Trends, inequalities and determinants of low birth weight in Sri Lanka

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(Index words: low birth weight, nutrition, inequality)

Abstract

Introduction This study analyses the DHS 1993, 2000 and 2006-07 and NFSS 2009 survey data to investigate trends, inequalities and determinants of low birth weight (LBW) in Sri Lanka.

Methods We re-evaluated recent trends in LBW incidence, adjusting for changes in the coverage of DHS surveys to ensure comparability, and used multivariate logistic regression to investigate determinants. We quantified the degree of economic inequality using wealth and concentration indices, and assessed the contribution of determinants to inequality by decomposition.

Results There was a continuing, but slowing decline in LBW incidence, reaching 17% during 2001/02-2006/07, whilst very low birth weight incidence declined from 0.9% to 0.6%. Concentration indices reveal persistent, large economic inequalities in LBW incidence. Maternal body mass index (BMI), height and education, altitude and Indian Tamil ethnicity were the major determinants of LBW, with supply of 'Thriposha' having no significant impact. Accounting for maternal BMI and height largely eliminates the impact of economic status, and reduces the impact of ethnicity. Decomposition analysis reveals the major contributors to the inequalities are maternal BMI (21%), height (12%) and education (14%), ethnicity (9%) and altitude (7%).

Conclusions The results imply that food insecurity mediates the association of LBW with poverty, and is the major amenable risk factor. The impact of maternal height and Indian Tamil ethnicity suggests that epigenetic mechanisms play a role, and that reductions in LBW incidence will take considerable time. There is a need to substantially improve the effectiveness of interventions to reduce LBW in coming generations.

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Introduction

Low birth weight (LBW), defined as birth weight (BW) <2,500 g, is a major risk factor for child undernutrition, with long-term sequelae, including impaired cognitive development and increased adulthood risks of non-communicable diseases (NCD), such as diabetes and dementia [1, 2]. Preterm birth accounts for half the LBW incidence in developed countries, but in developing countries, the primary pathway is intrauterine growth retardation (IUGR) caused primarily by maternal undernutrition, and other factors [2, 3] (Table 1).

LBW incidences have declined in Sri Lanka, but the reliability of trends reported by Sri Lanka's Demographic and Health Surveys (DHS) has been questioned, owing to changes in coverage. Nevertheless, the reported incidence of 17% in the most recent DHS surveys is high in comparison with countries at similar income levels, although this is true of all South Asian countries [4]. Lagging progress on child nutrition, despite investments in maternal nutrition and universal access to antenatal care, led the government in 2011 to establish a National Nutrition Council to formulate new strategies. Given the contribution of LBW to later morbidity and to social disadvantage, LBW trends and determinants must be monitored to inform policy.

Methods

We used data from the DHS surveys of the Department of Census and Statistics with BW information: 1993, 2000 and 2006-07, and the Medical Research Institute's Nutrition and Food Security Survey (NFSS) 2009 [5-8]. These sampled ever-married, 15-49 years old women and their children. The DHS surveys excluded the Eastern (EP) and Northern (NP) Provinces, except for the DHS 2006-07, which included EP. The NFSS 2009 used a two-stage, cluster sample design to survey 13 districts from all nine provinces, but its design does not support reliable national inferences. All surveys collected BW data of all living children born in the previous 5 years to sampled mothers. The source was the child health card, which was available for more than 90% of all children in each survey, except the DHS 1993, where maternal recall provided 18% of records.

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Table 1. Summary of literature on determinants of low birth weight and previous findings from Sri Lanka

Determinants[1]	*Strength of association*[2]	*Previously reported for Sri Lanka*	*Examined in this empirical analysis*
Maternal determinants			
Historical factors			
Short or long birth interval	+++	Yes [10]	Yes
Previous history of preterm/LBW births	+++	-	Yes
Parity	++	Yes [10]	No
Previous still births and abortions	+	-	Yes
Demographic factors			
Advanced maternal age	+	Yes [17]	Yes
Adolescent mothers	++	Yes [10]	Yes
Unmarried/cohabitation	++	-	No
Mother's education	++	Yes [10, 13]	Yes
Household wealth	++	Yes [13]	Yes
Urban/rural residence	+	Yes [13]	Yes
Nutritional factors			
Iodized salt	++	Yes [18]	Yes
Anatomical factors			
Maternal BMI	++	Yes [17]	Yes
Maternal height	++	Yes [10]	Yes
Weight gain during pregnancy	++	Yes [19]	No
Uterine factors	++	-	No
Placental factors	++	-	No
Maternal medical conditions			
Anaemia	+	Yes [10, 20]	Yes
Lifestyle-related factors			
Smoking	+++	-	No
Heavy alcohol use	+++	Yes [19]	No
Sleep deprivation	++	Yes [19]	No
Less walking hours	++	Yes [19]	No
Standing for more than 2.5 hours a day	++	Yes [17]	No
Environmental factors			
Altitude	+++	-	Yes
Environmental tobacco exposure	++	-	No
Passive inhalation of cooking smoke	++	Yes [10]	Yes
Exposure to physical and chemical hazards	++	Yes [19]	No
Piped water inside dwelling	+	Yes [13]	Yes
Poor neighbourhood	+	-	Yes
Violence/maternal abuse			
Violence or abuse	++	-	Yes
Paternal determinants			
Advanced paternal age	+	-	Yes
Paternal history of being LBW	+	-	No
Father's education	+	Yes [10]	Yes
Foetal determinants			
Sex of child	++	Yes [10]	Yes
Gestational duration	+++	Yes [10]	No
Multiple birth	+++	Yes [13]	Yes

[1] Based on systematic review by Ohlsson and Shah (2008), supplemented by additional review by authors.

[2] +++ strong association, ++ modest association, + weak association.

To allow analysis of living standards, household wealth indices were constructed based on household assets, using Principle Components Analysis (PCA), and households ranked into sample-weighted quintiles. Tabulation of LBW by household wealth quintiles was included for the first time in the DHS 2006/07 report, but we report this for the first time for prior DHS surveys. PCA was also applied to a number of variables concerning mother's participation in decision-making, and mothers divided into tertiles according to their level of autonomy.

Altitude is a determinant of LBW previously not examined in Sri Lanka [9]. The DHS 2006/07 survey recorded households' GPS coordinates. We derived the corresponding altitudes by referencing the NASA space shuttle generated global digital elevation database, SRTM1, via the GPS visualizer website (www.gpsvisualizer.com).

All statistical analyses were carried out using Stata, version 11.2 (Stata Corp, College Station, TX, USA), taking account of the multistage cluster sampling design of the surveys. During regression analyses, potential variable interactions were tested for, and multicollinearity of variables was assessed using variance inflation factors.

Results

Excluding EP and NP for valid comparison, the incidence of LBW declined substantially from 20.6% during 1987-1993 to 17.2% during 1993-2000, and then to 16.6% during 2000-2006/07 (Table 2). Including EP has negligible impact. These figures mask a large increase in LBW in the estate sector from 24% and 31% in the last two DHS surveys. The slow-down in LBW reduction since 2000 contrasts with rapid income growth nationally. Very low birth weight, defined as BW<1,500 g, decreased from 0.9% to 0.8% and then to 0.6% during the three surveys.

Similar LBW disparities are observed in all surveys. LBW incidence is higher in first, female and multiple births, and when the pregnancy interval is short (proxied by birth interval <1 year) [10, 11]. LBW is higher (25-26%) in underweight mothers than those of normal weight (16-17%), and least (11%) in overweight mothers.

LBW incidence is higher in rural than urban areas, whilst in estate areas it is more than double (31% versus 13% in DHS 2006/07). LBW increases with altitude in the DHS 2006/07, from 15% at the lowest elevations to 30% at the highest. LBW has concentrated in the plantation districts of Nuwara Eliya and Badulla, and in Trincomalee, with the lowest rates observed in the Western Province (Figure 1). LBW is twice as high in Indian Tamils and is lower in Moors, and decreases with maternal education.

The incidence of LBW is consistently higher the poorer the family, as proxied by wealth quintiles (Table 2). LBW rates in the poorest quintile are double those in the richest (DHS 2006/07: 22% versus 12%). This economic inequality is evident in each survey's concentration curve (Figure 2). The inequality represented in the concentration curve can be quantified using the concentration index (CI), whose value ranges from -1 to +1, with a value of -1 indicating that the variable is concentrated in the poorest household, a value of zero when there is no inequality (represented by the line of equality), and +1 when it is concentrated in the richest household. The negative CI values for the surveys are highly significant (p<0.001). Inequality increased from the DHS 1993 (CI= -0.14) to the DHS 2000 (CI= -0.20), before decreasing again in the DHS 2006/07 (CI= -0.13).

We then analysed determinants of LBW in the DHS 2006/07 using multivariate logistic regression. We selected variables based on a literature review of findings globally and in Sri Lanka (Table 1), and the UNICEF framework for determinants of childhood malnutrition [2, 3, 12]. Model building was done in a stepwise additive manner to estimate odds ratios (OR) for LBW.

Several covariates with no significant impact were excluded during model building. These included iron supplements during pregnancy and use of iodised salt, which is consistent with weak evidence in the literature. Other dropped covariates include birth interval, previous stillbirths, abortions or miscarriages, taking medication for heart disease (proxy for heart disease), paternal age and education, use of firewood without a chimney for ventilation (linked to indoor air pollution), and neighbourhood living standards. Contrary to a previous World Bank study, access to piped water was not a determinant [13]. None of the variable interactions examined proved significant.

Some covariates that were significant at a 15% confidence level were retained, if the coefficients were logically causal. Final results are shown in Table 3, which presents the results for one intermediate model (Model A) and for the final model (Model B). Goodness-of-fit testing indicates that Model B is well calibrated (Hosmer-Lemeshow statistic 1.025, p=0.42).

The results confirm the strong influence of proximal determinants. The risk of LBW is significantly higher if the child is a first, female, multiple, or caesarean birth, and if the mother has a history of LBW. There is an increased LBW risk in the youngest mothers, although the coefficients are of borderline significance.

Maternal height and BMI are each large, highly significant determinants of LBW. The relative risk of LBW decreases by 5% for each 1 cm increase in height, and decreases by 8% for each unit increase in BMI, with detailed analysis revealing an approximately linear relationship in each case. Altitude is highly significant, with the relative risk increasing by 7% for every 100 meters increase in elevation above sea level.

Table 2. Percentage of low birth weight by descriptive characteristics, DHS 1993, 2000 and 2006-07

Background characteristics[1]	*DHS 1993*[1]	*DHS 2000*[1]	*DHS 2006-07*[2]	
			Excluding EP	*Including EP*
Child sex				
Male	18.7	15.8	15.4	15.2
Female	22.7	18.7	17.8	17.8
Birth interval				
1st child	21.8	21.6	20.7	20.9
1-12 months	40.4	4.4	28.0	25.3
>12 months	19.6	13.4	13.4	13.3
Low birth weight history				
No	19.7	16.7	16.3	16.2
Yes	43.5	32.8	34.3	31.7
Birth type				
Single	18.7	16.9	15.3	15.3
Multiple	79.3	41.3	73.5	73.9
Mother's age				
15-19	22.7	15.7	30.2	28.4
20-24	24.3	22.3	21.2	21.5
25-29	20.1	19.4	15.7	15.4
30-34	17.0	14.8	15.0	14.8
35-49	21.9	12.5	15.5	15.6
Mother's BMI				
Underweight (BMI≤18)	-	25.1	26.4	26.3
Normal weight	-	15.2	17.1	17.0
Overweight (BMI≥25)	-	11.2	11.3	11.3
Mother's ethnicity				
Sinhalese	19.5	16.2	15.8	15.9
Sri Lanka Tamil	19.8	17.9	19.8	19.4
Indian Tamil	41.7	30.8	36.8	36.6
Moor	17.0	14.1	14.9	13.9
Mother's education				
No education	32.9	36.4	34.0	30.5
Primary	25.8	21.4	22.8	21.4
Secondary	20.2	17.8	17.3	17.1
Higher	15.2	12.6	13.5	13.6
Sector				
Urban	17.7	12.8	13.1	12.6
Rural	19.9	17.0	16.3	16.3
Estate	39.9	23.7	31.4	31.4
Altitude (meters)				
0 - 250	-	-	15.2	15.3
251 - 500	-	-	17.4	17.4
500 - 1,000	-	-	22.4	22.4
>1,000	-	-	29.6	29.6
Wealth quintile				
Poorest	25.6	24.5	21.7	22.0
2	24.7	19.8	22.2	21.0
3	22.2	16.0	13.8	14.3
4	16.1	14.1	15.3	15.5
Richest	14.1	9.4	11.6	11.5
Total	**20.6**	**17.2**	**16.6**	**16.5**
Concentration index (CI)	-0.14	-0.20	-0.13	-0.13
Standard error in CI	0.02	0.03	0.02	0.02
Number of observations (N)	**3,531**	**2,589**	**5,664**	**6,402**

[1] Detailed tabulations available online in *Trends and inequalities in child undernutrition, Sri Lanka 1987-2009*, IHP Health Statistics Reports, No 3. Colombo: Institute for Health Policy (www.ihp.lk/publications).

[2] Estimates refer to births in past five years, excluding any children not alive at time of survey.

Table 3. Adjusted odds ratios (95% confidence intervals) of low birth weight by birth, parental, household and social characteristics, DHS 2006/07

Category	*Characteristics*	*Logistic regression: Low birth weight (<2,500g)*			
		Model A		*Model B*	
		aOR[1]	*CI 95%*	*aOR*[1]	*CI 95%*
Infant and birth factors	First child	1.77***	1.48-2.12	1.81***	1.50-2.19
	Female child	1.25**	1.07-1.45	1.30***	1.11-1.52
	Twin or multiple birth	18.24***	11.20-29.71	24.29***	14.69-40.17
	Caesarean birth	1.42***	1.18-1.69	1.48***	1.23-1.79
Maternal birth factors[2]	Age <19 years	1.58*	1.09-2.28	1.42	0.98-2.06
	Age 19-23 years	1.19	0.97-1.45	1.12	0.91-1.38
	Prior LBW in past 5 years			2.34***	1.52-3.59
Maternal size	Maternal BMI			0.92***	0.90-0.94
	Mother's height (cm)			0.95***	0.93-0.96
Maternal education[2]	Primary	0.70	0.45-1.09	0.77	0.49-1.20
	Secondary	0.54**	0.36-0.82	0.59*	0.39-0.89
	Higher	0.43***	0.27-0.68	0.47**	0.29-0.75
Female autonomy (tertiles)[2]	Middle	0.71***	0.58-0.87	0.69***	0.56-0.85
	Highest	0.74***	0.61-0.89	0.77**	0.64-0.93
Post-tsunami birth[3]		1.86	0.79-4.36	1.73	0.81-3.67
Maternal medical care	Treated for asthma	1.46	0.93-2.28	1.50	0.98-2.28
	Treated for hypertension	1.85	0.92-3.69	2.31*	1.12-4.75
	Family health worker visits	0.97	0.95-1.00	0.97*	0.94-1.00
Household wealth[2]	Second quintile	0.99	0.78-1.25	1.11	0.88-1.41
	Third quintile	0.75*	0.57-0.97	0.88	0.67-1.15
	Fourth quintile	0.75*	0.57-0.97	1.02	0.78-1.34
	Highest quintile	0.62**	0.45-0.84	0.97	0.70-1.33
Household size (persons)		1.00	0.96-1.04	0.97	0.93-1.02
Maternal ethnicity[2]	Sri Lankan Tamil	1.23	0.92-1.64	1.32	0.98-1.78
	Indian Tamil	2.24***	1.43-3.52	1.84*	1.13-3.00
	Sri Lanka Moor	0.80	0.61-1.05	0.90	0.69-1.17
	Other	1.07	0.34-3.30	1.41	0.42-4.75
Sector[2]	Rural	1.33*	1.05-1.67	1.28*	1.01-1.62
	Estate	1.32	0.85-2.04	0.85	0.54-1.36
Altitude (100m)			1.07***	1.04-1.10	
Number of observations (N)		**6,374**		**6,089**	

[1] Results of the multiple logistic regression analysis are given as adjusted odds ratios (aOR), with 95% confidence intervals (CI). For non-categorical variables, the aOR represents the increase in relative risk of LBW per unit increase in the variable. Asterisks indicate significance of adjusted odds ratios: * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

[2] Reference categories are 24-49 years (for maternal age), no schooling (for maternal education), lowest tertile (for maternal autonomy), poorest quintile (for household wealth), Sinhalese (for maternal ethnicity), and urban (for sector).

[3] Births taking place in tsunami-affected households in the six months following 2004 Tsunami.

Table 4. Adjusted odds ratios (95% confidence intervals) of low birth weight by child and household characteristics including food security, NFSS 2009

Category	*Characteristics*	*Logistic regression: Low birth weight (<2,500g)*			
		Model A		*Model B*	
		aOR[1]	*CI 95%*	*aOR*[1]	*CI 95%*
Infant and birth factors	Female child	1.33*	1.06-1.66	1.41**	1.10-1.79
	Twin or multiple birth	12.05***	6.53-22.23	13.07***	7.19-23.74
Maternal birth factors[2]	<19 years	1.28	0.76-2.13	1.28	0.75-2.18
	19-23 years	1.36*	1.01-1.81	1.28	0.94-1.73
	Prior LBW in past 5 years			2.79***	1.51-5.15
Maternal size	Maternal BMI			0.96**	0.93-0.98
	Mother's height (cm)			0.95***	0.92-0.96
Maternal education[2]	Primary	1.17	0.73-1.88	1.09	0.63-1.86
	Secondary	0.96	0.64-1.43	1.00	0.61-1.63
	Higher	0.86	0.52-1.41	0.92	0.51-1.64
Post-tsunami birth[3]		1.18	0.67-2.05	1.24	0.67-2.27
Maternal anaemia (<11 g/dl)[4]				1.70**	1.20-2.41
Household wealth[2]	Second quintile	0.84	0.61-1.14	0.88	0.63-1.21
	Third quintile	0.58**	0.41-0.80	0.62**	0.43-0.87
	Fourth quintile	0.62*	0.41-0.92	0.66	0.42-1.01
	Highest quintile	0.47***	0.31-0.70	0.53**	0.33-0.83
Household size		0.99	0.91-1.06	0.96	0.88-1.04
Religion (maternal)[2]	Hindu	0.75*	0.56-0.99	0.75	0.54-1.01
	Muslim	0.58**	0.41-0.82	0.60*	0.39-0.89
	Roman Catholic	0.77	0.52-1.12	0.88	0.58-1.32
	Other	0.86	0.31-2.36	1.00	0.34-2.92
Sector[2]	Rural	0.86	0.64-1.16	0.83	0.60-1.14
	Estate	2.56***	1.65-3.95	2.07**	1.28-3.33
Food security indicators	No. of food types consumed			0.98	0.85-1.11
	No. of months food insufficient in last year			0.99	0.95-1.02
	Adult equivalent per capita food expenditure			1.00	0.99-1.00
	Received Thriposha in the last 6 months			1.27	0.88-1.81
Number of observations (N)		**3,885**		**3,536**	

[1] Results of the multiple logistic regression analysis are given as adjusted odds ratios (aOR), with 95% confidence intervals (CI). For non-categorical variables, the aOR represents the increase in relative risk of LBW per unit increase in the variable. Asterisks indicate significance of adjusted odds ratios: * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

[2] Reference categories are 24-49 years (for maternal age), no schooling (for maternal education), poorest quintile (for household wealth), Buddhist (for maternal religion), and urban (for sector).

[3] Births taking place in tsunami-affected households in the six months following 2004 Tsunami.

[4] Blood haemoglobin was measured at time of interview, which is after pregnancy.

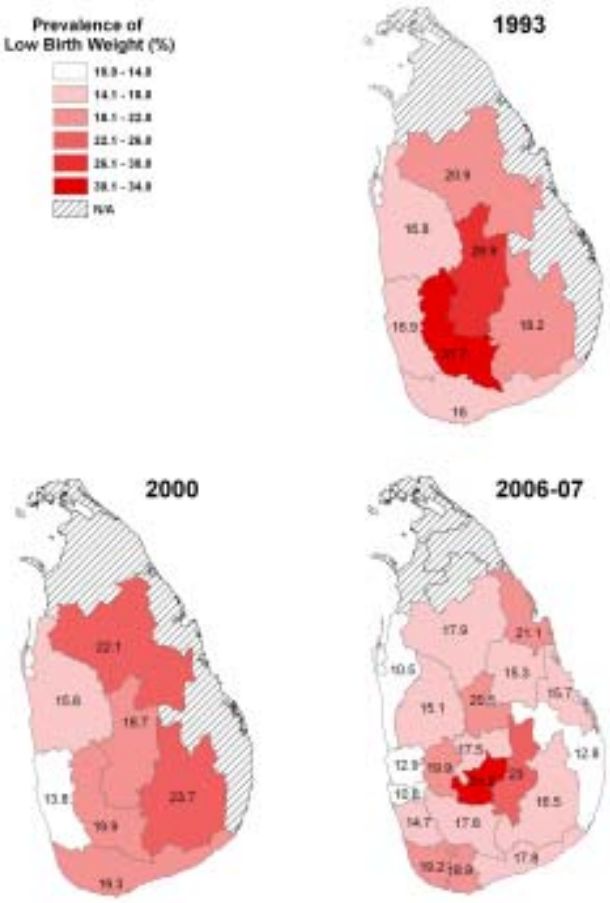

Figure 1. **Geographical prevalence of low birth weight (%), DHS 1993, 2000 and 2006-07**
Source: Authors' estimates based on geographical areas represented in each survey's design.

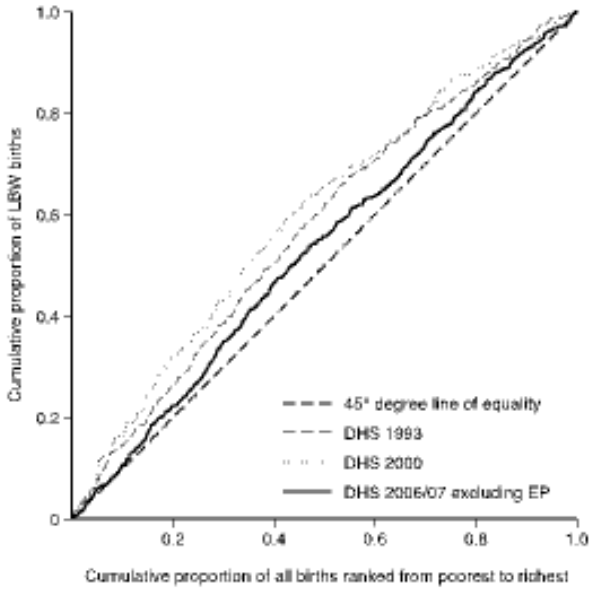

Figure 2. **Concentration curves for low birth weight, DHS 1993, 2000 and 2006-07**

LBW risk increases with maternal hypertension, reduced maternal education, and with reduced female autonomy, confirming other South Asian research [14]. There was an increased risk in tsunami-affected pregnancies (potential cause of maternal stress), and if the mother takes medications for asthma (proxy for asthma), although the coefficients were not significant at 5%.

Once these determinants are controlled for, household wealth and sector have no independent influence on LBW risk. As illustrated by Models A and B, the impact of household wealth is eliminated when controlled for maternal height and BMI. This suggests that the largest part of the influence of economic status on LBW incidence is via access to food (mean BMI increases by 3.3 units from the poorest to richest quintiles), and via its correlation with maternal height, which increases by 3 cm between the poorest and richest quintiles. In addition, having controlled for altitude and other factors, estate sector residence is associated with a reduced LBW risk, but being Indian Tamil remains associated with an increased risk (OR=1.84).

We similarly analysed the NFSS 2009 survey, which contains fewer variables, but has other variables related to household food security. The results of this are comparable (Table 4), and the final model is well calibrated (Hosmer-Lemeshow statistic 1.395, p=0.188). The highly significant odds ratio for estate residence is likely confounded by the omission of ethnicity, which is not available in the NFSS. However, none of the added food security variables are significant, including an increased risk of LBW associated with receiving 'Thriposha' in the past six months, which may reflect the targeting of 'Thriposha' to mothers at higher risk of LBW. The absence of the expected relationships may be because these indicators are not good measures of food security during the relevant pregnancy, since the impacts of maternal height and BMI are comparable to the DHS data.

To assess the relative contribution of the determinants to the economic inequalities, we analysed the CI in the DHS 2006/07, using the method of decomposition that exploits the mathematical property of the CI that it can be decomposed into a linear combination of concentration indices of its determinants [15]. This found that the largest single contribution (21%) was made by maternal BMI, with other significant contributions being by infant and birth factors (15%), maternal education (14%), wealth quintile (14%), maternal height (12%), ethnicity (9%) and altitude (7%).

Discussion

LBW incidence has declined in Sri Lanka to 17%. In the richest households, rates are comparable to the

10-11% seen in UK-born South Asian mothers, suggesting that these households have closed the gap with their UK peers [16]. However, significant social inequalities in LBW exist, and some have worsened. Incidence is highest in the poor and Indian Tamils.

Our analysis identifies several factors that independently increase the risk of LBW. Some of these, such as multiple pregnancy or altitude, are not amenable to intervention. The critical determinants are maternal BMI, height and education. The impacts of maternal BMI and height are substantial, and controlling for them largely eliminates the association of LBW with poverty, and substantially reduces the risk associated with Indian Tamil ethnicity.

The BMI results imply that poverty leads to increased LBW through the mechanism of food insecurity, with poorer households having less adequate intake of food. Government food transfers, including 'Thriposha' for mothers, target poor families, but the results indicate these do not adequately mitigate food insecurity. This suggests the need for substantial changes in the effectiveness of these programmes, and for research into why recent economic growth has not translated into improved food security for the poorest.

Maternal height is a marker for the nutritional conditions that the mother was born in. Global evidence shows that inter-generational effects have large impacts on LBW, especially in poor settings, mediated by epigenetic mechanisms [3]. Although short stature, poverty and altitude explain a large part of the increased LBW incidence in Indian Tamils, a significant independent risk remains. This may be rooted in the colonial system of indentured labour that brought Indian Tamils to Sri Lanka in the 19th century, which targeted the poor and destitute. These effects and the persistence of a higher LBW incidence in South Asians in UK suggest that LBW incidence will change slowly, and that sustained, scaled-up and targeted efforts are needed to reduce future LBW incidence in Sri Lanka [16].

Finally, the country needs to systematically track LBW incidence and determinants, including preterm birth, which we could not assess. Given Sri Lanka's circumstances, the country should emulate advanced nations by recording BW in the birth certificate, and making such data available for analysis.

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