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Cohort Profile: SLCGC, a population-based cohort study on child growth in Sri Lanka

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Cohort Profile: SLCGC, a population-based cohort study on child growth in Sri Lanka

ABSTRACT

Purpose

This paper aims to describe the study design and baseline characteristics of the Sri Lanka Child Growth Cohort (SLCGC), established to assess timing, pattern and determinants of growth faltering in infants and young children in Sri Lanka.

Participants

Term-born babies (≥ 37 weeks of gestation), currently in the ages between 12 to 24 months were eligible. A sample of 1875 mother-child pairs were recruited using two-stage stratified cluster sampling method. Data on socio-demographic characteristics, pregnancy care, feeding practices, childhood illnesses, and home risk factors were collected through direct interviews with the care givers. Pregnancy related data were obtained from the pregnancy record. Birth weight, serial weight and length records and growth pattern were extracted from the Child Health and Development Record**.** Current weight and length of the children were measured directly.

Key findings

The SLCGC serves as a comprehensive cohort study with a countrywide distribution in Sri Lanka, covering the 3 main residential sectors, namely the urban, rural and estate sectors in equal proportions. Majority of mothers were housewives (76.8%), and aged less than 35 years (77.9%). The proportions achieved secondary education in mothers and fathers were 69.0% and 63.7%, respectively. Approximately 30% of mothers were overweight or obese, while 15% were underweight on entry to antenatal care. Of the children, 49.2% were girls, 42.5% were the first-born children in their family, and 34.2% were born by cesarean section. Mean birth weight was 2917g (SD 0.406), with the proportion of low birth weight (less than 2500g) being 13%.

Future plans

This data enables investigation of the effects of single exposures on child growth, as well as, more complex epidemiological analyses on multiple simultaneous and time-varying exposures. Data will be available for researchers for further analysis. The next wave of assessment is expected to be done after 12 months.

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Strengths and limitations

- This study harnessed a wealth of longitudinal data recorded during pregnancy and early childhood, and performed direct interviews and anthropometric assessments as well.
- This data enables investigation of more complex epidemiological analyses on multiple simultaneous and time-varying exposures on the growth of the child.
- The findings would fill-up evidence gaps that are needed to inform policy and program decisions to improve child malnutrition in the country
- Measures taken to assure quality of data is a major strength. Careful selection of the study team, adequate training, and close monitoring process at different stages enhanced the validity of the study.
- The cohort excluded children born before 37 weeks of gestation, limiting the applicability of findings for preterm babies. Some weight and length data were missing in the records at certain time points.

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INTRODUCTION

The first 1000 days of life has been identified as a crucial window of opportunity for interventions to optimize child growth [1,2]. Growth failure in this period could adversely affect the subsequent physical growth and potential loss of human capital with poor cognitive development, low educational attainment and increased health care costs[2–4]. However, child growth, especially in the first 24 months of life, most often assumes a dynamic pattern due to the influence of multiple factors over time. The maternal parameters, including pre-pregnancy and pregnancy characteristics, birth indicators, child parameters including the feeding patterns and illness as well as wider family and social environment could affect the growth of children. Providing a suitable environment for growth by optimizing such factors is important to prevent growth faltering at this stage [3,5].

The term ' growth faltering ' is widely used to refer to a slower rate of weight gain in childhood than expected for age and sex. Globally, various definitions of faltering growth have been used in the past, resulting in widely varying estimates of prevalence [6]. The definition used by the Family Health Bureau of the Ministry of Health (FHB), Sri Lanka to identify growth faltering at population level states that a child's growth should continue to rise parallel to reference lines based on the birth weight [7]. Therefore, any deviation of a child's growth curve compared to the reference curve such as inadequate weight gain, no weight gain or drop in weight between two consecutive weight measurements is defined as growth faltering.

World Health Organization's (WHO) Global Database on Child Growth and Malnutrition with results from developing countries shows that mean weight starts to falter at about 3 months of age and continues to decline until the catch-up growth is observed after 18 months [8,9]. However, the timing of growth faltering could vary in different countries depending on the mix of risk factors in each setting [9]. Hence, identifying the pattern of growth faltering and the risk factors contributing to such faltering at different stages is of paramount importance to carry out tailor-made nutritional interventions.

Malnutrition remains a challenging and unresolved public health problem in Sri Lanka [10] and the importance of early childhood nutrition to development outcomes is well recognized. A single center cross sectional descriptive study conducted in Sri Lanka with a sample of 254 children aged 0-24 months has revealed a high prevalence of growth faltering until 18 months of age [11]. In this study, drops in mean weight-for-age and length-for-age Z scores were noted at 4 months. Weight faltering, compared to birth weight, was noted in 50.4% of infants by 4 months of age. Of them majority (76.6%) continued to show similar trends at 12 months. However, there was no population-based study to confirm the above findings.

Factors affecting growth

The global literature reveals the potential of interaction of direct and indirect health factors as well as direct and indirect non-health factors leading to growth faltering. The direct factors being, breast

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feeding status, dietary diversity, supplementation, illness etc. and indirect factors include household wealth, maternal and paternal education, and sanitation standards etc. [12–14].

A pooled analysis of Democratic Health Survey (DHS) data from 35 Lower Middle-Income Countries (LMIC) found that maternal nutritional status such as height and Body Mass Index (BMI), and poor household socioeconomic conditions such as household wealth and maternal education, as the leading factors associated with childhood anthropometric failure [14,15] . However, the cross-sectional nature of data is recognized as a major limitation in making any causal inferences in this regard.

A recent Sri Lankan study revealed that onset of growth faltering is seen very early in life in the majority of Sri Lankan infants [11]. Persistent exclusive breastfeeding without starting complementary feeding was evident despite detecting growth faltering. This was also confirmed by other Sri Lankan studies [16] Sub-optimal complementary feeding practices among infants and young children were elicited through a mixed method study [17]. In conforming to Ministry of Health recommendations [18] most caregivers had introduced solid foods to their children around 6 months of age. Further, the contribution of socio demographic factors could also be relevant, for example, women's participation in the labour force and their engagement in the agriculture sector is predictive of higher stunting rates, while participation in the service sector is protective against stunting according to the findings of a review by [19].

Purpose of the Sri Lanka Child Growth Cohort (SLCGC)

Growth is a dynamic process, and it is important to detect any abnormal growth early and to investigate its onset, causes and consequences to provide required interventions. We hypothesize that there are multiple factors operating at individual, household and organizational level leading to inadequate growth in infants and young children, and these factors may vary according to the timing of growth faltering. Hence, the growth, as well as its determinants should be explored in relation to age of child.

Purpose of the Sri Lanka Child Growth Cohort (SLCGC) is to describe the timing and pattern of growth faltering in infants and young children, and to determine the evolution of maternal, child and social factors affecting their growth over time, in order to assist better planning of interventions. This paper describes the study design and baseline characteristics of the SLCGC.

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COHORT DESCRIPTION

Cohort design and population

The aim of the cohort was to sample children 12 to 24 months of age covering all three residential sectors across the country (urban, rural and the estate consisting of plantations), with longitudinal data being collected retrospectively from the pre-pregnancy stage.

In the Sri Lankan state preventive health system, pregnant women and children are registered with the Medical Officer of Health (MOH) for the provision of clinic based and domiciliary maternal and child health (MCH) services. Around 90% of the respective target populations (89.8% of pregnant women, 90.8% of infants) obtain preventive health care through this service [20]. Public Health Midwives (PHMs) are the frontline health care providers in the MOH areas who provide field level MCH services. The PHM maintains registers and records relevant to MCH care such as Register of Pregnant Mothers, Birth and Immunization Register, and personal health records such as Pregnancy Record (containing details of the mother before and during pregnancy), and the Child Health Development Record (CHDR) (containing birth details, immunization, health and development screening, micronutrient supplementation and growth monitoring data). During the first 2 years of life, weight is measured in every month, and length, at 4, 9, 12, 18 and 24 months.

Recruitment of participants for the present cohort was carried out during October and November 2023. Mother-child pairs of term babies (born at 37 weeks of gestation or later) currently between 12 to 24 months of age were selected from the Birth and Immunization Registers. Exclusion of pre-term babies was due to the fact that their growth pattern is different from that of term babies [21,22]. The children with less than 4 weight recordings in their CHDR during the first 12 months and those with chronic medical conditions and structural deformities causing feeding difficulties were excluded.

Cohort sampling

A total of 1875 mother-child pairs were recruited using a two-stage stratified cluster sampling method. Stratification was carried out at the level of residential sector as defined by the Department of Census and Statistics [23] with approximately 600 mother-child pairs selected from each sector, namely urban, rural and estates. In the first stage, three districts each from the urban (Colombo, Gampaha and Galle) and rural sectors (Kilinochchi, Polonnaruwa and Ampara), and 2 districts from the estate sector (Nuwaraeliya and Badulla) were purposely selected as the most appropriate districts to represent the respective sector. An MOH area was considered a cluster. In the second stage, clusters (MOH areas) were sampled from a list comprising all MOH divisions in the selected district. MOH areas with the highest percentage of urban population were selected for the urban stratum. Similarly, the MOH areas with the highest percentage of rural and estate populations were selected for the rural and estate strata, respectively. Forty-five clusters were selected, and from each cluster 40-mother child pairs were sampled systematically according to the Birth and

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Immunization registers of the PHMs. Figure 1 illustrates the Medical Officer of Health areas selected for the cohort.

MEASUREMENTS AND PROCEDURE

Development of the study tools of the cohort and selecting the appropriate variables and measurements were guided by a conceptual framework as illustrated in Figure 2. A structured data collection tool was developed to gather data from the mothers or caregivers and from relevant health records including the pregnancy record and the CHDR. This was pretested in a similar setting after which minor modifications were made .

Measurement taken for outcome assessment:

Weights and lengths recorded serially in the CHDR were extracted. On the date of the interview the weight and the lengths of the child were measured by the trained enumerators adhering to the standard protocol. Visual inspection of the weight-for-age chart, which are based on WHO multi country growth reference curves [24] in the local CHDR of the child was carried out by the enumerators and presence of any growth faltering (faltering i.e. deviation of the growth curve downwards, flattening or downward dip of the curve) was recorded.

Measurements taken for exposure assessment:

Detailed information on exposure status was collected using a life course approach. Pregnancy related information including illness before and during pregnancy, use of micronutrients, blood haemoglobin level, pre pregnancy/booking visit BMI and weight gain during pregnancy were gathered from the pregnancy record. Baseline characteristics of the child including the date of birth, sex, parity, singleton or multiple pregnancy, period of amenorrhoea (POA) at delivery, and measurements recorded at birth such as birth weight, length and head circumference were extracted from the CHDR. The mode of delivery, and the reason for caesarian delivery if performed, was collected through interviews.

In order to generate infant and young child feeding (IYCF) indicators, details on breastfeeding practices, complementary feeding, including the timing, frequency, decision making on feeding and responsive feeding behaviors were assessed by questioning the principal caregiver. Feeding of specific food items at each month was collected through a recall, which can also be used to assess dietary diversity at different ages. Additionally, micronutrient supplement use and food supplements given to the child were also gathered.

Illnesses of the child were recorded at 3 monthly intervals during the first year and 6 monthly intervals during the second year of life. Respiratory illness, fever, diarrhoea, urine infection and other illness requiring hospitalization were assessed. An episode of respiratory tract infection (RTI) was defined as an illness with upper respiratory symptoms and signs, which lasted more

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than 48 hours with or without fever. An episode of diarrhoeal illness was defined as watery loose stools with more than 3 bouts per day lasting more than 48 hours, with frequent passage of formed or pasty stools seen in breastfed babies being excluded. Urinary tract infection and other illness requiring hospitalization was considered if it was indicated in medical records of the child. Any change in the diet of the child during illness was gathered during the interview.

Several socio-demographic and family level factors were assessed using the questionnaire. The variables included education level and employment of both mother and father, income of the family, maternity leave, housing conditions, water and sanitation and indicators to assess the Household Wealth Index. Availability of social safety nets for the family and presence of home risk factors as per the guidelines of the Ministry of Health [25] was also collected.

Table 1 and 2 provide a description of the key variables with the time period relevant to the information and the source of information.

Table 1 Key exposure variables assessed at different time points before or during pregnancy, and at delivery of the mother

Measurement	Period before or during pregnancy				
	Pre-conception	1st trimester	2nd trimester	3rd trimester	Delivery
Illness					
Diabetes	●	●	●	●	
Hypertension	●	●	●	●	
Heart disease	●	●			
Fever		◆	◆	◆	
Hospitalization		◆	◆	◆	◆
BMI		●			
Weight		●	●	●	●
Height		●			
Haemoglobin		●	●	●	
Food and micronutrient supplementation					
Iron		◆	◆	◆	
Folate	◆	◆	◆	◆	
Calcium		◆	◆	◆	
Vitamin C		◆	◆	◆	
Thriphosa		◆	◆	◆	
Mode of delivery					●
POA at delivery					●

● Obtained from pregnancy record

◆ Inquired from history

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Table 2 Key variables assessed at different time points from birth up to 24 months of age of the child

Measurement	Age of child in months														
	birth	0 to <1	1 to <2	2 to <3	3 to <4	4 to <5	5 to <6	6 to <7	7 to <8	8 to <9	9 to <10	10 to <11	11 to <12	12 to <18	18-24
Parental measurements															
Weight of mother														■	■
Height of mother														■	■
Weight of father														■	■
Height of father														■	■
Measurements at birth															
Birth weight	●														
Length at birth	●														
Head circumference	●														
IYCF practices															
Breastfeeding	◆			◆			◆						◆	◆	◆
Any semisolid solid food		◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆		
Water		◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆		
Any powdered milk (formula or other)		◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆		
Fresh milk		◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆		
Specific water-based liquids[a]		◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆		
Specific semisolid/solid food[b]		◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Specific unhealthy food[c]		◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Responsive feeding[d]														◆	◆
Childhood illness															
Admitted to PBU	●														
Fever			◆			◆			◆			◆		◆	◆
Respiratory illness			◆			◆			◆			◆		◆	◆
Diarrhea			◆			◆			◆			◆		◆	◆
Urinary tract infection			◆			◆			◆			◆		◆	◆
Feeding during illness[e]			◆			◆			◆			◆		◆	◆

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Measurement	Age of child in months														
	birth	**0 to <1**	**1 to <2**	**2 to <3**	**3 to <4**	**4 to <5**	**5 to <6**	**6 to <7**	**7 to <8**	**8 to <9**	**9 to <10**	**10 to <11**	**11 to <12**	**12 to <18**	**18-24**
Food /Micronutrient supplementation															
Vitamin A								◆						◆	◆
Multiple micronutrient powder								◆						◆	◆
Food supplementation														◆	◆
Anthropometry															
Weight of child		●	●	●	●	●	●	●	●	●	●	●	●	● ■	● ■
Length of child		●	●	●	●	●	●	●	●	●	●	●	●	● ■	● ■
Growth faltering															
Onset of growth faltering		●	●	●	●	●	●	●	●	●	●	●	●	●	●
Reasons for growth faltering		●	●	●	●	●	●	●	●	●	●	●	●	●	●
Action taken during growth faltering		●	●	●	●	●	●	●	●	●	●	●	●	●	●

● Obtained from pregnancy record or CHDR

◆ Inquired from history

■ Measured on-site (Measurements were taken during the interview according to the current age of the child)

[a] Inquired about specific water-based liquids separately: fruit juices, and rice kunjee

[b] Inquired about specific food items under solid/semi-solid food separately: starchy food, yellow-color vegetables, other vegetables, yellow-color fruits, others fruits, legumes, flesh food, eggs

[c] Inquired about specific unhealthy food separately: sweets, biscuits, malted beverages and sodas/colas.

[d] Inquired responsive feeding referring to the current time period

[e] Inquired about feeding during illness referring to any episode of illness in the past

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DATA COLLECTION AND ANALYSIS

Data collection

Enumerators were trained to administer the questionnaire and to conduct anthropometric measurements. National and regional level clearance was obtained to conduct face-to-face interviews and to collect data from the relevant records. The selected participants were requested via telephone to come to a center within their village or estate for data collection. If they did not respond for three separate attempts of contact, or when a participant did not have a means of communication, a home visit was made for this purpose. If all attempts failed, the next eligible child was sampled. It was explicitly mentioned that participation is voluntary and that all data would be confidential. All study material was in the local language (Sinhala / Tamil). The research team regularly monitored the data collection in the field.

Two enumerators were assigned to collect data from one mother-child pair. Photo images of the relevant sections of the pregnancy record, and CHDR including the growth charts (weight-for-age chart, length-for-age chart, weight-for-length chart) and the table for weight and length records were obtained. The data was entered into a tailor-made online database in parallel to data collection during the field work. The current database contains password protected, de-identified data along with the images of the documents as a single PDF file under serial numbers.

Statistical analyses

Data processing

Frequency distributions were generated for all variables and the relevant records (pregnancy record or CHDR) were revisited when there were missing data or extreme values for appropriate corrections.

Repeatability of certain variables for which the same information was gathered from 2 different approaches was assessed by ICC (intraclass correlation coefficient) for numeric data or by Cohen's Kappa for categorical data. High and significant ICC were reported for the following variables: age of child according to mother's history vs calculated age by date of birth (ICC=0.99; 95% CI 0.650 to 0.997); mothers height according to pregnancy record vs. height measured on site; the last weight record in the CHDR vs weight measurement onsite during the survey. Percent agreement was tested for some categorical variables, i.e., giving breastmilk, feeding powdered milk, and introducing solid/semisolid food, and a high percentage agreement with a significant Cohen's Kappa was found for all these variables.

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Basic statistical analysis

Data were summarized into frequency tables illustrating the characteristics of cohort participants. New variables were generated using the recode option in the statistical package in order to transform data into standard or meaningful categories, such as maternal age group, child age group, educational levels, birth interval, birth weight etc.

BMI was calculated and classified according the WHO definition of BMI for adults (26). Household Wealth Index was calculated by using data on main sources of drinking and cooking water, type of toilet facility, main sources of lighting, cooking fuel, main material used in floor, roof and walls of the house, ownership of the house, household assets, and animal husbandry (27). Principle Component Analysis was performed to create an asset score which was divided into 5 quintiles for comparison purposes.

Statistical analyses were performed using STATA (28) and SPSS (29). Anthropometric measurements were transformed into weight-for-age Z score, length-for-age Z and weight-for length Z score as per WHO growth reference standards (30) using AnthroPlus Software (31).

Quality of data

In order to ensure the reliability and validity of collected information, investigators followed the best practices given below:

- High standards were maintained in recruiting suitable persons with experience in field work, and adequate training was provided on interviewing techniques and the subject matter of the survey. All team members were given a two-day classroom and a field day training program, including training on anthropometric measurements of a child. .
- Interviews were conducted in a language conversant to the respondents. Data collection tools were available in all three languages. Interviews were conducted at a time most convenient to the respondents through an appointment system.
- Interviewing etiquettes were strictly followed by the enumerators and survey supervisors closely monitored the process.
- The interviewer assured the respondents of the confidentiality of information, indicated the time required for completing the interview and sought their approval to continue with the survey.

Best practices followed to ensure quality of data collection

- The survey consultants and data managers undertook random field visits to ensure surveys are conducted appropriately and acceptably.

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- Completed questionnaires were scrutinized first by the supervisors to ensure completeness and accuracy of the filled responses and incomplete questionnaires were returned to the field enumerator to complete the same. Entered data were randomly checked to ensure accuracy.
- The survey teams conducted further quality checking before entering the data into the online database.

BASELINE FINDINGS

Characteristics of the participants

The cohort covered 3 main residential sectors of the Sri Lankan population namely the urban, rural and estate, in nearly equal proportions (Table 3). The majority of mothers of the children were less than 35 years of age (77.9%) and housewives (78.4%). The proportion completing General Certificate of Examinations (GCE Ordinary Level) education was 69% in mothers in contrast to 63.7% in fathers. A great majority of fathers (94.4%) were engaged in some form of economic activity. Approximately 30% of mothers were overweight or obese, while 15.0% were underweight at the time of registering for pregnancy.

Of the children, 49.2% were girls, 42.5% were the first-born children in their family, and 34.2% were born by cesarean section. Their ages ranged from 12 months to 24 months, and the number of children in the age 21-24 months and 12-14 months were somewhat higher than other age categories. This cohort includes only term-born children, and the mean birth weight was 2917 g (SD 406), with the proportion of low birth weight (less than 2500 g) being 13.0%.

Table 3 Characteristics of parents and their children recruited in the cohort

Characteristics		No	%
Parental characteristics			
Residential sector	Urban	646	34.5
	Rural	593	31.6
	Estate	636	33.9
Maternal age category	<35 years	1460	77.9
	35 and above	415	22.1
Mother's education level[1]	Passed Grade 5 or less	64	3.4
	Passed Grade 6-10	518	27.60
	Passed O/L	797	42.50
	Passed A/L	393	21.0
	Degree and above	103	5.5
Mother’s occupation	Employed Government sector	81	4.3

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	Employed private sector	107	5.7
	Self-employed / Own business	61	3.3
	Casual Worker	156	8.3
	Take care of house work	1470	78.4
Father's education level[2]	Passed Grade 5 or less	53	2.8
	Passed Grade 6-9	614	32.7
	Passed Ordinary Level	821	43.8
	Passed Advanced Level	300	16.0
	Degree and above	74	3.9
	Data not available	13	0.7
Father's occupation	Employed Government sector	233	12.4
	Employed private sector	618	33.0
	Self-employed / Own business	376	20.1
	Casual Worker	544	29.0
	Take care of house work	84	4.5
	Data not available	20	1.1
Wealth Index Quintile	Lowest	375	20.0
	Second	375	20.0
	Middle	378	20.2
	Fourth	372	19.8
	Highest	375	20.0
Pre-pregnancy BMI category (kg/m^2)	Less than 18.5	280	14.9
	18.5-24.9	841	44.9
	25.0-29.9	413	22.0
	>30 and higher	142	7.6
	Data not available	199	10.6
Child characteristics			
Birth interval (years)	No previous birth	796	42.5
	1-2 years	180	9.6
	3-4 years	345	18.4
	5 years or more	554	29.5
Sex	Female	922	49.2
	Male	953	50.8
Mode of delivery	Caesarian	642	34.2

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	Vaginal	1233	65.8
Birth order	First	796	42.5
	2nd	640	34.1
	3rd or higher	439	23.4
Gestational age on delivery (weeks)	37-37^{+6}	359	19.1
	38- 38^{+6}	615	32.8
	39- 39^{+6}	475	25.3
	≥40	426	22.7
Birth Weight Category (grams)	<2000	20	1.1
	2000-2499	224	11.9
	2500-2999	842	44.9
	3000-3499	644	34.3
	>3500	145	7.7
Current age of child (months)	12-14	461	24.6
	15-17	422	22.5
	18-20	417	22.2
	21-24	575	30.7
Total		1875	100.0

STRENGTHS AND LIMITATIONS

Strengths

The SLCGC serves as a comprehensive cohort study with a countrywide distribution in Sri Lanka, covering the 3 main residential sectors namely the urban, rural and estate sectors. It captures data on a wide spectrum of individual, household, and societal determinants of child growth commencing from the pre pregnancy period up to the current time point. This is one of the few studies that harnessed a wealth of longitudinally recorded data during pregnancy and early childhood, supplemented with direct interviews and anthropometric assessments. The findings will fill-up evidence gaps that are needed to inform policy and program decisions to improve child malnutrition in the country, such as the predictors of low birth weight, and timing and determinants of early growth faltering etc. This data enables investigation of the effects of single exposures on child growth, as well as, more complex epidemiological analyses on multiple simultaneous and time-varying exposures on the growth of the child. Furthermore, potential confounders and effect modifiers are available to model the outcome through advanced statistical modeling.

Measures and precautions to assure quality of data is one major strength of the SLCGC. Careful recruitment of the study team, adequate training, and close monitoring process at different stages of the study enhanced the validity data.

All children in the cohort had completed at least 12 months of age at the time of enrollment. This enabled retrospective assessment of exposures during the first 12 months of life of all children.

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Limitations

The SLCGC is not fully representative of the Sri Lankan child population with respect to socio-economic diversity of the country. The study may have not adequately covered the upper socio-economic strata of the population since those may not register for field-based services provided through the state health sector.

Secondary data were extracted from the pregnancy records and CHDR. Certain weight measurements and higher number of length measurements were not available in the CHDR B portions. Anthropometric measurements extracted from the records had been taken for the purpose of service delivery, therefore may not be ideally suited for research purposes. Recall bias is a problem when collecting the details regarding breastfeeding and complementary feeding practices.

The cohort did not enroll children born preterm, that is before 37 weeks of gestation, and this limits the interpretation of findings regarding growth of preterm babies. As the cohort did not include preterm births, the proportion of low birth weight children is an under-representation of the overall expected low birth weight prevalence.

It is noteworthy to understand that this cohort was followed-up in the backdrop of an ongoing economic crisis in the country. Children recruited to the cohort were those born between October 2021 to September 2022, thus their conception, gestational period, birth and postnatal period would have been exposed to economic crisis and its consequences. Further, there is no clear starting point or endpoint of the economic crisis and all that can be stated is that the study outcomes could have been influenced to a varying degree by the economic crisis. Thus, due caution should be exercised to in interpreting results.

Way Forward (Future Plans)

Further analysis of available data

Data analyses will be continued according to the aims of the cohort. Analysis will be extended to identify the determinants of low birth weight including the effect of weight gain and other parameters during pregnancy, using multivariate regression models. Growth faltering at different time-points will be correlated with the concurrent events including IYCF practices, childhood illness, care practices and utilization of health services. Furthermore, longitudinal data analysis techniques will be applied to explain different growth patterns. Current growth status in terms of stunting, wasting and underweight will be analyzed against a range of socio-demographic and other predictors. Correlation of growth faltering with other measures of anthropometric deficits at different points in time would also be investigated using this data.

Continuation of the cohort

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The next wave of assessment is expected to be done after 12 months of recruitment. SLCGC team recommends that this cohort be extended with clearly defined waves of assessment through their childhood and adolescence.

Further research / adding-on

Data will be available for researchers, on submission of a clear plan of utilization of this data conforming to guidelines for data dissemination. A data dissemination strategy is being formulated by the SLCGC study collaboration.

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Figure 1 Map of Sri Lanka showing the Medical Officer of Health areas selected for the cohort

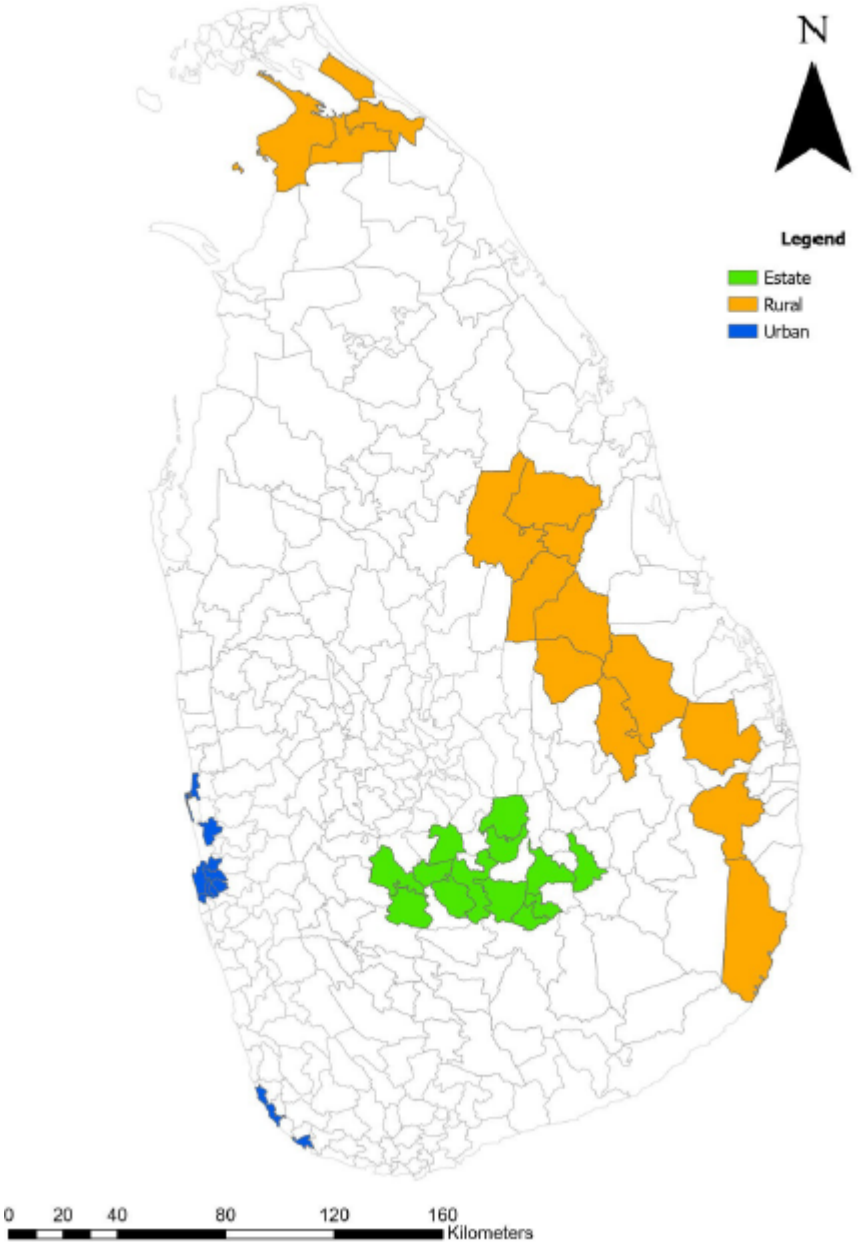

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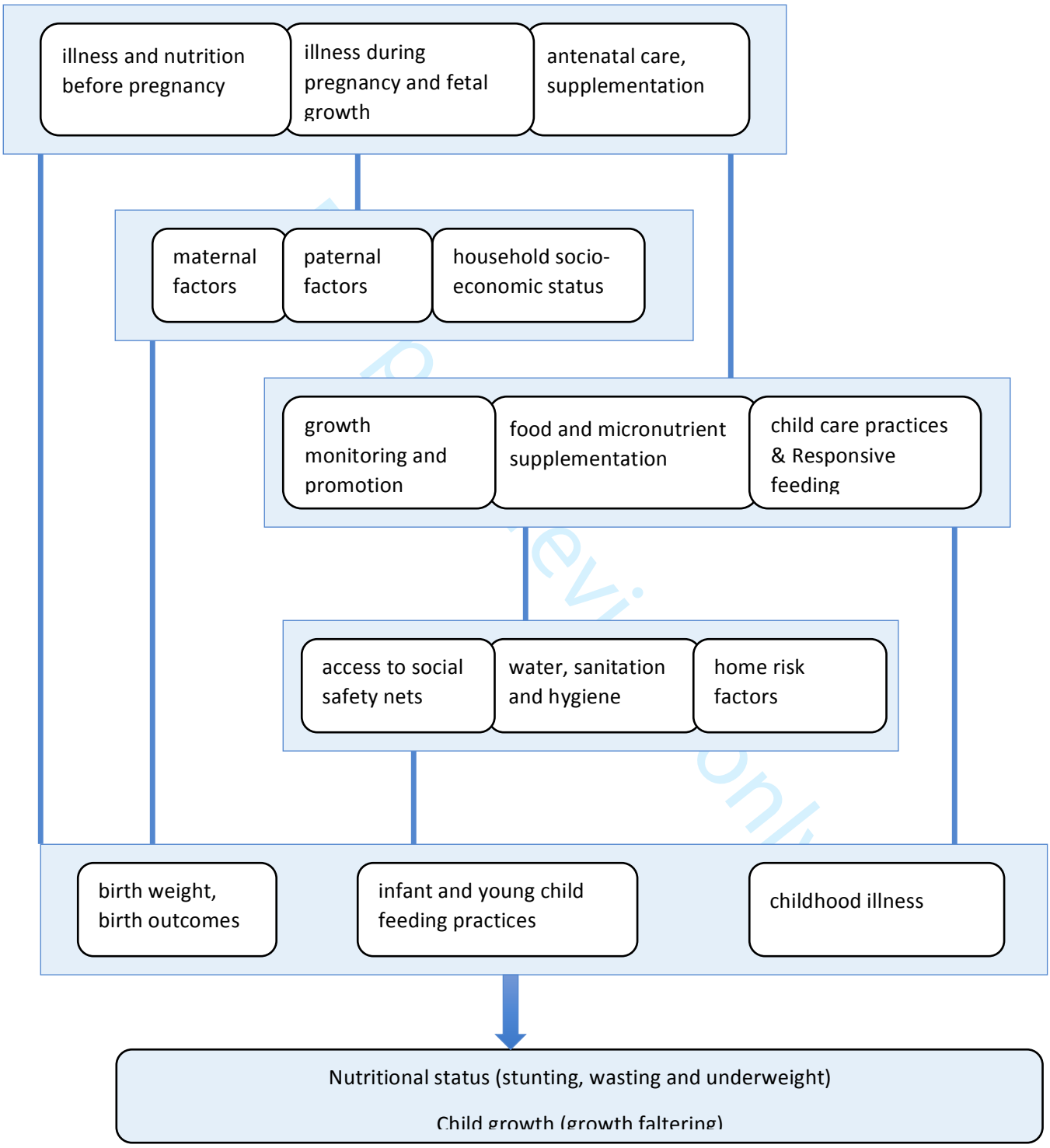
Figure 2 Conceptual framework of the Sri Lanka Child Growth Cohort Study.



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Cohort Profile: Sri Lanka Child Growth Cohort (SLCGC), a population-based study on growth faltering of children

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Cohort Profile: Sri Lanka Child Growth Cohort (SLCGC), a population-based study on growth faltering of children

ABSTRACT

Purpose

This paper aims to describe the study design and baseline characteristics of the Sri Lanka Child Growth Cohort (SLCGC), established to assess timing, pattern and determinants of growth faltering in infants and young children in Sri Lanka.

Participants

A retrospective cohort study was conducted among term-born babies (≥ 37 weeks of gestation), currently aged between 12-24 months. A sample of 1875 mother-child pairs were recruited using two-stage stratified cluster sampling method. Data on socio-demographic characteristics, pregnancy care, feeding practices, childhood illnesses, and home risk factors were collected through direct interviews with the care givers. Pregnancy related data were obtained from the pregnancy record. Birth weight, serial weight and length records and growth pattern were extracted from the Child Health and Development Record**.** Current weight and length of the children were measured directly.

Key findings

The SLCGC serves as a comprehensive cohort study with a countrywide distribution in Sri Lanka, covering the 3 main residential sectors, namely the urban, rural and estate sectors in equal proportions. Majority of mothers were housewives (76.8%), and aged less than 35 years (77.9%). The proportions achieved secondary education in mothers and fathers were 69.0% and 63.7%, respectively. Approximately 30% of mothers were overweight or obese, while 15% were underweight on entry to antenatal care. Of the children, 49.2% were girls, 42.5% were the first-born children in their family, and 34.2% were born by cesarean section. Mean birth weight was 2917g (SD 0.406), with the proportion of low birth weight (less than 2500g) being 13%.

Future plans

This data enables investigation of the effects of single exposures on child growth, as well as, more complex epidemiological analyses on multiple simultaneous and time-varying exposures. Data will be available for researchers for further analysis. The next wave of assessment is expected to be done after 12 months.

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Strengths and limitations

- This study harnessed a wealth of longitudinal data recorded during pregnancy and early childhood, and performed direct interviews and anthropometric assessments as well.
- This data enables investigation of more complex epidemiological analyses on multiple simultaneous and time-varying exposures on the growth of the child.
- The findings would fill-up evidence gaps that are needed to inform policy and program decisions to improve child malnutrition in the country
- Measures taken to assure quality of data is a major strength. Careful selection of the study team, adequate training, and close monitoring process at different stages enhanced the validity of the study.
- The cohort excluded children born before 37 weeks of gestation, limiting the applicability of findings for preterm babies. Some weight and length data were missing in the records at certain time points.

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INTRODUCTION

The first 1000 days of life has been identified as a crucial window of opportunity for interventions to optimize child growth [1,2]. Growth failure in this period could adversely affect the subsequent physical growth and potential loss of human capital with poor cognitive development, low educational attainment and increased health care costs [2–4]. However, child growth, especially in the first 24 months of life, most often assumes a dynamic pattern due to the influence of multiple factors over time. The maternal parameters, including pre-pregnancy and pregnancy characteristics, birth indicators, child parameters including the feeding patterns and illness as well as wider family and social environment could affect the growth of children. Providing a suitable environment for growth by optimizing such factors is important to prevent growth faltering at this stage [3,5].

The term 'growth faltering' is widely used to refer to a slower rate of weight gain in childhood than expected for age and sex. Globally, the lack of consensus on definitions of faltering growth has resulted in varying estimates of prevalence [6, 7, 8]. A review on ‘new and old dimensions of growth faltering’ states that, criteria most frequently used for evaluating growth faltering include weight falling through two major centile lines on standard weight charts, weight falling below the 3rd centile, or weight for height less than 2 standard deviations below the mean for age and sex [7]. The criteria used by the maternal and child health programme in Sri Lanka to identify growth faltering at population level is through recognition of any deviation such as inadequate weight gain, no weight gain or drop in weight between two consecutive weight measurements of a child's growth curve compared to the reference curve based on WHO child growth standards, 2006 [9].

World Health Organization’s (WHO) Global Database on Child Growth and Malnutrition with results from developing countries shows that mean weight starts to falter at about 3 months of age and continues to decline until the catch-up growth is observed after 18 months [10,11]. However, the timing of growth faltering could vary in different countries depending on the mix of risk factors in each setting [10]. Hence, identifying the pattern of growth faltering and the risk factors contributing to such faltering at different stages is of paramount importance to carry out tailor-made nutritional interventions.

Malnutrition remains a challenging and unresolved public health problem in Sri Lanka [12] and the importance of early childhood nutrition to development outcomes is well recognized. A single center cross sectional descriptive study conducted in Sri Lanka with a sample of 254 children aged 0-24 months has revealed a high prevalence of growth faltering until 18 months of age [13]. In this study, drops in mean weight-for-age and length-for-age Z scores were noted at 4 months. Weight faltering, compared to birth weight, was noted in 50.4% of infants by 4 months of age. Of them majority (76.6%) continued to show similar trends at 12 months. However, there was no population-based study to confirm the above findings.

Factors affecting growth

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The global literature reveals the potential of interaction of direct and indirect health factors as well as direct and indirect non-health factors leading to growth faltering. The direct factors being, breast feeding status, dietary diversity, supplementation, illness etc. and indirect factors include household wealth, maternal and paternal education, and sanitation standards etc. [14–16].

A pooled analysis of Demographic and Health Survey (DHS) data from 35 lower-middle income countries found that maternal nutritional status such as height and Body Mass Index (BMI), and poor household socioeconomic conditions such as household wealth and maternal education, as the leading factors associated with childhood anthropometric failure [16,17] . However, the cross-sectional nature of data is recognized as a major limitation in making any causal inferences in this regard.

A recent Sri Lankan study revealed that onset of growth faltering is seen very early in life in the majority of Sri Lankan infants [13]. Persistent exclusive breastfeeding without starting complementary feeding was evident despite detecting growth faltering. This was also confirmed by other Sri Lankan studies [18] Sub-optimal complementary feeding practices among infants and young children were elicited through a mixed method study [19]. In conforming to Ministry of Health recommendations [20] most caregivers had introduced solid foods to their children around 6 months of age. Further, the contribution of socio demographic factors could also be relevant, for example, women's participation in the labour force and their engagement in the agriculture sector is predictive of higher stunting rates, while participation in the service sector is protective against stunting according to the findings of a review by [21].

Purpose of the Sri Lanka Child Growth Cohort (SLCGC)

Growth is a dynamic process, and it is important to detect any abnormal growth early and to investigate its onset, causes and consequences to provide required interventions. We hypothesize that there are multiple factors operating at individual, household and organizational level leading to inadequate growth in infants and young children, and these factors may vary according to the timing of growth faltering. Hence, the growth, as well as its determinants should be explored in relation to age of child.

Purpose of the Sri Lanka Child Growth Cohort (SLCGC) is to describe the timing and pattern of growth faltering in infants and young children, and to determine the evolution of maternal, child and social factors affecting their growth over time, in order to assist better planning of interventions. This paper describes the study design and baseline characteristics of the SLCGC.

COHORT DESCRIPTION

Cohort design and population

The aim of the cohort was to sample children 12 to 24 months of age covering all three residential sectors across the country (urban, rural and the estate consisting of plantations), with longitudinal

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data being collected retrospectively from the pre-pregnancy stage. The cohort design intended to capture growth parameters and associated factors at defined time points within the first 1000 days of life, from conception up to 2 years.

In the Sri Lankan state preventive health system, pregnant women and children are registered with the Medical Officer of Health (MOH) for the provision of clinic based and domiciliary maternal and child health (MCH) services. Around 90% of the respective target populations (89.8% of pregnant women, 90.8% of infants) obtain preventive health care through this service [22]. Public Health Midwives (PHMs) are the frontline health care providers in the MOH areas who provide field level MCH services. The PHM maintains registers and records relevant to MCH care such as Register of Pregnant Mothers, Birth and Immunization Register, and personal health records such as Pregnancy Record (containing details of the mother before and during pregnancy), and the Child Health Development Record (CHDR) (containing birth details, immunization, health and development screening, micronutrient supplementation and growth monitoring data). During the first 2 years of life, weight is measured in every month, and length, at 4, 9, 12, 18 and 24 months.

Recruitment of participants for the present cohort was carried out during October and November 2023. Mother-child pairs of term babies (born at 37 weeks of gestation or later) currently between 12 to 24 months of age were selected from the Birth and Immunization Registers. Exclusion of pre-term babies was due to the fact that their growth pattern is different from that of term babies [23, 24,]. The children with less than 4 weight recordings in their CHDR during the first 12 months and those with chronic medical conditions and structural deformities causing feeding difficulties were excluded.

Cohort sampling

A total of 1875 mother-child pairs were recruited using a two-stage stratified cluster sampling method. Stratification was carried out at the level of residential sector as defined by the Department of Census and Statistics [25] with approximately 600 mother-child pairs selected from each sector, namely urban, rural and estates. In the first stage, three districts each from the urban (Colombo, Gampaha and Galle) and rural sectors (Kilinochchi, Polonnaruwa and Ampara), and 2 districts from the estate sector (Nuwaraeliya and Badulla) were purposely selected as the most appropriate districts to represent the respective sector. An MOH area was considered a cluster. In the second stage, clusters (MOH areas) were sampled from a list comprising all MOH divisions in the selected district. MOH areas with the highest percentage of urban population were selected for the urban stratum. Similarly, the MOH areas with the highest percentage of rural and estate populations were selected for the rural and estate strata, respectively. Forty-five clusters were selected, and from each cluster 40-mother child pairs were sampled systematically according to the Birth and Immunization registers of the PHMs. Figure 1 illustrates the Medical Officer of Health areas selected for the cohort.

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MEASUREMENTS AND PROCEDURE

Development of the study tools of the cohort and selecting the appropriate variables and measurements were guided by a conceptual framework as illustrated in Figure 2. A structured data collection tool was developed to gather data from the mothers or caregivers and from relevant health records including the pregnancy record and the CHDR. This was pretested in a similar setting after which minor modifications were made .

Measurement taken for outcome assessment:

Weights and lengths recorded serially in the CHDR were extracted in a longitudinal manner. Weight at birth and monthly intervals were available with the date of weighing in the B-portion of the CHDR. Length at birth and subsequent time points were also available with measurement date in the same record. On the date of the interview the weight and the lengths of the child were measured by the trained enumerators adhering to the standard protocol. Visual inspection of the weight-for-age chart, which are based on WHO multi country growth reference curves [26] in the local CHDR of the child was carried out by the enumerators and presence of any growth faltering (faltering i.e. deviation of the growth curve downwards, flattening or downward dip of the curve) was recorded.

Measurements taken for exposure assessment:

Detailed information on exposure status was collected using a life course approach. Pregnancy related information including illness before and during pregnancy, use of micronutrients, blood haemoglobin level, pre pregnancy/booking visit BMI and weight gain during pregnancy were gathered from the pregnancy record. Data on haemoglobin and weight were obtained at booking visit (first trimester), second trimester, and before the delivery (third trimester). Baseline characteristics of the child including the date of birth, sex, parity, singleton or multiple pregnancy, gestational age at birth , and measurements recorded at birth such as birth weight, length and head circumference were extracted from the CHDR. The mode of delivery, and the reason for caesarian delivery if performed, was collected through interviews.

In order to generate infant and young child feeding (IYCF) indicators, details on breastfeeding practices, complementary feeding, including the timing, frequency, decision making on feeding and responsive feeding behaviors were assessed by questioning the principal caregiver. Feeding of specific food items at each month was collected through a recall, which can also be used to assess dietary diversity at different ages. Longitudinal data on feeding different liquids and solid food items every month from birth up to the current age were inquired from the mother or caregiver. Additionally, micronutrient supplement use and food supplements given to the child were also gathered.

Illnesses of the child were recorded longitudinally at 3 monthly intervals during the first year and 6 monthly intervals during the second year of life. Respiratory illness, fever, diarrhoea, urine infection and other illness requiring hospitalization were assessed. An episode of respiratory tract

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infection (RTI) was defined as an illness with upper respiratory symptoms and signs, which lasted more than 48 hours with or without fever. An episode of diarrhoeal illness was defined as watery loose stools with more than 3 bouts per day lasting more than 48 hours, with frequent passage of formed or pasty stools seen in breastfed babies being excluded. Urinary tract infection and other illness requiring hospitalization was considered if it was indicated in medical records of the child. Any change in the diet of the child during illness was gathered during the interview.

Several socio-demographic and family level factors were assessed using the questionnaire. The variables included education level and employment of both mother and father, income of the family, maternity leave, housing conditions, water and sanitation and indicators to assess the Household Wealth Index. Availability of social safety nets for the family and presence of home risk factors as per the guidelines of the Ministry of Health [27] was also collected.

Table 1 and 2 provide a description of the key variables with the time period relevant to the information and the source of information.

Table 1 Key exposure variables assessed at different time points before or during pregnancy, and at delivery of the mother

Measurement	Period before or during pregnancy				
	Pre-conception	1st trimester	2nd trimester	3rd trimester	Delivery
Illness					
Diabetes	●	●	●	●	
Hypertension	●	●	●	●	
Heart disease	●	●			
Fever		◆	◆	◆	
Hospitalization		◆	◆	◆	◆
BMI		●			
Weight		●	●	●	●
Height		●			
Haemoglobin		●	●	●	
Food and micronutrient supplementation					
Iron		◆	◆	◆	
Folate	◆	◆	◆	◆	
Calcium		◆	◆	◆	
Vitamin C		◆	◆	◆	
Thriphosa		◆	◆	◆	
Mode of delivery					●
Gestational age at birth					●

● Obtained from pregnancy record

◆ Inquired from history

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Table 2 Key variables assessed at different time points from birth up to 24 months of age of the child

Measurement	Age of child in months														
	birth	0 to <1	1 to <2	2 to <3	3 to <4	4 to <5	5 to <6	6 to <7	7 to <8	8 to <9	9 to <10	10 to <11	11 to <12	12 to <18	18-24
Parental measurements															
Weight of mother														■	■
Height of mother														■	■
Weight of father														■	■
Height of father														■	■
Measurements at birth															
Birth weight	●														
Length at birth	●														
Head circumference	●														
IYCF practices															
Breastfeeding	◆			◆			◆						◆	◆	◆
Any semisolid solid food		◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆		
Water		◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆		
Any powdered milk (formula or other)		◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆		
Fresh milk		◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆		
Specific water-based liquids[a]		◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆		
Specific semisolid/solid food[b]		◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Specific unhealthy food[c]		◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Responsive feeding[d]														◆	◆
Childhood illness															
Admitted to special care baby unit	●														
Fever			◆			◆			◆			◆		◆	◆
Respiratory illness			◆			◆			◆			◆		◆	◆
Diarrhea			◆			◆			◆			◆		◆	◆
Urinary tract infection			◆			◆			◆			◆		◆	◆

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Measurement	Age of child in months														
	birth	0 to <1	1 to <2	2 to <3	3 to <4	4 to <5	5 to <6	6 to <7	7 to <8	8 to <9	9 to <10	10 to <11	11 to <12	12 to <18	18-24
Feeding during illness[e]			◆			◆			◆			◆		◆	◆
Food /Micronutrient supplementation															
Vitamin A								◆						◆	◆
Multiple micronutrient powder								◆						◆	◆
Food supplementation														◆	◆
Anthropometry															
Weight of child		●	●	●	●	●	●	●	●	●	●	●	●	● ■	● ■
Length of child		●	●	●	●	●	●	●	●	●	●	●	●	● ■	● ■
Growth faltering															
Onset of growth faltering		●	●	●	●	●	●	●	●	●	●	●	●	●	●
Reasons for growth faltering		●	●	●	●	●	●	●	●	●	●	●	●	●	●
Action taken during growth faltering		●	●	●	●	●	●	●	●	●	●	●	●	●	●

● Obtained from pregnancy record or CHDR

◆ Inquired from history

■ Measured on-site (Measurements were taken during the interview according to the current age of the child)

[a] Inquired about specific water-based liquids separately: fruit juices, and rice kunjee

[b] Inquired about specific food items under solid/semi-solid food separately: starchy food, yellow-color vegetables, other vegetables, yellow-color fruits, others fruits, legumes, flesh food, eggs

[c] Inquired about specific unhealthy food separately: sweets, biscuits, malted beverages and sodas/colas.

[d] Inquired responsive feeding referring to the current time period

[e] Inquired about feeding during illness referring to any episode of illness in the past

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DATA COLLECTION AND ANALYSIS

Data collection

Enumerators were trained to administer the questionnaire and to conduct anthropometric measurements. National and regional level clearance was obtained to conduct face-to-face interviews and to collect data from the relevant records. The selected participants were requested via telephone to come to a center within their village or estate for data collection. If they did not respond for three separate attempts of contact, or when a participant did not have a means of communication, a home visit was made for this purpose. If all attempts failed, the next eligible child was sampled. It was explicitly mentioned that participation is voluntary and that all data would be confidential. All study material was in the local language (Sinhala / Tamil). The research team regularly monitored the data collection in the field.

Two enumerators were assigned to collect data from one mother-child pair. Photo images of the relevant sections of the pregnancy record, and CHDR including the growth charts (weight-for-age chart, length-for-age chart, weight-for-length chart) and the table for weight and length records were obtained. The data was entered into a tailor-made online database in parallel to data collection during the field work. The current database contains password protected, de-identified data along with the images of the documents as a single PDF file under serial numbers.

Statistical analyses

Data processing

Frequency distributions were generated for all variables and the relevant records (pregnancy record or CHDR) were revisited when there were missing data or extreme values for appropriate corrections.

Repeatability of certain variables for which the same information was gathered from 2 different approaches was assessed by ICC (intraclass correlation coefficient) for numeric data or by Cohen's Kappa for categorical data. High and significant ICC were reported for the following variables: age of child according to mother's history vs calculated age by date of birth (ICC=0.99; 95% CI 0.650 to 0.997); mothers height according to pregnancy record vs. height measured on site; the last weight record in the CHDR vs weight measurement onsite during the survey. Percent agreement was tested for some categorical variables, i.e., giving breastmilk, feeding powdered milk, and introducing solid/semisolid food, and a high percentage agreement with a significant Cohen's Kappa was found for all these variables.

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Basic statistical analysis

Data were summarized into frequency tables illustrating the characteristics of cohort participants. New variables were generated using the recode option in the statistical package in order to transform data into standard or meaningful categories, such as maternal age group, child age group, educational levels, birth interval, birth weight etc.

BMI was calculated and classified according the WHO definition of BMI for adults [28]. Household Wealth Index was calculated by using data on main sources of drinking and cooking water, type of toilet facility, main sources of lighting, cooking fuel, main material used in floor, roof and walls of the house, ownership of the house, household assets, and animal husbandry [29]. Principle Component Analysis was performed to create an asset score which was divided into 5 quintiles for comparison purposes.

Statistical analyses were performed using STATA [30] and SPSS [31]. Anthropometric measurements were transformed into weight-for-age Z score, length-for-age Z and weight-for length Z score as per WHO growth reference standards [32] using AnthroPlus Software [33].

Quality of data

In order to ensure the reliability and validity of collected information, investigators followed the best practices given below:

- High standards were maintained in recruiting suitable persons with experience in field work, and adequate training was provided on interviewing techniques and the subject matter of the survey. All team members were given a two-day classroom and a field day training program, including training on anthropometric measurements of a child.
- Interviews were conducted in a language conversant to the respondents. Data collection tools were available in all three languages. Interviews were conducted at a time most convenient to the respondents through an appointment system.
- Interviewing etiquettes were strictly followed by the enumerators and survey supervisors closely monitored the process.
- The interviewer assured the respondents of the confidentiality of information, indicated the time required for completing the interview and sought their approval to continue with the survey.

Best practices followed to ensure quality of data collection

- The survey consultants and data managers undertook random field visits to ensure surveys are conducted appropriately and acceptably.
- Completed questionnaires were scrutinized first by the supervisors to ensure completeness and accuracy of the filled responses and incomplete questionnaires were returned to the

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field enumerator to complete the same. Entered data were randomly checked to ensure accuracy.

- The survey teams conducted further quality checking before entering the data into the online database.

Patient and Public Involvement

At the stage of designing the study, 3 group discussions were held with the mothers of children under 2 years of age from the 3 residential sectors, and their views were considered in defining certain variables such as types of food given to children, responsive feeding behaviour, and childhood illness according to their socio-cultural context. It is expected to inform the relevant findings to participants during the 2nd wave of assessment in this cohort after one year.

BASELINE FINDINGS

Characteristics of the participants

The cohort covered 3 main residential sectors of the Sri Lankan population namely the urban, rural and estate, in nearly equal proportions (Table 3). The majority of mothers of the children were less than 35 years of age (77.9%) and housewives (78.4%). The proportion completing General Certificate of Examinations (GCE Ordinary Level) education was 69% in mothers in contrast to 63.7% in fathers. A great majority of fathers (94.4%) were engaged in some form of economic activity. Approximately 30% of mothers were overweight or obese, while 15.0% were underweight at the time of registering for pregnancy.

Of the children, 49.2% were girls, 42.5% were the first-born children in their family, and 34.2% were born by cesarean section. Their ages ranged from 12 months to 24 months, and the number of children in the age 21-24 months and 12-14 months were somewhat higher than other age categories. This cohort includes only term-born children, and the mean birth weight was 2917 g (SD 406), with the proportion of low birth weight (less than 2500 g) being 13.0%.

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Table 3 Characteristics of parents and their children recruited in the cohort

Characteristics		No	%
Parental characteristics			
Residential sector	Urban	646	34.5
	Rural	593	31.6
	Estate	636	33.9
Maternal age category	<35 years	1460	77.9
	35 and above	415	22.1
Mother's education level[1]	Passed Grade 5 or less	64	3.4
	Passed Grade 6-10	518	27.60
	Passed Ordinary Level	797	42.50
	Passed Advanced Level	393	21.0
	Degree and above	103	5.5
Mother's occupation	Employed Government sector	81	4.3
	Employed private sector	107	5.7
	Self-employed / Own business	61	3.3
	Casual Worker	156	8.3
	Take care of house work	1470	78.4
Father's education level[2]	Passed Grade 5 or less	53	2.8
	Passed Grade 6-9	614	32.7
	Passed Ordinary Level	821	43.8
	Passed Advanced Level	300	16.0
	Degree and above	74	3.9
	Data not available	13	0.7
Father's occupation	Employed Government sector	233	12.4
	Employed private sector	618	33.0
	Self-employed / Own business	376	20.1
	Casual Worker	544	29.0
	Take care of house work	84	4.5
	Data not available	20	1.1
Wealth Index Quintile	Lowest	375	20.0

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	Second	375	20.0
	Middle	378	20.2
	Fourth	372	19.8
	Highest	375	20.0
Pre-pregnancy BMI category (kg/m^2)	Less than 18.5	280	14.9
	18.5-24.9	841	44.9
	25.0-29.9	413	22.0
	>30 and higher	142	7.6
	Data not available	199	10.6
Child characteristics			
Birth interval (years)	No previous birth	796	42.5
	1-2 years	180	9.6
	3-4 years	345	18.4
	5 years or more	554	29.5
Sex	Female	922	49.2
	Male	953	50.8
Mode of delivery	Caesarian	642	34.2
	Vaginal	1233	65.8
Birth order	First	796	42.5
	2nd	640	34.1
	3rd or higher	439	23.4
Gestational age at birth(weeks)	37-37^{+6}	359	19.1
	38- 38^{+6}	615	32.8
	39- 39^{+6}	475	25.3
	≥40	426	22.7
Birth Weight Category (grams)	<2000	20	1.1
	2000-2499	224	11.9
	2500-2999	842	44.9
	3000-3499	644	34.3
	>3500	145	7.7
Current age of child (months)	12-14	461	24.6
	15-17	422	22.5
	18-20	417	22.2
	21-24	575	30.7
Total		1875	100.0

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STRENGTHS AND LIMITATIONS

Strengths

The SLCGC serves as a comprehensive cohort study with a countrywide distribution in Sri Lanka, covering the 3 main residential sectors namely the urban, rural and estate sectors. It captures data on a wide spectrum of individual, household, and societal determinants of child growth commencing from the pre pregnancy period up to the current time point. This is one of the few studies that harnessed a wealth of longitudinally recorded data during pregnancy and early childhood, supplemented with direct interviews and anthropometric assessments. The findings will fill-up evidence gaps that are needed to inform policy and program decisions to improve child malnutrition in the country, such as the predictors of low birth weight, and timing and determinants of early growth faltering etc. This data enables investigation of the effects of single exposures on child growth, as well as, more complex epidemiological analyses on multiple simultaneous and time-varying exposures on the growth of the child. Furthermore, potential confounders and effect modifiers are available to model the outcome through advanced statistical modeling.

Measures and precautions to assure quality of data is one major strength of the SLCGC. Careful recruitment of the study team, adequate training, and close monitoring process at different stages of the study enhanced the validity data.

All children in the cohort had completed at least 12 months of age at the time of enrollment. This enabled retrospective assessment of exposures during the first 12 months of life of all children.

Limitations

The SLCGC is not fully representative of the Sri Lankan child population with respect to socio-economic diversity of the country. The study may have not adequately covered the upper socio-economic strata of the population since those may not register for field-based services provided through the state health sector.

Secondary data were extracted from the pregnancy records and CHDR. Certain weight measurements and higher number of length measurements were not available in the CHDR B portions. Anthropometric measurements extracted from the records had been taken for the purpose of service delivery, therefore may not be ideally suited for research purposes. Recall bias is a problem when collecting the details regarding breastfeeding and complementary feeding practices.

The cohort did not enroll children born preterm, that is before 37 weeks of gestation, and this limits the interpretation of findings regarding growth of preterm babies. As the cohort did not include preterm births, the proportion of low birth weight children is an under-representation of the overall expected low birth weight prevalence.

It is noteworthy to understand that this cohort was followed-up in the backdrop of an ongoing economic crisis in the country. Children recruited to the cohort were those born between October 2021 to September 2022, thus their conception, gestational period, birth and postnatal period would have been exposed to economic crisis and its consequences. Further, there is no clear starting point or endpoint of the economic crisis and all that can be stated is that the study outcomes

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could have been influenced to a varying degree by the economic crisis. Thus, due caution should be exercised to in interpreting results.

Way Forward (Future Plans)

Further analysis of available data

Data analyses will be continued according to the aims of the cohort. Analysis will be extended to identify the determinants of low birth weight including the effect of weight gain and other parameters during pregnancy, using multivariate regression models. Growth faltering at different time-points will be correlated with the concurrent events including IYCF practices, childhood illness, care practices and utilization of health services. Furthermore, longitudinal data analysis techniques will be applied to explain different growth patterns. Current growth status in terms of stunting, wasting and underweight will be analyzed against a range of socio-demographic and other predictors. Correlation of growth faltering with other measures of anthropometric deficits at different points in time would also be investigated using this data.

Continuation of the cohort

The next wave of assessment is expected to be done after 12 months of recruitment. SLCGC team recommends that this cohort be extended with clearly defined waves of assessment through their childhood and adolescence.

Collaboration

SLCGC was established by the Sri Lanka College of Pediatricians in collaboration with the Family Health Bureau of the Ministry of Health Sri Lanka, South Asia Infant Feeding Research Network and UNICEF Sri Lanka country office. SLCGC seeks further collaboration with researchers who are interested in child nutrition and growth in order to conduct advanced analysis of longitudinal data. Deidentified micro-data of the cohort will be available for researchers, upon reasonable request to the corresponding author with clear plan of utilization of such data. Collaborative work is also required to extend follow-up and widen its scope.

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Council extended their fullest cooperation to conduct this study. Authors wish to acknowledge the South Asia Infant Feeding Research Network (SAIFRN) for conducting the field work of this study.

Author contribution

VPW initiated the collaborative project, conceived the study, designed data collection tools, monitored data collection, and revised the draft paper. GL designed data collection tools, monitored data collection and revised the draft paper. SDSW designed the cohort, developed data collection tools, trained enumerators, monitored data collection, cleaned data, and drafted the paper. YNW designed the cohort, developed data collection tools, trained enumerators, monitored data collection, cleaned data, and revised the paper. IS developed database, prepared statistical analysis plan, monitored data collection, cleaned and analyzed data. KP developed data collection field plan, trained enumerators, monitored data collection, cleaned data, and revised the paper. YS developed data collection tools, trained enumerators, monitored data collection, cleaned data, and revised the paper. DR, AD and HSJ conceived the study, designed the cohort, developed data collection tools, monitored data collection, and revised the paper. US designed the cohort, developed data collection tools, trained enumerators, monitored data collection, cleaned and analysed data, and wrote the paper. All members of SLCGC designed the cohort, monitored data collection, and provided inputs for data analysis.

Competing interests

AD and DR are affiliated to UNICEF Country Office of Sri Lanka, but contributed independently to the design, analysis and review of this manuscript.

Funding

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Data sharing statement

Deidentified micro-data of the cohort will be available for researchers, upon reasonable request with clear plan of utilization of such data conforming to guidelines for data dissemination. Available data are listed in Tables 2 and 3 in the article. Requests for statistical code and anonymized data may be made to the corresponding author, and will be reviewed by the SLCGC team.

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Ethics approval statement

Ethics clearance was obtained from the Ethics Review Committee of the Sri Lanka College of Paediatricians (ERC Ref No: SLCP/ERC/2023/08). Informed consent was obtained from participants.

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Figure 1 Map of Sri Lanka showing the Medical Officer of Health areas selected for the cohort

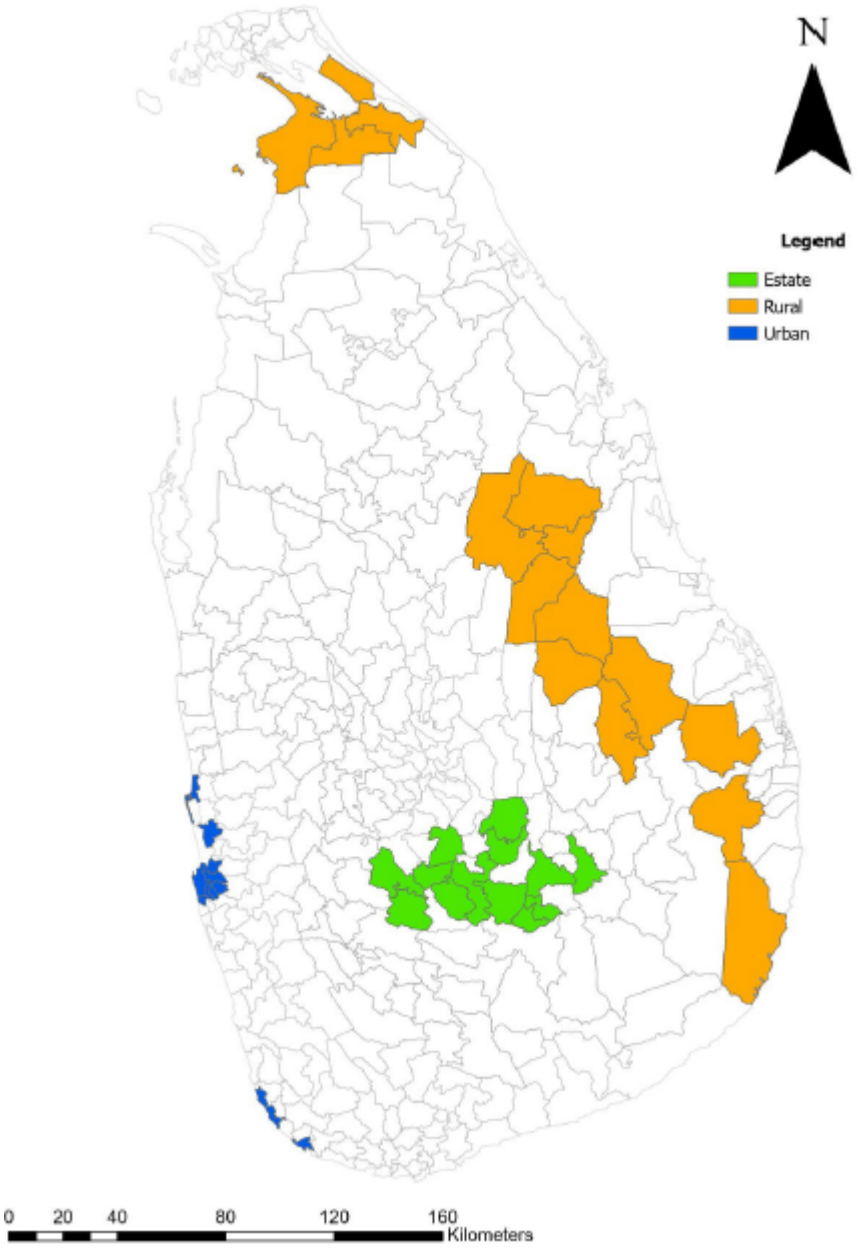

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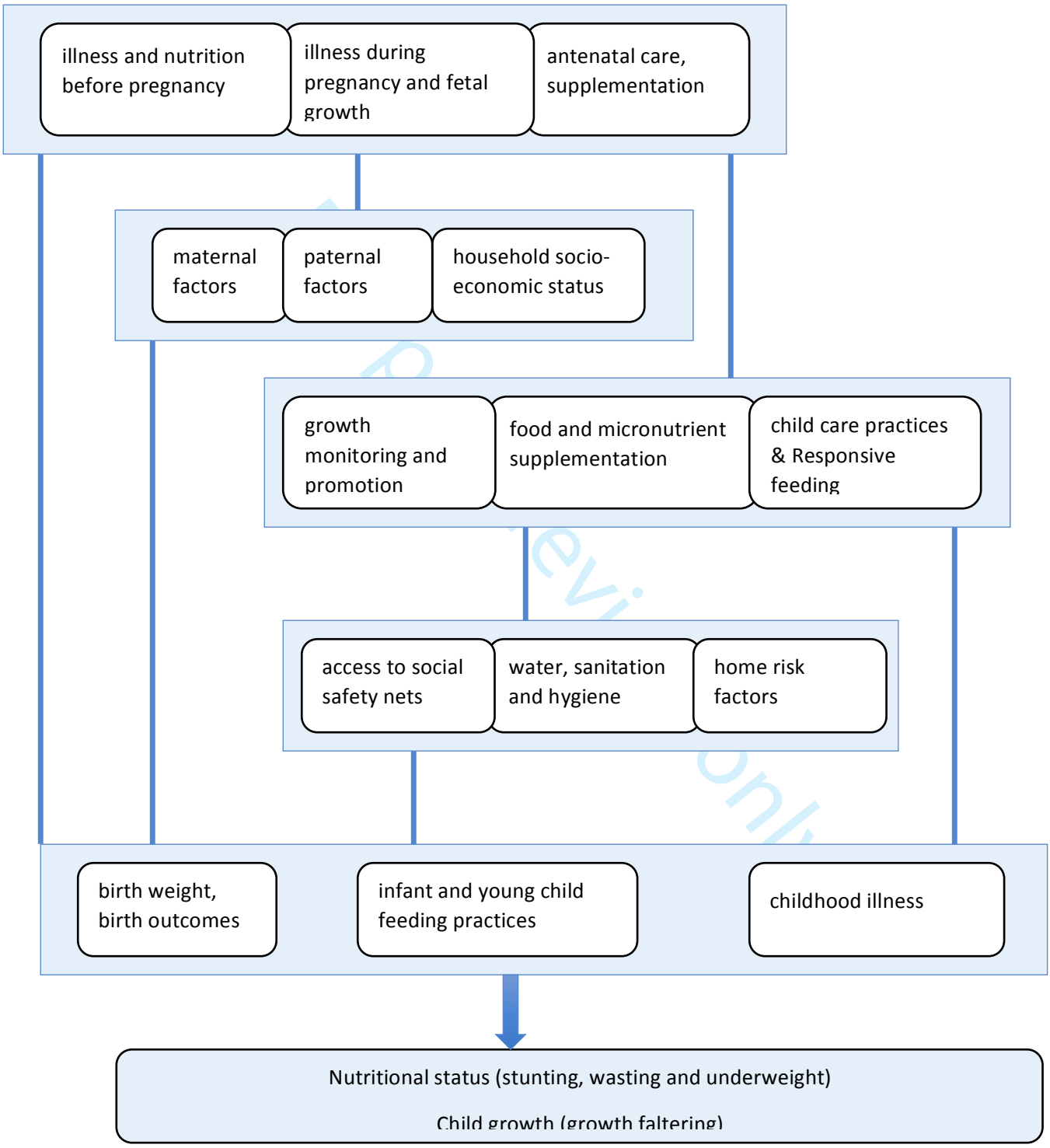
Figure 2 Conceptual framework of the Sri Lanka Child Growth Cohort Study.



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