedded hospital,

with free outpatients' clinic and free normal vaginal delivery care facilities round the clock which caters to mainly slum and low income group population from the adjoining areas. District hospital is a 150-bedded hospital, which is well-equipped in dealing with complicated obstetric cases referred from Lucknow and adjoining areas. While the district hospital has both paid as well as free inpatient facilities, for this study we have recruited mothers from the free facility only, which caters to mainly lower income group so that economic status of subjects could be similar to those recruited from the RCH center.

2.3. Study population

2.3.1. Inclusion and exclusion criteria

Mothers of neonates born at the study sites and who gave written informed consent were enrolled.

Excluded were the mothers of neonates who required any resuscitation at birth and/or presented with any clinically detectable serious congenital malformation.

Mothers who were not residents of Lucknow or who were likely to move out of the city in next 1 month were also excluded.

2.3.2. Enrollment

Mothers in this study were enrolled from March 2007 to April 2008. At enrollment, a pre-tested questionnaire was used to elicit data on identification (unique identifier, name and address) and baseline variables as shown in [Table 1](#).

Mothers were requested to come back to the outpatients' clinic of the respective hospital on a specified date after 6 weeks, for follow-up and routine immunization. Dates (along with days) of follow-up were written on the copy of the informed consent form given to mothers.

Mothers were requested to keep prescriptions, receipts, wrappers, investigation reports, bottles of medicines etc. in case their newborn suffered any illness and were informed that this information would be collected at follow-up.

2.3.3. Follow-up

If the mother along with the baby did not turn up in the outpatients' department at the pre-specified dates for routine immunization at 6 weeks, home follow-up was done by a trained research person within next 2 days to obtain the same information.

At the time of follow-up mothers/caregivers were asked if their baby faced any health problem in the neonatal period and if answered in affirmation, symptoms of morbidity were recorded as narrated by them. A structured and pre-tested questionnaire was used to elaborate the details of illnesses and established (voluntary) neonatal breastfeeding pattern (exclusive, predominant, partial, never breastfed) as told by the mother. A comprehensive list of illnesses and symptoms was prepared in local terminology to avoid any translation problem. Information about the health care providers consulted was also obtained from the study participants. Medical prescriptions, investigation records, medicine bottles, chemist's receipts, etc., one or more of which were available in all cases, were also taken into account to support the information provided by the caregivers. Diagnosis and prescriptions by qualified health care providers, if available, were taken into

Table 1 – Baseline characteristics of the mothers enrolled (N = 1020).

Variables	(N = 1020) n (n/N)%	Site 1 (n = 397) m (m/n)%	Site 2 (n = 623) m (m/n)%
Mother's education			
No schooling	387 (37.9)	211 (53.1)	176 (28.3)
≤5 years education	91 (8.9)	24 (6.0)	67 (10.8)
Secondary/higher	542 (53.2)	162 (40.8)	380 (61.0)
Father's education			
No schooling	398 (39.0)	231 (58.2)	167 (26.8)
≤5 years education	266 (26.1)	122 (30.7)	144 (23.1)
Secondary/higher	356 (34.9)	44 (11.1)	312 (50.1)
Mother's occupation			
Unemployed	976 (95.7)	380 (95.7)	596 (95.7)
Any vocation	44 (4.3)	17 (4.3)	27 (4.3)
Father's occupation			
Daily wages	129 (12.6)	57 (14.4)	72 (11.6)
Salaried/professionals	222 (21.8)	65 (16.4)	157 (25.2)
Self-employed	635 (62.3)	270 (68.0)	365 (58.6)
Others	34 (3.3)	5 (1.3)	29 (4.7)
Religion			
Hindus	467 (45.8)	124 (31.2)	343 (55.1)
Muslims	550 (53.9)	273 (68.8)	277 (44.5)
Others	3 (0.3)	0 (0.0)	3 (0.5)
Residence			
Slum	318 (31.1)	187 (47.1)	131 (21.0)
Non-slum	702 (68.9)	210 (52.9)	492 (79.0)
Socio-economic status ^a			
Low	662 (64.9)	345 (86.9)	317 (50.9)
Medium	358 (35.1)	52 (13.1)	306 (49.1)
Joint family	753 (73.8)	276 (69.5)	477 (76.6)
Mother's age (mean (±SD))	24.9 (±3.9)	25.1 (±4.0)	24.7 (±3.9)
Father's age (mean (±SD))	29.5 (±5.0)	29.8 (±5.1)	29.4 (±5.0)
Family income ^b (mean (±SD))	2777 (±1495)	2373 (±1067)	3035 (±1662)
Other maternal variables			
Any antenatal care (ANC) prior to this delivery	966 (94.7)	366 (92.2)	600 (96.3)
ANC at public hospital	922 (90.4)	351 (88.4)	571 (91.7)
≥3 ANC visits	758 (74.3)	268 (67.5)	490 (78.9)
Tetanus toxoid (≥2 doses)	908 (89.0)	336 (84.6)	572 (91.8)
Maternal morbidity			
Fever in prenatal period	92 (9.1)	29 (7.3)	63 (10.1)
Leaking/bleeding per vaginum in prenatal period	67 (6.6)	19 (4.8)	48 (7.7)
Any chronic disease	34 (3.3)	10 (2.5)	24 (3.9)
Newborn variables			
Males	539 (52.8)	214 (53.9)	325 (52.2)
Singletons	998 (97.8)	393 (99.0)	605 (97.1)
Birth weight (<2500 g)	315 (30.9)	99 (24.9)	216 (34.7)
Gestational age			
On the basis of LMP (< 37 weeks)	76/664 (11.4)	15/204 (7.4)	61/460 (13.2)
On basis of Ballard (score = 30 or less)	197/969 (20.3)	61/386 (15.8)	136/583 (23.3)
Birth order = 1	350 (34.3)	95 (23.9)	255 (40.9)
Type of delivery			
Normal vaginal	904 (88.6)	395 (99.5)	509 (81.7)
Cesarean	116 (11.4)	2 (0.5)	114 (18.3)

Site 1, Reproductive and Child Health (RCH) center; Site 2, District hospital.

^a As per Kuppusswamy Scale¹⁵ (low corresponds to lower class and upper lower class and medium includes lower middle class as per Kuppusswamy scale. There were no participants from upper middle or upper class in our study sample).

^b Indian rupees (INR) [1 US\$ = 53 INR].

account by the study pediatrician to categorize symptoms of neonatal illnesses for diagnosis.

2.3.4. Operational definitions

Socio-economic status of the study participants was calculated based on Kuppusswamy's scale for the reference period

concurrent to the duration of our study.¹⁵ Newborns were weighed using a weighing machine accurate to 50 grams by the research person. Gestational age of the newborn was computed on the basis of (i) Last Menstrual Period and (ii) Ballard score.¹⁶ Ballard scoring was done by the study pediatrician.

Table 2 – Multiple feeding pattern among sick neonates and among those with uneventful neonatal period (N = 937).

Neonatal illnesses status N = 937		Feeding mode				Feeding substance				
		Breast feeds	Cup-spoon	Bottle Feeds	Cotton balls/syringe	Breast milk	Top milk	Formula	Water	Others ^a
IMNCI illnesses (n (%))	189	175 (92.6)	122 (64.6)	106 (56.1)	5 (2.6)	175 (92.6)	105 (55.6)	48 (25.4)	108 (57.1)	26 (13.8)
Diarrhea with dehydration	5	4	2	2	0	4	2	1	1	0
Dysentery	1	1	0	1	0	1	1	0	1	0
Persistent diarrhea	10	9	9	7	0	9	6	4	8	1
Septicemia	42	37	27	28	0	37	27	17	18	7
Meningitis	3	3	1	2	0	3	2	1	1	0
Pneumonia	52	49	36	27	3	49	26	9	37	8
Pathological jaundice	5	5	2	3	0	5	2	3	1	0
Necrotizing enterocolitis	3	3	3	0	0	3	3	0	1	0
Unexplained fever	30	27	18	15	2	27	16	7	16	5
Ear discharge	7	7	4	5	0	7	4	4	5	0
Multiple pustules	24	24	14	11	0	24	11	2	13	4
Umbilical sepsis	7	6	6	5	0	6	5	0	6	1
Non-IMNCI illnesses (n (%))	242	223 (92.1)	128 (52.9)	143 (59.1)	5 (2.1)	223 (92.1)	105 (43.4)	59 (24.4)	135 (55.8)	32 (13.2)
Diarrhea	72	63	43	46	1	63	31	24	51	12
URI	111	107	57	59	2	107	48	22	64	8
Dermatitis	26	24	12	26	0	24	14	6	12	4
Conjunctivitis	15	12	8	5	1	12	5	2	7	2
Physiological jaundice	18	17	8	7	1	17	7	5	1	6
Uneventful neonatal period	506	496 (97.8)	216 (42.6)	147 (29.0)	9 (1.8)	496 (97.8)	126 (24.9)	58 (11.4)	202 (39.8)	40 (7.9)

^a This category included sweetened water, rice water, juices (including sugarcane juice), honey, teas, herbal drinks, mashed banana, mashed biscuits, etc.

To categorize neonatal illnesses, we used simple clinical definitions applicable in field settings, from those recommended by the Integrated Management of Neonatal and Childhood Illnesses (IMNCI)¹⁷ and National Neonatology Forum (NNF) of India.¹⁸

IMNCI definitions were used for classifying patients as having diarrhea with dehydration, persistent diarrhea, pneumonia, meningitis, ear discharge, fever, more than ten pustules, jaundice and sepsis.¹⁷ IMNCI danger signs were the signs presented in a neonate likely to be suffering from serious bacterial infection, severe jaundice, diarrhea with dehydration or severe persistent diarrhea. Non-IMNCI illnesses were defined and classified as per the guidelines of NNF of India.¹⁸ Non-IMNCI illnesses were upper respiratory tract infection (URI), diarrhea, conjunctivitis, dermatitis, physiological jaundice and others.

We used WHO's definitions for breastfeeding patterns.¹⁹ Exclusive breastfeeding was defined as feeding only breast milk and nothing else, not even water, with the exception of prescribed medicines. Predominant breastfeeding was defined as feeding of breast milk along with other non-milk fluids (water/sweetened water/juices/teas/herbal drinks, etc.). Neonates who were given breast milk along with top milk (and/or infant formula) and other non-milk fluids/solids were considered to be partially breastfed. Neonates who received any type of milk or non-milk fluids but never received breastmilk were defined as never breastfed.

2.3.5. Data analysis

χ^2 test and Student's t-test have been used for comparison of categorical and continuous baseline variables, across the study sites (Table 1). χ^2 test has been used for comparison of

proportion of neonatal illnesses by feeding substances, modes of feeding and breastfeeding pattern (Tables 2 and 3).

The effect of breastfeeding pattern on all neonatal illnesses as well as IMNCI-specific illnesses was assessed using multinomial logistic regression, adjusting for potential confounders (Table 4).

Potential confounders relating to the mother (prenatal health, parity, age, educational level, socio-economic status, type of delivery), household (slum/non-slum), health system utilization (number of antenatal visits, number of tetanus toxoid vaccination, place of delivery) and the newborn (gender, birth weight, gestational age, season of birth) were included in the neonatal illnesses models (both IMNCI specific as well as all illnesses).

To reduce issues with reverse causality (i.e., the possibility that the pattern of breastfeeding was affected by any serious morbidity), only newborns who were successfully discharged from the hospital and who were successfully breastfed were included in the analyses. We excluded 44 (4.7%) of the newborns who did not initiate breastfeeding, stopped in between or were never breastfed. Fig. 1 depicts the flow of study participants in the study and those included in the final analysis.

Two-tailed hypothesis was used and we report crude odds ratios as well as adjusted odds ratios along with 95% confidence intervals and corresponding p-values. p-Values <0.05 were considered to be significant. All analyses were conducted in Statistical Package for Social Sciences (SPSS), ver. 17.

To further reduce issues of reverse causality, analyses were repeated, excluding newborns conventionally at higher risk of morbidity (preterm, low birth weight, non-initiators, and multiple births).

Table 3 – Neonatal illnesses by types of established feeding patterns (N = 937).

Neonatal illnesses	Exclusive (n = 248)	Predominant (n = 269)	Partial (n = 376)	Never breastfed (n = 44)	χ^2 , p-value
IMNCI illnesses	18 (7.3%)	48 (17.8%)	109 (28.9%)	14 (31.8%)	48.5, $p < 0.0001$
Diarrhea with dehydration	2	0	2	1	
Dysentery	0	0	1	0	
Persistent diarrhea	1	2	6	1	
Septicemia	5	3	29	5	
Meningitis	1	0	2	0	
Pneumonia	2	21	26	3	
Pathological jaundice	2	0	3	0	
Necrotizing enterocolitis	0	0	3	0	
Isolated fever	2	8	17	3	
Ear discharge	1	1	5	0	
Multiple pustules	2	11	11	0	
Umbilical sepsis	0	2	4	1	
Non-IMNCI illnesses	29 (11.7%)	76 (28.3%)	117 (31.1%)	20 (45.4%)	41.0, $p < 0.0001$
Diarrhea	2	23	38	9	
URI	13	38	55	5	
Dermatitis	4	5	15	2	
Conjunctivitis	3	7	2	3	
Physiological jaundice	7	3	7	1	
All illnesses (total)	47 (18.9%)	124 (46.1%)	226 (60.1%)	34 (77.2%)	120.5, $p < 0.0001$

Although, not the objective of the current study, we have also presented the effect of established breastfeeding patterns on risk of hospitalization and/or neonatal mortality.

3. Results

From March 2007 to April 2008, a total of 1020 neonates were enrolled from the RCH center (n = 397) (39%) and district

hospital (n = 623) (61%) and followed-up once at 6 weeks at the outpatients' clinic of the respective hospitals or at home. Overall, 971 (95.2%) neonates were followed-up and 49 (4.8%) were lost-to-follow-up.

3.1. Baseline characteristics

Overall, 37.9% of the mothers had never been to school (Table 1), the proportion from the RCH center (53.1%) being

Table 4 – Established feeding pattern and neonatal illnesses among breastfed^a neonates (N = 893).

Neonatal illnesses	Type of feeding pattern	OR (95% CI)	Adj. OR ^b (95% CI)
All illnesses			
Whole population	Exclusive	1	1
	Predominant	3.6 (2.4–5.4)	3.4 (2.0–5.8)
	Partial	6.4 (4.4–9.4)	6.6 (4.0–10.8)
	p for trend		<0.001
Term, singletons, normal birth weight	Exclusive	1	1
	Predominant	4.2 (2.5–7.1)	4.0 (2.3–6.9)
	Partial	7.3 (4.4–12.1)	7.3 (4.4–12.4)
	p for trend		<0.001
IMNCI illnesses			
Whole population	Exclusive	1	1
	Predominant	2.8 (1.6–4.9)	2.9 (1.3–6.4)
	Partial	5.2 (3.1–8.8)	5.8 (2.9–11.8)
	p for trend		<0.001
Term, singletons, normal birth weight	Exclusive	1	1
	Predominant	2.9 (1.4–6.0)	2.9 (1.4–6.2)
	Partial	4.6 (2.3–9.0)	4.7 (2.3–9.4)
	p for trend		<0.001

^a We excluded 44 (4.7%) neonates who either did not initiate breastfeeding or were never breastfed.

^b Adjusted for maternal education, father's education, socio-economic status, place of residence (slum/non-slum), season of birth, antenatal care (ANC visits, number of tetanus toxoid), place of delivery, maternal ethnicity, maternal prenatal health, maternal age, mode of delivery (normal/cesarean), birth order, neonate's gender, gestational age, birth weight and multiple births.

^c We refitted the model excluding preterm, multiple births, and low birth weight neonates.

Fig. 1 – Flow of study participants in the study and data analysis.

significantly higher ($p < 0.001$) than those from the district hospital (28.3%). Similarly, 39% of the fathers had never been to school, and the proportion of these from RCH center (58.2%) also being significantly higher ($p < 0.001$) than those from the district hospital (26.8%). The proportion of Muslims was significantly higher ($p < 0.001$) among the mothers from the RCH center and although the proportion of slum dwellers among those from the RCH center was comparable with the proportion of non-slum dwellers, this proportion was significantly less ($p < 0.001$) among those enrolled from the district hospital. The average monthly household income among those from RCH center was significantly lower ($p < 0.001$) than those from the district hospital and the proportion of mothers from low socio-economic status were significantly higher ($p < 0.001$) in the RCH center as compared to the district hospital. Our study population was predominantly (65%) from the low socio-economic status (Table 1) and the rest were from lower middle class. Based on Kuppuswamy socio-economic status scale, there was neither Upper middle class nor Upper class in our study sample.

We observed that the proportion of mothers having ≥ 3 ANC visits was significantly lower ($p < 0.001$) among those from the RCH center as compared to those from the district hospital.

The proportion of low birth weight ($p = 0.001$) and neonates with first birth order were significantly higher ($p < 0.001$) among those from the district hospital as compared to those from the RCH center.

The distribution of other socio-economic and newborn variables was similar across the study sites.

3.2. Follow-up

At follow-up ($n = 971$), 937 (96.4%) respondents were mothers while 34 (3.6%) respondents were other caregivers (grandmothers/grandfathers/fathers/other relatives in the household). In the analysis for established breastfeeding pattern we only considered mothers to be a reliable category of respondents, and, hence excluded (3.6%) the instances where mothers were not the key respondents.

Around half (46% (431/937)) neonates developed any illness in the neonatal period. Of these 20.2% (189/937) developed an illness which incorporated one or more IMNCI danger signs while 25.8% (242/937) had an illness associated with non-IMNCI signs. Mean number of illnesses per neonate was 1.07 (± 0.23), $n = 431$. We have considered only primary disease conditions in neonatal morbidity classification.²⁰

Table 5 – Neonatal hospitalization and/or mortality due to possible infectious causes.

Neonatal mortality	Exclusive (n = 248)	Predominant (n = 269)	Partial (n = 376)	None (n = 44)	OR (95% CI), p-value (partial vs exclusive)
Septicemia			5	1	
Pneumonia			2		
Meningitis			1		
Pathological jaundice					
Necrotizing enterocolitis			3		
Diarrhea with dehydration	1				
Sub-total	1	0	11	1	7.5 (0.95–58.1), $p = 0.056$
Hospitalization ^a					
Septicemia	2		5		
Pneumonia		1	1		
Meningitis	1		2		
Pathological jaundice	2		3		
Necrotizing enterocolitis			2		
Diarrhea with dehydration			1	1	
Sub-total	5	1	14	1	1.9 (0.66–5.28), $p = 0.19$
Total ^b (hospitalization or mortality)	6	1	22 ^b	2	2.5 (1.0–6.3), $p = 0.049$

^a All diagnoses made at hospital.

^b We excluded three neonates (necrotizing enterocolitis ($n = 2$), meningitis ($n = 1$)) who were partially breastfed prior to hospitalization and who died during hospitalization to avoid counting them twice.

3.3. Neonatal illness by feeding substances and modes of feeding

We found that proportions of bottle-fed and cup-spoon fed newborns was significantly higher among those who presented with IMNCI as well as non-IMNCI illnesses as compared to those who had uneventful neonatal period ($p < 0.001$, for both categories) (Table 2). We also found that proportions of newborns who were given top-milk, formula feeds, and water were also significantly higher for those who presented with IMNCI or non-IMNCI illnesses as compared to those who had an uneventful neonatal period ($p < 0.001$, for all three categories).

3.4. Neonatal illnesses by established breastfeeding patterns

There was a significant trend of increasing risk of neonatal illnesses (IMNCI, non-IMNCI as well as all illnesses) from exclusive to predominant to partial to never breastfed neonates ($p < 0.0001$ for all three illness categories) (Table 3).

We found that predominantly breastfed neonates were significantly more likely to develop any illness (Adj. OR = 3.4; 95% CI: 2.0–5.8) as well as IMNCI illnesses (Adj. OR = 2.9; 95% CI: 1.3–6.4) as compared to exclusively breastfed neonates (Table 4). We observed that partially breastfed neonates were also significantly more likely to develop any illness (Adj. OR = 6.6; 95% CI: 4.0–10.8) as well as IMNCI illnesses (Adj. OR = 5.8; 95% CI: 2.9–11.8) as compared to exclusively breastfed neonates.

We refitted the model, excluding neonates at higher risk of morbidity (preterm, multiple births, low birth weight), but the strength and consistency of epidemiological associations remained similar (Table 4).

3.5. Breastfeeding pattern and risk of neonatal hospitalization and/or mortality

Hospitalization was sought for 23 neonates. We have information on breastfeeding pattern for 21 neonates. All of these hospitalizations were due to IMNCI illnesses (Table 5). Among these, 18 were perceivably cured as per their mothers at follow-up, and three died due to necrotizing enterocolitis ($n = 2$) and meningitis ($n = 1$).

We found that among the 13 neonates who died of suspected infectious causes, 11 were partially breastfed, one was never breastfed and one was exclusively breastfed.

We observed that partially breastfed newborns were at a higher risk of infection-specific neonatal mortality or infection-specific hospitalization, although these were not statistically significant. Further, the risk of infection-specific hospitalization or mortality (combined) was marginally significantly higher for partially breastfed newborns as compared to exclusively breastfed newborns (Table 5). The low numbers did not permit meaningful multivariate adjusted analysis.

4. Discussion

Breastfeeding was nearly universal in our study population, with 95.3% (95% CI: 93.7–96.5) neonates being ever breastfed. Despite this, we found that exclusive breastfeeding during the neonatal period was only 26.4% (95% CI: 23.7–29.4). According to Annual Health Survey²¹ of Uttar Pradesh, the rate of exclusive breastfeeding for first 6 months in urban Lucknow was 25.2%. Our study population was predominantly from lower income strata, already at higher risk for neonatal morbidity^{22,23} and one of the most alarming findings from our

study was that potentially harmful external feeding (animal milk/formula/water/teas/juices/semi-solids, etc.) was introduced to a majority (73.6%) of infants as early as in the neonatal period, when an infant was at the highest risk of contracting infection from external feeding than in any other time during infancy or childhood.⁷

The principal finding of our study was that partially breastfed neonates as well as predominantly breastfed neonates were significantly more likely to develop any illness (Adj. OR = 6.6 (95% CI: 4.0–10.8) and 3.4 (95% CI: 2.0–5.8), respectively) as well as IMNCI illnesses (Adj. OR = 5.8 (95% CI: 2.9–11.8) and 2.9 (95% CI: 1.3–6.4), respectively) as compared to exclusively breastfed neonates, both in the whole study population as well as in the sub-group of term, singleton, normal birth weight neonates (Adj. OR = 7.3 (95% CI: 4.4–12.4) and 4.0 (95% CI: 2.3–6.9), respectively for all illnesses and Adj. OR = 4.7 (95% CI: 2.3–9.4) and 2.9 (95% CI: 1.4–6.2), respectively for IMNCI illnesses), in the unadjusted analysis as well as in the analysis adjusted for potential confounders (Table 4). We observed a marked dose–response relationship between the level of breastfeeding exposure and neonatal illnesses, with a significant trend ($p < 0.0001$) of increasing risk for both IMNCI illnesses as well as all illnesses, from exclusive to predominant to partial to never breastfed neonates (Table 3). Another study analyzing the national data from the United States also reported such relationship between breastfeeding exposure and infant illnesses.²⁴

Major strength of this study was that it quantified the protective effect of exclusive breastfeeding as compared to predominant and partial breastfeeding on the occurrence of all neonatal illnesses as well as illnesses mentioned in the IMNCI program, in a resource-poor setting, and used standard WHO study definitions so that the four types of established breastfeeding categories (exclusive, predominant, partial, never breastfed) could be compared. Further, evidence lacks the comparison of predominant vs exclusive breastfeeding in relation to morbidity in the first month of life¹¹ and our study contributes to fill this gap.

We also found that partially breastfed neonates were more likely (OR = 7.5; 95% CI: 0.95–58.1) to die of infectious causes and more likely to suffer severe adverse event (hospitalization and mortality) (OR = 2.5; 95% CI: 1.0–6.3) as compared to exclusively breastfed neonates, although the effects on these two outcomes were not significant due to constrained statistical power (66% and 73%). Nevertheless, one prospective observational cohort study, previously done on 10, 942 breastfed singleton neonates in Ghana,¹⁰ has reported that partial breastfeeding was associated with a 5.7-fold adjusted risk of death as a result of infectious disease (Adj. OR: 5.73; 95% CI: 2.75, 11.91). Exclusive breastfeeding has also been previously reported to significantly protect against infection-specific hospital admissions among infants.^{25,26}

Breastfeeding has been reported to be protective against variety of infections in infants, such as gastroenteritis,²⁷ wheezing lower respiratory tract illness,²⁸ pneumonia,^{9,27} upper respiratory tract illnesses,²⁹ dermatitis,³⁰ acute otitis media,³¹ meningitis,³² sepsis³³ and necrotizing enterocolitis³⁴ as compared to partial breastfeeding, never breastfed, bottle feeding or formula feeding (odds ratios ranging from 2 to 18). One of the major problems when comparing similar studies in

different settings is that infant feeding patterns are not well defined. Based on inconsistent study definitions, some studies^{35,36} recommend predominant breastfeeding for young infants; however, these recommendations cannot be generalized. Further, findings from a multi-centric study³⁷ suggest that non-breastfed as well as partially breastfed infants had a higher risk of mortality as compared to predominantly breastfed and that there was no significant difference in mortality between exclusively and predominantly breastfed infants. On the basis of our study findings, we suggest that the recommendation of exclusive breastfeeding for 6 months should be continued with, against the recommendation by others³⁷ to sustain predominant breastfeeding in areas where predominant breastfeeding was already highly prevalent rather than attempting a shift from predominant to exclusive breastfeeding. Predominant breastfeeding could be protective against partial breastfeeding (or never breastfed) for more severe outcomes (mortality and hospitalization)³⁷ but not against the overall incidence of illnesses in young infants, particularly in neonatal period and in resource-poor settings. Hence, the recommendation of exclusive breastfeeding for 6 months was suitable for infants (including neonates) in all settings, and should only be continued with.

We have previously reported²³ that the out-of-pocket expenditure on neonatal illnesses had a major share or exceeded the monthly household income of the lower strata of the low-income group in the community. Thus, the burden on these families due to out-of-pocket expenditure on neonatal illnesses could be tremendous. These families are most likely to benefit from the promotion of exclusive breastfeeding.

5. Conclusions

We conclude that exclusive breastfeeding during the neonatal period was significantly protective against the occurrence of any illness as well as illnesses mentioned in the IMNCI program, as compared to predominant or partial breastfeeding. Mothers should be counseled for exclusive breastfeeding for 6 months, paying stress on its importance, particularly during the neonatal period, since this was the time when protective effect of exclusive breastfeeding could be highest.

6. Limitations

Our study was done in public hospitals among mothers from low socio-economic groups and therefore cannot be generalized for all institutional deliveries. The patterns of neonatal illnesses and breastfeeding could differ among home-delivered neonates and those from the general population. Further, though we used structured and pre-tested questionnaire with local terminology and tried to corroborate the maternal reporting of symptoms of neonatal illnesses through medical provider's diagnosis and prescriptions, investigation records, medicine bottles and chemist's receipts (one or more of which were available in all cases), there could be some misclassification.

Though experimental studies could produce better evidence, however, owing to ethical concerns, the study design was chosen. As per the available evidence (predominantly due

to ethical concerns), there is no experimental study addressing this topic.¹¹ This is a gap in literature and needed to be addressed in future studies.¹¹

Further, though, we have adjusted for the potential confounders, however, due to the observational nature of the study, some difference due to residual confounding may not be ruled out.³⁸ Nevertheless, the consistency and strength of the epidemiological associations (both in the total study population as well as in the sub-group of term, singleton, normal birth weight newborns), together with biological plausibility are suggestive of a causal sequence.

Authors' contribution

SA conceptualized the study and supervised the data collection, analysis and manuscript writing process. NMS analyzed the data. Both authors prepared the manuscript.

Conflicts of interest

The authors have none to declare.

Acknowledgements

This work was funded through a grant from the Indian Council of Medical Research (ICMR), New Delhi, India. Dr. Shubha Pant and Mr. Atul Chandra were involved in the data collection as well as data entry. We thank the district authorities as well as the staff of the participating sites for their support during the project activity.

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