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The first 1000 days of life: prenatal and postnatal risk factors for morbidity and growth in a birth cohort in southern India

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ABSTRACT

Objective: To estimate the burden and assess prenatal and postnatal determinants of illnesses experienced by children residing in a semiurban slum, during the first 1000 days of life.

Design: Community-based birth cohort

Setting: Southern India

Participants: Four hundred and ninety-seven children of 561 pregnant women recruited and followed for 2 years with surveillance and anthropometry.

Main outcome measure: Incidence rates of illness; rates of clinic visits and hospitalisations; factors associated with low birth weight, various illnesses and growth.

Results: Data on 10 377.7 child-months of follow-up estimated an average rate of 14.8 illnesses/child-year. Gastrointestinal and respiratory illnesses were 20.6% and 47.8% of the total disease burden, respectively. The hospitalisation rate reduced from 46/100 child-years during infancy to 19/100 child-years in the second year. Anaemia during pregnancy (OR=2.3, 95% CI=1.08 to 5.18), less than four antenatal visits (OR=6.8, 95% CI=2.1 to 22.5) and preterm birth (OR=3.3, 95% CI=1.1 to 9.7) were independent prenatal risk factors for low birth weight. Female gender (HR=0.88, 95% CI=0.79 to 0.99) and 6 months of exclusive breast feeding (HR=0.76, 95% CI=0.66 to 0.88) offered protection against all morbidity. Average monthly height and weight gain were lower in female child and children exclusively breast fed for 6 months.

Conclusions: The high morbidity in Indian slum children in the first 1000 days of life was mainly due to prenatal factors and gastrointestinal and respiratory illness. Policymakers need disease prevalence and pathways to target high-risk groups with appropriate interventions in the community.

Strengths and limitations of this study

- This study had intensive biweekly surveillance visits to record postnatal morbidity information.
- Weekly validation of field data and confirmation of illness by a physician or medical records reduced recall bias and facilitated accurate recording of morbidity.
- This study lacked complete data on antenatal care and pregnancy outcome of all enrolled women, although we found no differences between children with and without complete maternal data.
- Studies have shown the first 2 years of life to be crucial for cognitive development in children, but cognitive function was not assessed in this study.
- The study area may not represent a typical Indian slum because of the good availability and accessibility of healthcare in the public and private sectors.

INTRODUCTION

One of the millennium developmental goals (goal 4) is to reduce the under five mortality by two thirds by 2015. This includes reinforcement of efforts against pneumonia and diarrhoea, and strengthening the nutritional status of mothers and children.[1] In the past few decades, rapid urbanisation, growing urban slums in developing countries, especially in India, has raised concerns on public health issues, such as overcrowding, lack of safe drinking water, sanitation and deprivation in multiple domains,[2 3] which in turn exposes a vulnerable age group to high risks of infectious diseases,[4] malnutrition[5] and impaired cognitive development,[6] in the early formative years of life.

It is estimated that more than 200 million children under 5 years of age in developing countries do not attain their developmental potential.[7] The cognitive and physical development of a child is influenced by the first 1000 days of life, from conception to the second birthday.[8–10] This, in turn, is affected

by biological factors, such as nutrition of the mother during pregnancy, gestational age, birth weight, duration of breast feeding, childhood malnutrition, childhood infections and psychosocial factors, such as economic status, parental education and environmental exposures.[11] Often these are interdependent domains and children exposed to multiple factors are the most vulnerable. The accumulation of risk over time compromises the overall development of the child.

Data on the burden of disease and the complex association of multiple environmental and host factors with disease are essential to permit planning of healthcare and prevention policies in the developing countries. Population-based longitudinal/cohort studies can provide better insights into the complex interaction among the different domains affecting childhood growth and development because they capture data on disease burden at the community level, provide insights into multiple exposures in disease aetiology and help establish temporality. Longitudinal data collection overcomes the lacunae of data from cross-sectional studies, especially hospital-based studies, which reflect only the tip of the iceberg, that is, more severe diseases, and does not provide evidence on the temporality of association.

The objective of the study was to describe the burden of morbidity and the effect of prenatal and postnatal factors on low birth weight (LBW), childhood morbidity and growth in the first 1000 days of life in a birth cohort established in semiurban slums of Vellore in southern India.

MATERIAL AND METHODS

Study area and population

The study area is located in four geographically adjacent semiurban slum areas, Ramnaickapalayam, Chinnallapuram, Kaspa and Vasanthapuram, on the western outskirts of Vellore, Tamil Nadu, India. The most common occupation of the families is manual production of 'beedis' (indigenous cigarettes made of tobacco wrapped in dried leaves) and followed by unskilled labour such as building or road construction work. The population is predominantly of low-socioeconomic and middle-socioeconomic strata.

Free government healthcare facilities are available at the Urban Health Centre, located in the study area, and at a 500-bed government general hospital located 5 km away. There are also large numbers of private clinics, nursing homes and traditional medicine clinics. The 2500-bed Christian Medical College (CMC), Vellore, and its extensions—the Community Health and Development (CHAD) and the Low Cost Effective Care Unit (LCECU) hospitals, are located within a few kilometres of the study area. Most homes are built of permanent construction materials, with some mixed construction (eg, brick walls but thatched roof). Roads are paved, but have open drains that are cleaned manually by the municipality.

Vellore has a dry and hot climate, with a temperature range from 18°C in December to 44°C in May. It receives its maximum rainfall during the Northeast monsoon (September–November) with a mean annual rainfall of 996.7 mm (http://vellorecorp.tn.gov.in). The local municipality supplies piped drinking water to domestic taps and street stand-pipes at intervals ranging from 2 to 28 days. The common practice is to collect and store water in multiple wide-mouthed plastic/steel containers. People usually do not treat water before consumption.

Study design and recruitment

The primary objective of establishing the cohort was to study the natural history and immune response to *Cryptosporidium* spp in children from birth to 3 years of age. A door-to-door survey was conducted from March 2009 to May 2010 to identify new pregnancies by screening women of childbearing age. Children of pregnant women intending to stay in the study area for a period of 3 years were eligible for participation. Recruitment started after written informed consent was obtained from the parents or legal guardians of the eligible children. Infants with very LBW (less than 1500 g) and major congenital malformations were excluded from participation, but data were collected on pregnancy outcomes where available.

Establishment of cohort and follow-up

A total of 561 pregnant women who fulfilled the eligibility criteria after the door-to-door survey were identified and were asked to participate in the study. Before delivery, every pregnant woman was visited weekly by the field worker to enquire about her well-being and build a rapport with the study family. During the antenatal and perinatal follow-up period, 64 pregnant women became unavailable (figure 1). Baseline information on demography, socioeconomic factors, delivery and birth details were obtained, postdelivery, from each household. The prenatal/antenatal data were obtained from the antenatal cards of mothers. Gestation period was calculated from the last menstrual period and the date of delivery recorded on the antenatal cards. Definitions of risk factors including number of antenatal care (ANC) visit of less than four,[12] maternal anaemia (moderate–severe) with a cut-off of <10 g%[12] and exclusive breast feeding for less than 6 months[13] were as specified by WHO. A median cut-off of five was used to categorise households as those with equal to or lesser and greater than five members. The maternal age was categorised into teenage mothers (<20 years) or those at least or older than 20 years. Socioeconomic status (SES) was assessed using a five-point scale, which is a modification of the Kuppuswamy scale, and includes highest education, occupation, possessions and type, ownership and number of rooms in a house.[14 15] Mothers of children enrolled in the cohort were not sociodemographically different from those not recruited (data not shown).

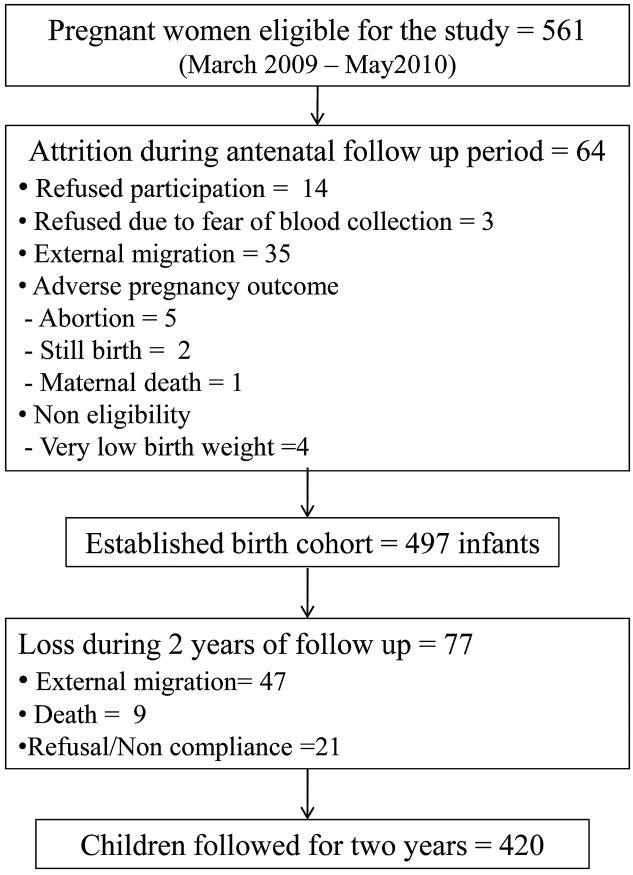

Figure 1 Flow chart of cohort recruitment and follow-up.

Surveillance

Each of 497 enrolled infants had two surveillance visits a week, resulting in 314 403 observation points. Of them 444 infants (89.33%) completed 1 year of follow-up and 420 (84.5%) completed 2 years. The most common reason for loss to follow-up was migration out of the study area. The baseline sociodemographic characteristics of children who were lost to follow-up did not differ from children who remained in the study (data not shown). The median (range) period of follow-up for each child was 23.6 (0.39–23.96) months, accounting for a total of 10 377.7 child-months of follow-up.

Data collection

During surveillance visits, the child was observed, and the caregiver interviewed about any illness experienced by the child during each day since the last visit, using a structured questionnaire. Field workers were trained to use standard definitions to identify illness. The data collected by the field workers were validated weekly by a field supervisor in a 10% random subsample.

A physician-run study clinic was established within the study area to cater to the health needs of all children less than 5 years of age living in the area. Children were either managed at the clinic or referred to the CHAD or CMC hospitals depending on the severity of the disease. All hospital visits and hospitalisations were recorded.

The morbidity experience of children captured on field visits was classified into broad categories based on maternal/caregiver report or hospitalisation discharge summaries. Gastrointestinal (GI) illnesses were defined as diarrhoea (three watery stools in a 24 h period) or vomiting lasting for more than 24 h. Upper respiratory illnesses were defined as runny nose or cough, either with or without fever, lasting for five or more days. Undifferentiated fever was defined as fever not associated with other symptoms lasting at least 48 h. Skin lesions were defined as rashes, vesicles, pustules, cysts, ulcerations and traumatic ulcers. Other infections included infections of the eyes, ears or any other localised infection with or without fever. Non-infectious morbidities included non-specific swellings, surgical conditions, such as hernia, congenital diseases, fractures, injuries, insect bites, and accidents. A new episode for GI morbidities was defined as illness occurring at least 48 h after cessation of the previous episode. For all other illnesses, an interval of 72 h separated two episodes. All severe illnesses were assessed and managed by the physicians/paediatricians at the study clinic or at the hospital where children were referred.

Anthropometry

At the beginning of the study during the protocol training, the field team received training on measuring the height and weight of children. Interobserver and intraobserver standardisations were carried out during these training workshops. Weight and height/length were measured every month for all children at the study clinic. Only in situations where the child could not be brought to the clinic, field workers took the anthropometric measurement at home. Electronic weighing scales were used to weigh the children and a length board/infantometer was used to measure the length of the children. The machines were calibrated every 6 months. Malnutrition in children was defined by calculating the height-for-age (HAZ), weight-for-height (WHZ) and weight-for-age (WAZ) z-scores, using the 2006 WHO child growth standards as the reference population.[16] Based on the 24th month measurement, children were categorised as stunted, wasted or underweight if their HAZ, WHZ or WAZ were <−2 SD, respectively. The monthly rate of growth was calculated from length and weight at 2 years and at birth.

Statistical analysis

Double data entry was carried out using Epi-Info 2002 (CDC, Atlanta, Georgia, USA) software and analysed using STATA V.10.1 for Windows (StataCorp, College Station, Texas, USA) software.

Descriptive analysis of baseline sociodemographic results are presented for all the 561 pregnant women enrolled in the study, and maternal and delivery details are presented for the 497 infants who were recruited into the birth cohort. The baseline demographic comparison between children with and without prenatal

maternal data was performed using χ^2 test or Fisher's exact test for categorical variables and two-tailed student t tests or Wilcoxon rank sum tests for continuous variables, depending on the distribution of the data.

Incidence rates were calculated as the number of episodes divided by the child-years of follow-up. The total person-time at risk was calculated as the total days under surveillance minus days of missing surveillance data (if ≥1 week).

Multiple failures within a child were accounted for using frailty Poisson Survival models, which were fitted to obtain the variance corrected incidence rates and rate ratios to assess the factors associated with overall (summation of GI, respiratory, undifferentiated fever, skin, non-infectious and other infectious morbidity), GI and respiratory morbidities and the risk is presented as HR with 95% CI. Logistic regression was performed to identify the factors associated with the risk of LBW and are presented as OR with 95% CI. Linear regression was performed to determine the factors associated with growth rate and the results are presented as β-coefficient with 95% CI.

The explanatory variables used in the regression models were time-independent sociodemographic variables such as religion, maternal education, type of family, SES and antenatal/delivery/postnatal variables, such as maternal anaemia, hypertension, diabetes, preterm birth, parity, history of abortion/still birth and duration of breast feeding. Factors identified in the univariate analysis at the significance level of 0.30 and clinically relevant variables were considered for inclusion in the full multivariate models. Multivariable analysis was performed using backward stepwise method. A parsimonious regression model was chosen considering the significance of predictors in the full model. For biological comparisons some non-significant variables, such as socioeconomic status, were retained in the final model where considered relevant. Risk factor analyses for LBW, morbidities and growth rate was restricted to a subgroup of 216 children, because of the availability of complete prenatal data.

RESULTS

Baseline demographics of pregnant women

Of the 561 pregnant women screened, 54.2% were Hindus and 41.5% were Muslims. Predominantly, they were from nuclear families (60.3%) with a median (IQR) family size of 5 (4–7). Firewood was used as primary cooking mode in 40% of the households. About 60% of the pregnant women belonged to a low socioeconomic stratum (table 1).

Information on mothers, ANC and mode of delivery are presented in table 1. Ninety-eight per cent of deliveries were institutional. Almost one-fifth of the study children were born in consanguineous marriages and 17% weighed less than 2.5 kg and were classified as LBW. Subgroup analyses between children with and without complete prenatal maternal information demonstrated that both groups did not differ sociodemographically (see online supplementary table S1).

Factors associated with LBW

The mean birth weight was 2.9 kg and the mean gestational age was 39.6 weeks. Preterm birth (OR, 95% CI 3.31, 1.12 to 9.78), less than four ANC visits (6.88, 2.10 to 22.51), and anaemia defined as haemoglobin <10 g/dL during pregnancy (2.36, 1.08 to 5.18) were independent risk factors associated with LBW. Although beedi making at home was associated with risk of LBW, it did not remain significant in the multivariate model (table 2).

Illness in the birth cohort

A total of 12 803 episodes of illness which included all episodes of GI illnesses, upper and lower respiratory tract illnesses, undifferentiated fever, skin lesions, non-infectious illnesses and other infections such as infections of the eyes, ears or any other localised infection with or without fever were recorded during the 2-year follow-up period, resulting in an incidence (95% CI) of 14.77 (14.26 to 15.30) episodes of illness/child-year. Children had more illnesses during infancy (16.04 episodes of illness/child-year) than during the second year of life (13.45 episodes of illness/child-year; p<0.001). Table 3 presents the incidence rates of different illnesses during the first and second year of life.

Respiratory infections were the most common, accounting for 47.8% (6122/12 803) of all morbidities, with an incidence (95% CI) of 7.06 (6.86 to 7.27) episodes/child-year. The median (IQR) duration of an episode of respiratory illness was 14 (9–24) days, since all uncomplicated upper respiratory infections (eg, runny nose or cold with no other associated symptoms) of less than 5 days were not included.

GI illness accounted for 20.6% (2634/12 803) of all reported illnesses, with an incidence (95% CI) of 3.04 (2.82 to 3.28) episodes of GI illness/child-year. The median (IQR) duration of an episode of GI illness was 4 (3–6) days.

The overall incidence of undifferentiated fever during the 2 years of follow-up was 0.80 episodes/child-year, decreasing from 0.94/child-year in the first year to 0.66 episodes/child-year in the second year. Incidences of other infectious illnesses were 0.96 episodes/child-year. In general, the incidence of skin and other infectious illnesses was less among children during the second year. The overall incidences of non-infectious illness were 1.03 episodes/child-year, increasing from 0.40 episode/child-years during infancy to 1.68 in the second year.

A large proportion of morbidities (7681/12803, 60%) resulted in clinic or hospital outpatient visits. Among all morbidity reported, healthcare (clinic/hospital visits) was sought most frequently for respiratory illnesses (4346/6122, 71%), followed by GI (1524/2634, 57.9%)

Table 1 Baseline demographics and antenatal/delivery data of the birth cohort

Variable	Number	Percentage	Variable	Number	Percentage
Demographic details (n=561)			ANC/delivery details (n=497)		
Religion			Median (IQR) days gestation period*	278 (269–286)	
Hindu	304	54.19			
Muslim	233	41.53	Gravida		
Christian	24	4.28	Primiparous	196	39.44
			2	154	31
Type of family			>2	147	29.56
Joint	111	19.79			
Extended	112	19.96	History of abortion	67	13.48
Nuclear	338	60.25	History of stillbirth	18	3.62
Number of household members			Median (IQR) ANC visit†	7 (6–9)	
≤5	295	52.58			
>5	266	47.42	Maternal haemoglobin‡		
			<10 g%	66	29.60
Ownership of house			10–12 g%	128	57.40
Own house	354	63.10	>12 g%	29	13
Rented/lease/government	207	36.90			
			Maternal hypertension (>120/80)§	44	17.53
Primary mode of cooking					
Firewood	225	40.11	Vaccination for TT¶	244	96.06
Kerosene	124	22.10			
Gas stove/other	212	37.79	Mode of delivery		
			Normal	387	77.87
Socioeconomic status			Instrumental	20	4.02
Low	338	60	Cesarean	90	18.11
Middle	197	35.12			
High	26	4.63	Place of birth		
			Hospital	487	98
Maternal factors of study children (n=497)			Home	10	2
Mean (SD) maternal age in years	24 (3.6)		Birth weight in kg**		
			<2.5	84	17.14
Maternal education			≥2.5	406	82.86
Illiterate	184	37			
Primary/middle	167	33.60	BMI of mother††		
High/higher secondary	129	26	≤18.5 (underweight)	60	15.46
College	17	3.40	18.6– 24.99 (normal)	184	47.42
			25–29.99 (overweight)	107	27.58
Mean (SD) height of mother (cm)‡‡	153.03 (6.4)		≥30 (Obese)	37	9.54
Consanguineous marriage§§	47	20.60	Median (IQR) duration of exclusive breast feeding in months	4.09 (2.36–5.24)	

*n=470.
†n=242.
‡n=223.
§n=251.
¶n=254.
**n=490.
††n=388.‡‡n=388.
§§n=228.
ANC, antenatal care; BMI, body mass index; TT, tetanus toxoid.

Table 2 Risk factors associated with low birth weight in univariate and multivariate analyses in 216 infants in a birth cohort

	Univariate		Multivariate	
Variable	OR (95% CI)	p Value	OR (95% CI)	p Value
Female child	2.45 (1.50 to 4.00)	<0.0001	1.73 (0.80 to 3.73)	0.16
Preterm (<37 weeks)*	3.45 (1.81 to 6.57)	<0.0001	3.31 (1.12 to 9.78)	0.03
Less than four antenatal care visits†	3.11 (1.19 to 8.11)	0.001	6.88 (2.10 to 22.5)	0.001
Anaemia during pregnancy (Hb <10)‡	2.00 (0.98 to 4.06)	0.05	2.36 (1.08 to 5.18)	0.03
Beedi work at home	1.79 (1.08 to 2.96)	0.02	1.66 (0.76 to 3.63)	0.19
Maternal illiteracy	1.18 (0.73 to 1.91)	0.48		
Maternal age <20 years	1.37 (0.67 to 2.81)	0.37		
Low SES	1.38 (0.82 to 2.32)	0.21		
History of stillbirth	2.27 (0.76 to 6.72)	0.13		

*n=467.
†n=241.
‡n=222.
Hb, haemoglobin; SES, socioeconomic status.

and other infectious (470/835, 56.3%) morbidities (table 3).

Overall, 2.27% (290/12 803) of illnesses required hospitalisation, at a rate of 0.33/child-year. A slightly larger proportion of GI illnesses (72/2634, 2.7%) required hospitalisation than respiratory (149/6122, 2.4%), skin (37/1622, 2.3%) and non-infectious (14/891, 1.6%) illnesses. The rate of hospitalisation in the first year was higher (0.46/child-year) than the rate (0.19/child-year) in the second year.

Nutritional status of the cohort at 2 years of age

Anthropometric measurements obtained from 414 children at 24 months of age indicated that 153 (37%) children were stunted, 39 (9.4%) children had wasting and 125 (30.2%) children were underweight. The average rate of monthly height and weight gain were 1.35 cm and 290 g, respectively, for the first 730 days of follow-up.

Factors associated with overall morbidity, GI and respiratory illness

In the multivariate Poisson regression model, factors such as older age of the child (HR, 95% CI=0.86, 0.79 to 0.94), female gender (0.88, 0.79 to 0.99) and exclusive breast feeding for 6 months (0.77, 0.67 to 0.89) exhibited significant protective effect against overall morbidity. Low SES (1.11, 1.00 to 1.25) was associated with an increase in overall morbidity (table 4).

Although female gender (0.76, 0.57 to 1.03) and exclusive breast feeding for 6 months (0.76, 0.52 to 1.10) were protective, they were not statistically significant, whereas usage of firewood as the main fuel, a proxy for low SES, was associated with increased risk of GI (1.52, 1.11 to 2.08) and respiratory (1.10, 1.00 to 1.21) illness (see online supplementary table S2a,b).

Factors associated with growth velocity

The average monthly height gain in girls was 0.05 cm less than in boys (p=0.001), resulting in a difference of 6 mm/year. Children born to primiparous mothers had a higher growth rate than ones born to non-primiparous mothers (p=0.030); their average monthly gain of height was 0.03 cm more per month reflecting a difference of 3.6 mm/year. Maternal height had a positive association with the growth rate. One cm increase in maternal height (above the average) resulted in a 1.44 mm greater height gain in children over the 2 year period. Exclusively breastfed children had a monthly gain of height that was 0.06 cm less per month reflecting a difference of 7.2 mm/year (p=0.006; see online supplementary table S3a).

Average monthly gain of weight in girls was 20 g less than in boys (p<0.0001), a weight difference of 240 g in a year. Children born to primiparous mothers had a weight gain of 20 g/month more than later born children (p<0.0001). Exclusive breast feeding till 6 months adversely affected weight gain, but it was not statistically significant (p=0.06; see online supplementary table S3b).

Mortality

Seven perinatal deaths were reported, of which five were spontaneous abortion and two were stillbirths. Nine deaths were reported during 2 years of follow-up; three children died of diarrhoea, two due to lower respiratory infections, two due to congenital metabolic conditions and two due to unknown causes.

DISCUSSION

The introduction of conditional cash transfers for institutional deliveries under the Janani Suraksha Yojana or JSY scheme in 2005 has resulted in an increase in the proportion of institutional deliveries increased in the state of Tamil Nadu from 79.3% in 1998–1999 to 90.4% in 2005–2006.[17 18] In this study as well, 98% of the mothers delivered in an institutional facility. This change of practice has indirectly led to more antenatal visits, likely improving awareness of good ANC and health-seeking behaviour during pregnancy, and thereby improving maternal and neonatal survival which, in

Table 3 Incidence rates of illness and proportion of clinic visits and hospitalisations during first 730 days of postnatal life in the birth cohort

	Overall	First year	Second year
Number of children at start of follow-up	497	497	444
Child-years of follow-up	866.58	443.04	423.54
All cause morbidity			
Number of episodes	12 803	7107	5696
Rate (95% CI)/child-year	14.77 (14.26 to 15.3)	16.04 (15.45 to 16.66)	13.45 (12.89 to 14.03)
Number of episodes requiring clinic visits (%)	7681 (60)	4538 (63.85)	3143 (55.18)
Number of episodes requiring hospitalisation (%)	290 (2.27)	207 (2.91)	83 (1.46)
Gastrointestinal illness			
Number of episodes	2634	1935	699
Rate (95% CI)/child-year	3.04 (2.82 to 3.28)	4.36 (4.06 to 4.70)	1.65 (1.46 to 1.87)
Number of episodes requiring clinic visits (%)	1524 (57.86)	1126 (58.19)	398 (56.94)
Number of episodes requiring hospitalisation (%)	72 (2.73)	52 (2.69)	20 (2.86)
Respiratory illness			
Number of episodes	6122	3283	2839
Rate (95% CI)/child-year	7.06 (6.86 to 7.27)	7.41 (7.17 to 7.65)	6.70 (6.44 to 6.97)
Number of episodes requiring clinic visits (%)	4346 (70.99)	2509 (76.42)	1837 (64.71)
Number of episodes requiring hospitalisation (%)	149 (2.43)	105 (3.20)	44 (1.55)
Undifferentiated fever			
Number of episodes	699	416	283
Rate (95% CI)/child-year	0.80 (0.73 to 0.89)	0.94 (0.83 to 1.06)	0.66 (0.58 to 0.77)
Number of episodes requiring clinic visits (%)	255 (36.48)	125 (30.05)	130 (45.94)
Number of episodes requiring hospitalisation (%)	5 (0.72)	5 (1.20)	0
Skin infections			
Number of episodes	1622	843	779
Rate (95% CI)/child-year	1.87 (1.73 to 2.02)	1.90 (1.74 to 2.08)	1.83 (1.67 to 2.03)
Number of episodes requiring clinic visits (%)	796 (49.08)	435 (51.60)	361 (46.34)
Number of episodes requiring hospitalisation (%)	37 (2.28)	28 (3.32)	9 (1.16)
Other infections			
Number of episodes	835	451	384
Rate (95% CI)/child-year	0.96 (0.86 to 1.08)	1.02 (0.90 to 1.15)	0.90 (0.79 to 1.05)
Number of episodes requiring clinic visits (%)	470 (56.29)	259 (57.43)	211 (54.95)
Number of episodes requiring hospitalisation (%)	13 (1.56)	9 (2.00)	4 (1.04)
Non-infectious morbidity			
Number of episodes	891	179	712
Rate (95% CI)/child-year	1.03 (0.91 to 1.16)	0.40 (0.32 to 0.51)	1.68 (1.49 to 1.90)
Number of episodes requiring clinic visits (%)	290 (32.55)	84 (46.93)	206 (28.93)
Number of episodes requiring hospitalisation (%)	14 (1.57)	8 (4.47)	6 (0.84)

turn, is reflected in the lack of early neonatal deaths and the lower proportion of LBW in this study (17%) as compared to the national average of 22%, but similar to the Tamil Nadu average of 17.2%.[17]

Antenatal check-ups are important for screening of high-risk mothers, monitor weight gain during pregnancy, screen for anaemia, provide nutritional supplements that are vital for good pregnancy outcome, and help reduce and/or prevent maternal and neonatal complications and mortality. Studies have demonstrated that increasing number of ANC visits coupled with good quality ANC reduces the likelihood of having LBW babies.[19–21] In this study, children born to mothers with fewer than four antenatal visits had six times greater odds of LBW; similar to previous reports from Tanzania and India.[22–24] Birth weight is an important health indicator for vulnerability to childhood illnesses and survival. LBW has been linked to higher mortality and morbidity,[25] impaired mental development,[26] and the risk of chronic adult diseases such as cardiovascular diseases and diabetes in later days of life.[27 28]

In developing countries, over 50% of pregnant women are anaemic,[29] which reflect inadequate maternal nutritional status with respect to micronutrients. Routine ANC visits will result in early detection of anaemia, which can then be managed through iron and folic acid supplements and appropriate nutritional advice. In this study, mothers with haemoglobin <10 g/dL during pregnancy had twice the risk of having LBW babies. Studies elsewhere[30–32] have also demonstrated the negative effect of maternal anaemia on birth weight. A study in Pakistan reported 64% low birth among anaemic mothers compared with only 10% in non-anaemic mothers.[33] Taken together, these findings highlight the importance of at least four regular antenatal checkups, as recommended by WHO.[12]

Table 4 Factors associated with episodes of overall morbidity in univariate and multivariate analyses of longitudinal data from 216 infants

Variable	Number of episodes	Univariate		Multivariate	
		HR (95% CI)	p Value	HR (95% CI)	p Value
Sociodemographic variable					
Age (years)					
One*	3390	1			
Two	2880	0.88 (0.80 to 0.97)	0.01	0.87 (0.79 to 0.95)	0.002
Female	3014	0.89 (0.78 to 1.01)	0.07	0.88 (0.79 to 0.99)	0.03
Religion					
Muslim/Christian*	3007	1			
Hindu	3263	1.02 (0.90 to 1.17)	0.65		
Illiteracy of mother	2556	1.07 (0.94 to 1.22)	0.24		
Family type					
Joint/extended	2400	1			
Nuclear	3870	1.05 (0.92 to 1.19)	0.45		
Socioeconomic status					
Low SES	4217	1.10 (0.96 to 1.26)	0.13	1.06 (0.93 to 1.21)	0.31
Firewood as primary fuel	2953	1.15 (1.01 to 1.30)	0.02	1.12 (1 to 1.27)	0.05
Beedi work	2075	1.01 (0.87 to 1.16)	0.87		
Maternal factors					
Hypertension during pregnancy	733	1.16 (0.95 to 1.43)	0.13		
Anaemia in pregnancy (Hb <10)	1731	0.99 (0.86 to 1.14)	0.93		
Preterm (<37 weeks) delivery	500	1.03 (0.85 to 1.25)	0.69		
Primiparous	2584	0.94 (0.82 to 1.07)	0.39		
Mother with history of abortion	710	1.07 (0.88 to 1.30)	0.45		
Mother with history of stillbirth	322	1.27 (0.98 to 1.65)	0.06	1.15 (0.89 to 1.48)	0.27
More than four antenatal visits	5667	1.08 (0.89 to 1.31)	0.38		
Child admitted in ICU postdelivery	570	0.94 (0.78 to 1.12)	0.49		
Exclusive breast feeding for 6 months	905	0.75 (0.65 to 0.87)	<0.0001	0.76 (0.66 to 0.88)	<0.0001
Malnutrition					
Height gain rate		0.96 (0.51 to 1.78)	0.9		
Weight gain rate		0.44 (0.06 to 3.10)	0.41		

*Reference category.
ICU, intensive care unit; Hb, haemoglobin; SES, socioeconomic status.

Among all childhood morbidities, respiratory and diarrhoeal diseases are the major causes of morbidity among children in India [15 34 35] and other developing countries.[36 37] Children in this cohort also suffered predominantly from respiratory and GI illness. These estimates were very similar to the previous studies conducted in the same environment in the past decade for all illnesses, respiratory and GI disease.[15 35] The high estimates of GI illness can be attributed to widespread contamination of drinking water supply, which has been documented previously by other studies conducted in the same area.[38] In order to tackle this problem, there should be promotion for improvement in water, hygiene and sanitation systems in developing countries.

A child's age had an inverse effect on overall and GI illnesses, [35 39] although respiratory illness increased with age. Studies have documented that children from low-socioeconomic status were at higher risk for morbidity because of the lack of basic amenities needed to lead a healthy life.[40 41] Children from households where firewood was used as the main fuel had a higher risk of illness in this study. Firewood can be considered an indicator for low-socioeconomic status and also as an ambient pollutant and allergen that increases risk for respiratory illness and allergic airway diseases in children.[42–45] This highlights the impairing effect of indoor and outdoor air quality on upper respiratory illnesses. Provision of cost effective clean alternative fuel and properly designed ventilated houses to marginalised communities such as slum dwellers can minimise this burden.

Girls were protected from overall, GI and respiratory illnesses as compared with boys. Similar findings have been identified in various studies conducted in India and elsewhere,[40 46 35 47] which can be attributed to biological differences in gender. However, the growth rates in terms of average monthly height and weight gain were lower in girls, similar to a report from Brazil.[48] This could be because of social factors such as the preferential care and nutrition that a boy receives in developing countries.[49] With provision of proper nutrition to girls and with an added biological advantage over boys, girls could develop and perform better than they do currently.

WHO recommends exclusive breast feeding for 6 months of life for child survival.[13] Human milk glycans

are part of the natural immunological mechanism that offers protection against diarrhoeal diseases in breastfed infants.[50] In addition, breast feeding reduces the exposure to contaminated foods and liquids and contributes to adequate nutrition and non-specific immunity. Our data showed approximately 20–25% protection against overall morbidity and acute respiratory illness among children who were exclusively breast fed for 6 months. Although breast feeding offered some protection against GI morbidity, it was not statistically significant. The lack of protection in this study may be a reflection of the overall high rates of breast feeding. Reviews on breast feeding have determined the protection offered by exclusive breast feeding against diarrhoea,[50 51] respiratory infections[52] and for child survival.[47 53]

Interestingly, average monthly height and weight gain had an inverse relationship with duration of breast feeding. Children exclusively breast fed for 6 months had slower growth rates in terms of height and weight over 2-year period when compared against children who started weaning early. Studies conducted elsewhere, also documented the slower growth pattern among children with prolonged period of exclusive breast feeding than children on formula food or non-human milk.[48 54–56]

Even with economic barriers, provision of good quality healthcare can improve the health-seeking behaviour of people, which was reflected in this study by the high number of clinic/hospital visits. Timely intervention can prevent or slow the progression of the disease, thereby reducing complications and death. The higher than reported hospitalisation rates in this and previous community-based surveillance studies from Vellore[15 35] possibly reflect an unmet need for hospitalisation in resource-constrained settings.

It is becoming increasingly clear that the first 1000 days of life influences health and intellectual capacity. This report shows that antenatal factors influence birth outcomes in children, that children from impoverished urban slum communities in developing countries continue to have a high burden of morbidity predominantly respiratory and GI, in the first 2 years of life and that these also impact growth outcomes. It is critical for policymakers to understand the prevalence of these diseases to plan healthcare interventions during pregnancy and early childhood in the community.

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