ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 13
No.5December 2013
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

FIGHTING UNDERNUTRITION AND CHILD MORTALITY IN SIERRA LEONE

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ABSTRACT

This study has analysed the determinants of child undernutrition and mortality in Sierra Leone with the objective of identifying key predictors to advise policy. It utilises the country's Demographic and Health Survey 2008. The estimation of the empirical model employs a seemingly unrelated regression (SUR) technique and probit framework. The predictors of undernutrition found most significant are: mothers' education; housing environment measured by household density, accommodation capacity and sanitary condition; regional development differentials; having vegetables in the diet for mothers and children; and immunization. The predictors found significant for tackling mortality are: mothers' education; household density; recognition of gendered differential needs for children; nutritional deficiency; micronutrient supplement; and postnatal care. The policy simulations demonstrate that focusing policy on these factors could immensely help address child growth problems in the country. More particularly, the paper suggests the need for a greater focus on supporting mothers' education and strengthening public health in childcare management. That, while modern medicine is always crucial, it can be perceived only as bolstering good natural practices in caring for children. It is noted that children that are chronically undernourished can resist episodic sources of undernutrition more strongly than those that have not been undernourished before. This supports the argument that while 'vulnerability' and 'poverty' are closely related concepts, they are separable from a static and dynamic point of view; the former measures the probability of becoming poor due to exposure to shocks even if one is currently better-off, or the probability of becoming poorer for those that are already poor. Child wasting appears closer to vulnerability than stunting, which is mainly noted with those already in poverty. Therefore, policies should target both urban and rural settlers—the former are characterised in this study by higher incidence of child wasting (acute undernutrition) while the latter are characterised by higher incidence of stunting (chronic undernutrition). The study does not find any strict linearity in the expectation of the distribution and dynamics of the effects of nutritional deficiency and morbid episodes across the socioeconomic groups analysed, thereby evincing the need for careful policy targeting. The four regions of the country should be evaluated carefully in policy targeting processes, given that there are urban poverty pockets as well as rural poverty pockets.

Keywords: Undernutrition, Childcare, Cognitive Capacity, Productivity

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INTRODUCTION

Nutritionis a crucial development dimension and should, therefore, be central to any well thought out strategy for poverty reduction. Although the nutritional factor is often neglected in poverty policy discourses, its loading on human development is substantial and has had a long history of evidence-based conclusions [1 2].In Britain, the great decline (80 to 90 percent) in mortality from infectious diseases between the mid-19th century and the first half of the 20th century was largely attributed to improved nutrition[2]. Medical interventions like vaccinations and antibiotics had not been introduced until the 1940s and 50s[2, 3].These facts underscore the criticality of public health and the need to promote knowledge about nutritional alternatives at the community level, including the incorporation of the traditional epistemein healthcare systems [4,5].

This paper aims to pinpoint key policy areas to tackle child undernutrition and mortality in Sierra Leone by analysing their determinants. The rest of the paper is organised as follows: the next two sub-sections present a conceptual framework of the causes and effects of undernutrition, empirical evidence, and some facts about the nutrition situation in Sierra Leone. Section 2 presents the research materials and methods. Sections 3 and 4 present results and their discussion. Section 5 concludes the paper.

A Conceptual Framework and Empirical Evidence

Undernutrition is a negative health condition resulting from insufficient food and the manner and context in which food, care, health is managed. It encapsulates issues of affordability, availability and information regarding access to food in the right quantity and quality, and the process and methods of administering food in a given environment. Figure 1 depicts a cause-effect construct of undernutrition for a poor country. At the household level, the causes of undernutrition range from low household income and poor housing environment, to high dependency ratio; at the community level, they range from long distances to health facilities, to limited livelihood alternatives; at the regional level, the causes include uneven distribution of resources and weak administrative governance; while at the national level, they include ineffective macroeconomic policies and lack of political will[2].Consequently, undernourished populations shall be exposed to high risks of diseases, child mortality and impairment of the intellectual potential of children [2].

Empirically, the poverty scholarship has experienced burgeoning analytic works on the determinants of undernutrition and child mortality. Various regression frameworks have been utilized in this direction. This paper has reviewed empirical works on Uganda, India, Zambia, Sri Lanka, Malawi and cross-country studies that found various factors significant in explaining child undernutrition and mortality [6, 7, 8, 9, 10, 11, 12, 13, 14, 15]. Among these factors are: mothers' education; maternal age; housing, water and sanitation situation; household density; energy used for cooking; geographic location of households; household wealth; pre-/postnatal care; deliveries

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ISSN 1684 5374

attended by professionals; price of food; supply of micronutrients; gross domestic product; and health expenditure.

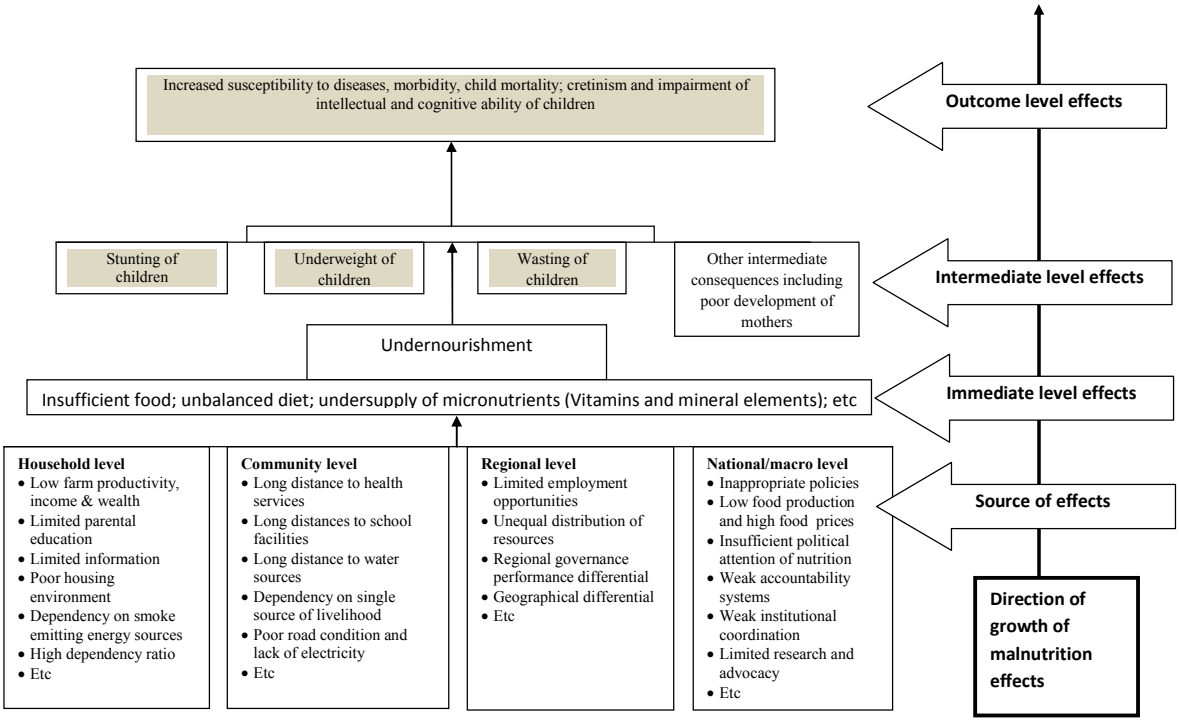

Figure 1: Causes and consequence of poor nutrition

Undernutrition and the Sierra Leone Economy

For a considerable period up to 2006, Sierra Leone was losing an estimated amount of over US$28 (estimate) million in GDP to vitamin and mineral deficiencies annually [15, 16, 17]. During this period, "scaling up core micronutrient interventions would cost less than US$4 million per year" [17]. The net present value of productivity losses resulting from stunting over a period of five years since 2003 was estimated at $41.5 million for Sierra Leone [18]. Deaths due to undernutrition are currently estimated at 26 per 100,000 live births, ranking the country 15th out of 192. While the impact of undernutritionon wellbeing dimensions such as national productivity has been analyzed by some studies on Sierra Leone, in-depth analysis of the predictors of undernutrition are yet to be discovered, a critical gap this paper attempts to fill [16, 17, 18].

MATERIALS AND METHODS

Specification of the regression model

The theoretical foundation of the estimation model draws from various scholarly constructs [11, 19, 20, 21, 22]. In the least developed nations, the average household is challenged by having to address simultaneous welfare problems including nutrition

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and health decisions in the optimisation of its utility function. These decisions underlie the operational regression framework for this paper specified as follows:

Undernutrition equations

$$\text{Height-for-age:}\quad Z_{1jk} = \Delta_1 + \gamma_1 \omega_1 + e_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

$$\text{Weight-for-age:}\quad Z_{2jk} = \Delta_2 + \gamma_2 \omega_2 + e_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

$$\text{Weight-for-height:}\quad Z_{3jk} - \Delta_3 + \gamma_3 \omega_3 + e_3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

Mortality equations

$$\text{Infant mortality:}\quad H_{1jk} = \pi_1 + \cap_1 \emptyset_1 + \tau_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

$$\text{Under-five mortality:}\quad H_{2jk} - \pi_2 + \cap_2 \emptyset_2 + \tau_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 5$$

The dependent variables,Z_{1jk}, Z_{2jk}, and $Z_{3jk}$are Z-scores, measuring stunting, underweight and wasting, respectively. These are commonly used in the literature as guided by international organisations like WHO. A child is said to be severely undernourished if it has a Z-score of less than -3.0; moderately undernourished if -3≤Z-score<-2; it experiences mild undernutrition growth if Z-score≥-2. The dependent variables,$H_{1jk}$and H_{2jk} denote infant and under-five mortality probabilities, respectively, taking value 1 if a child born in the previous five years at the time of the survey died before its first birthday (H_{1jk}) or died during the course of this reference period (H_{2jk}); they take value 0 otherwise [14]. The terms ω'sand Ø's in the equations are vectors of independent variables. The e's and $\tau's$are errors, while the rest are parameters to estimate.

Explanatory variables (predictors)

The relevant variables considered at *household level* for this paper are*:* mothers' education; maternal age; wealth level of the household; sex of child; birth order and household density(capturing resource distributional effect on child development); housing environmental variables (toilet facilities; cooking energy; material used for house flooring; and household accommodation capacity. Variables at the c*ommunity level* are*:* source of drinking water; employment status of mothers to control for effects of availability of economic opportunities in the communities. At the *regional level,* dummies are considered for the geographical location of households. Policy variables at *national level* include*:* adoption of family planning methods; supply of micronutrients for pregnant women, mothers and children; having vegetables in the

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ISSN 1684 5374

diet for mothers and children; professional birth attendance; malaria treatment for pregnant women; vaccination; breastfeeding; and access to communication facilities. Undernutrition measures are included in the mortality equations to capture direct effect of nutritional deficiency and effect of nutritional covariates that are not explicitly modelled [13].

Analytical techniques and survey data used

To enhance the identification of key policy areas for child development, the initially identified predictors are subject to factor analysis to reduce the number of independent variables to a parsimonious sub-set before applying regression methods[23]. (See Tables 2& 3 for descriptive statistics of the regressors). A Breusch-Pagan test is carried out to find out whether cross-equation error correlation among the undernutrition equations Z_1, Z_2, and Z_3exists. This is important to investigate the possible incidence of heteroscedasticity, an econometric problem that is common in household data. Since the data suggest the presence of such correlations, a seemingly unrelated regression (SUR)—a generalised least squares technique—is applied in the estimation of the undernutrition models[24]. A probit model is fitted in the estimation of the morality equations. The Sierra Leone Demographic and Health Survey 2008 (DHS2008) is used. The survey collected information on 7,374 women (15-49 olds) and 3,280 men (15-50 olds). The study focuses on children under five years of age within the survey period, precisely those born within the period January 2003—November2007.There are a few continuous variables in the analysis; most are discrete given the nature of the research.

RESULTS

Descriptive Analysis of Incidence of Child Undernutrition

Table 1 describes the nutritional status of 2189 children. At national level, 18.14% of the children were severely stunted and 16.49% moderately stunted, leaving the total prevalence at 34.63% (Table 1 and Figure 2).About 2.19 and 7.22%were severely and moderately wasted respectively. The severely underweight were 6.67%, while 19.64%were moderately underweight. For stunting (a measure of chronic undernutrition), regionally, the north accounted for the highest incidence (39.95%), followed by the south (36.54%). This incidence appears more of a rural phenomenon (at 38.61%) than an urban one (at 26.37%). About 38.35% of the children in houses with dirt/mud floors experienced chronic undernutrition. The incidence for children born to mothers not listening to radio and owning mobile phones ranges from 36 to 38%. The statistics are also sizeable for children in communities fetching drinking water from unprotected sources, mothers with no education, poorest wealth quintile households, and households using firewood for cooking (Table 1).

Regarding child wasting, it shows generally that those born to mothers with low level of education were thinner than those to mothers with higher education. Child wasting also appears as a key function of mothers not having access to communication gadgets such as radio and telephones, and household with dirt/mud floored houses, and children living in the poorest wealth quintile families. The theory is somewhat

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reversed comparing urban incidence of wasting to rural incidence, the former registering higher incidence at 11.08% on aggregate than the latter (8.60%). The west (despite the expected socio-economic advantage of the capital city of Freetown) registered higher incidence than the provincial north and east. It is also counterintuitive that households in communities with better sources of drinking water do not seem to be better-off in terms of wasting incidence than those in communities with unprotected sources. For wasting, the differential incidence between the richest and poorest wealth households is not as striking.

The incidence of underweight closely tracks stunting, as a composite measure of the latter and wasting. More underweight was reported for: mothers with no education; poorest wealth quintile households; communities with unprotected drinking water; using firewood for cooking; born to mothers not listening to radio and possessing mobile phones; and households located in the rural areas, and in the north and southern regions.

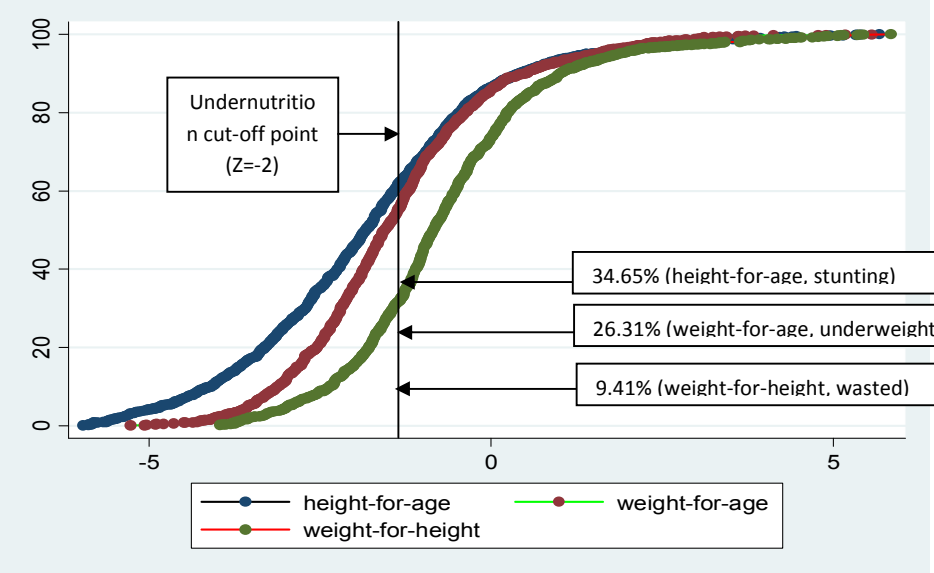

Figure 2: Share of child population that was undernourished, 2008

Descriptive Analysis of the Incidence of Childhood Mortality

At national level, based on a sample of 5455 children, the infant mortality rate is estimated at 83.00 deaths per 1000 live births; under-five mortality at 110.20 deaths per 1000.Table 2 suggests for the infants that, the probability of those dying was higher where they were not breastfed, where vegetables were not part of their diet, and where they never received vaccination, with estimated probabilities of 0.2563, 0.1666, and 0.1248, respectively; for the under-fives, the estimates are 0.3116, 0.2195 and 0.1656, respectively. That is, the infant mortality stood at 256.3, 166.6 and 124.8 deaths per 1000 births, respectively, while the under-fives' correspondingly stood at 311.6, 219.5 and 165.6 deaths (all above the national average). The mortality rates for

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infants in the western region, those associated with professionals not attending deliveries, and those relating to the poorest wealth quintile, are estimated at 100.00, 94.60 and 96.40 deaths, respectively; the rates for under-fives are correspondingly estimated at 131.8, 119.9 and 119.3 deaths. Higher rates are estimated for the urban than rural areas—for the urban areas, the infant and under-five mortality estimates are 89 and 126.6deaths, respectively; while the corresponding estimates for the rural areas are 79.7 and 118 deaths. There is no striking differential for the under-five mortality between the richest wealth quintile and the poorest wealth quintile, at 118.6 and 119.3 deaths, respectively. The difference in infant mortality between these two categories is estimated at 14.6 deaths in favour of the rich, with total infant deaths of 81.8.

Determinants of Child Undernutrition at National Level

From the regression results in Table 4, six regressors are noted as the most significant predictors of undernutrition: mothers' education; the number of rooms in the household; household size; regional/residential location of the households; having vegetables in the diet for mothers and children; and vaccination. Locational differentials particularly appear as strong predictors. Estimates suggest generally that rural children were about 0.50 points worse in undernutrition z-scores than urban children. The north is significantly worse than the east as base outcome in relation to stunting, the south and west showing no significant differential. The average differentials across the three measures (stunting, underweight and wasting), however, suggest that children in the west were worse by 0.50 points in scores relative to those in the east than as compared between the latter and the north (0.37) and the south (0.38)—the average coefficient for the west is -0.539; the south is -0.453 and the north is -0.551, relative to the east. The impact of education is the second highest in the stunting regression—children born to mothers with education beyond primary were 0.43 points better-off than those to mothers without education. They were 0.23 points better-off in terms of underweight. Children with vegetables in their diet and the diet of their mothers were 0.23 points less likely to be undernourished in relation to stunting and underweight. Children receiving vaccination were0.16 points less likely to be underweight and wasting. Nutritional status scores on account of these two measures tends to decline by 0.03 points for every additional person to the average household, while it tends to improve by 0.06 on account of stunting and underweight for every additional bed room to the household. Children in households where streams and bush were used as toilet were0.19points more likely to be chronically undernourished than those with better sewage disposal system.

Determinants of Child Undernutrition at Rural and Urban Level

The estimates from Table 4suggest that children located in western rural district were much worse (by 0.58 points) in terms of underweight and wasting scores relative to those in the eastern rural, than between the latter and the north (0.35) and the south (0.30).

The coefficient on vegetables dummy is highly significant for the rural area with reasonable magnitude compared to its urban counterpart. Vaccination appears with higher loading on rural areas than in the urban areas in terms of wasting and

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ISSN 1684 5374

underweight. Household accommodation capacity and size seem to be more of an issue in the urban areas than in the rural areas for childcare. Stunting due to households using streams and bush as toilet comes out as particularly an urban phenomenon, bearing the largest differential coefficient (1.23) in all six decomposed models (Table 4). Employment of mothers comes out significant only for the urban areas and in the stunting equation with the expected sign. It is counterintuitive that children born to mothers making efforts to delay pregnancy or adopt some form of family planning appear to be 0.81 points more chronically undernourished and 0.47points more likely to be underweight. The age of mothers comes out significant only in the rural setting with expected sign that maturity and experience count in child management. In all nine but one estimation cases for undernutrition, the models have been jointly significant on account of the chi-square statistics in Table4.

Determinants of Childhood Mortality

A probit model was fitted here and all coefficients are marginal effects evaluated at the means of the predictors except for the constant term (Table 4). While all three nutritional measures are consistently significant in explaining infant and under-five mortality in the six mortality regressions at national, rural, urban level, except in one, only the underweight shows expected sign; effects of stunting and wasting are counterintuitive, probably captured in the underweight as composite measure of the latter two. It suggests that a one percentage point decrease in child underweight increased the chance of infant and under-five survival by 3.1% and 3.7%(national level); 3.0 and 3.3%(rural level). At urban level, only the under-five case is significant with a chance of reduction of 4.1% if child underweight is decreased by one percentage point. The low marginal effects suggest that there are other factors other than reducing undernutrition that are worthy of consideration in efforts to increase child survival. Availing children of postnatal care appears to significantly increase chances of survival at all three levels investigated for both infants and under-fives. The survival rates range from 2.6% for urban infants, to 4.4, 4.6 and 4.9% for under-five for rural, national and urban respectively. Postnatal care for mothers is significant but counterintuitive, suggesting a need to improve on the clinical and treatment methods [4]. Children born to mothers supplied with vitamin A appear to have greater chances to survive at all levels. There is not much visibility of differentials regionally for childhood mortality except somewhat between the west and the east. Consistency in terms of significance(but not direction)is maintained on the mothers' employment dummy for the urban areas compared to its counterpart in the undernutrition regression above.

The coefficient on the sex dummy indicates that the girl child had higher chances of survival especially in the urban areas than the boy. The dummy on children born to households using streams and bush as toilet facility comes out significant in one out of six estimations (in the urban regression) but with counterintuitive sign, thereby reinforcing the seemingly non-strict linearity of effects between undernutrition and childhood mortality. An increase in household size had significant negative effects on child survival, although the probabilities appear very small, and it is more pronounced

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for the rural areas. The effect of mothers' education is as expected on child survival, with higher loading for rural areas than urban areas (Table 4.)

Some Simulated Effects

Table 5shows projected reductions in child undernutrition and mortality due to changes in selected predictors. For undernutrition, the underweight regression model is used in the projection as a composite index of stunting and wasting, and it fits best. Effect of mothers' education, household size, vegetable consumption, vitamin A supplement, and postnatal care for children are simulated. Improving mothers' education and downsizing household density appear to have an outstanding reducing effect on undernutrition overtime if the share of the educated mothers beyond primary is drastically increased from its current average of 13.33% (sample estimate) and household size reduced from its current sample average of about 7 persons. This is more plausible at national and urban level; estimates for the rural areas are marginal. Increasing vegetables in the diet for mothers and children appears to have more impact in the rural areas overtime. (Table5.)The projections indicate for the short run that, policies to improve Vitamin A supplement and postnatal care are more likely to reduce child mortality than investment in education and reducing household density—the effects of investment in the latter factors appear to be mainly long-term in nature (see estimates in Table 5).

DISCUSSION

It appears that stunting and wasting have some divergent structural profile. Stunting is the chronic dimensional aspect of undernutrition, seemingly permanent and structural in nature and appears to be more of a rural phenomenon. Wasting (thinning) seems transitory and episodic and could affect even the better-off. This evidence suggests the need for holistic and integrated sectoral and multilevel policy approaches to tackling undernutrition [25]. Wasting appears to be an urban phenomenon according to the results, reflecting the widespread poverty pockets often found in and around Third World cities. This lends support to theoretical arguments on urbanization in the Third World, where cities and the periphery are expanded due to influx of low skilled persons, driven by migrant decisions outside firm economic rationality. The consequences are the emergence of slums and shanty towns and single parent households. It cannot be unexpected, therefore, that, in times of economic crises, food affordability in urban settings could be a lot more situational than in rural areas.

From the results, the mortality estimates do not seem to conjure a strict linear logic and characterisation across socioeconomic groups, as well as in respect of the estimates and distribution of undernutrition incidences across these groups. For reasons alluded to earlier, mortality figures being higher for the western region (besides being the location of the capital city) is unexpected but can be explained, as a home to many impoverished pockets most of whom are legacies of the civil war and rural-urban migration with low employability. The dependency rates can be fairly high in these households with attendant negative effects on childcare, having to

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spread resources thinly *inter alia*. The results suggest some differentials in the immune system of children across groups in terms of the time lapse that the effects of incremental nutritional deficiency or related health risks could take to cause deaths. It suggests those effects could stay longer in chronically undernourished children than those not chronically undernourished. It appears undernutrition needs to be catalysed by other morbid situations to enforce deaths on children in certain instances.

The significance of the dummy on the inclusion of vegetables in the diet of rural children in the regression estimates is consistent with Babu's advocacy for Vitamin A and C rich *moringaleaves* for the poor in rural Malawi [26]. The counterintuitive outcome on the contribution of family planning to child development is difficult to explain, but a plausible reason for the negative coefficient could be gleaned from the methods of the family planning practised and its side effects on children.

Contrary to expectation but not uncommon in contemporary research is the evidence that all nine undernutrition regressions (national, rural and urban) do not reveal significant differentials between children born to poor wealth-quintile households and those to rich wealth-quintile households. There is sizeable literature that income and wealth do matter to meet health and nutritional needs, but other factors such as information dissemination on preventive healthcare and nutrition through robust public health programmes could matter most [2, 4, 6, 7, 9, 11]. Given the expected correlation between education and wealth, and wealth and other development variables, the effect of wealth may have passed through education and other significant covariates to affect undernutrition in this study. It is a general limitation is carrying out such analysis that welfare indicators are generally closely correlated [23] and thus conclusions could be useful but must be treated with a caveat.

The counterintuitive result revealed in the regression estimation regarding parental employment is also not expected but can be plausibly explained. While chances for better childcare can be enhanced through parental employment and increased income, there can be serious detrimental effects on children due to mothers spending out long time at work. This effect could bypass undernutrition symptom to become manifest only at critical life threatening stage due to improper day-care arrangement. On the other hand, employed mothers may not necessarily imply more wealth than those not employed—the survey reveals that the average wealth factor score for unemployed mothers is fivefold more than that for the employed.

CONCLUSION

Within the limitation of the data used in this analysis and model techniques employed, the most outstanding inference from this study is the need to focus policy on promoting public health and mothers' education in addressing nutritional deficiency and child mortality in Sierra Leone. This is also highly recommended for other developing countries [2, 4, 5, 6, 7, 9, 11, 26]. There is need to improve information dissemination on good behavioural practices and cost-effective nutritional alternatives to ensure optimal and sustainable childcare. Modern medicine is always critical but

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can be perceived as only bolstering good natural practices for childcare. The paper depicts that children that are chronically undernourished could resist episodic causes of undernutrition than those who have not been undernourished before. While not all children could currently be undernourished, all could be vulnerable to undernutrition [27, 28, 29]. Policies should, therefore, be focused on both the rural and urban settlements characterized in this study by chronic undernutrition and thinning, respectively, and there is need for considering regional specific development circumstances in policy targeting.

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Table 1: Malnutrition and child mortality by socio-economic characteristics

Variable/Indicator	Height-for-Age Z-scores			Weight-for-Age Z-score			Weight-for-Height Z-scores			Childhood Mortality Incidence			
	< -3	-3 to -2	≥ -2	< -3	-3 to -2	≥ -2	< -3	-3 to -2	≥ -2	Surviving infant	Deceased infant	Surving under 5	Deceased under5
Total sample	**18.14**	**16.49**	**65.37**	**6.67**	**19.64**	**73.69**	**2.19**	**7.22**	**90.59**	**91.70**	**8.30**	**88.98**	**11.02**
No of observations	**397**	**361**	**1431**	**146**	**430**	**1613**	**48**	**158**	**1983**	**5002**	**453**	**4854**	**601**
Individual and household characteristics													
Education: mothers with no education	19.48	17.81	62.71	7.66	21.20	71.14	2.20	7.30	90.50	91.65	8.35	89.14	10.86
Education: mothers with primary education	18.22	12.71	69.07	5.08	16.95	77.97	4.24	5.93	89.83	91.05	8.95	87.88	12.12
Education: mothers with higher education	9.67	11.52	78.81	1.86	12.27	85.87	0.37	7.81	91.82	92.59	7.41	89.17	10.83
Economic wellbeing: Poorest wealth quintile	19.38	16.04	64.59	8.46	19.60	71.94	2.45	8.46	89.09	90.36	9.64	88.07	11.93
Economic wellbeing: Richest wealth quintile	9.83	12.64	77.53	4.49	11.80	83.71	1.40	9.27	89.33	91.82	8.18	88.14	11.86
Toilet: not having flush facilities	18.46	16.67	64.87	6.85	20.07	73.09	2.03	7.13	90.60	91.70	8.30	89.02	10.98
Housing: Dirt or mud for flooring	20.71	17.64	61.65	7.74	21.34	70.92	2.58	7.53	89.89	91.65	8.35	89.26	10.74
Housing: Cement/improved material for flooring	13.25	14.30	72.45	4.64	16.42	78.94	1.46	6.62	91.92	91.87	8.13	88.50	11.50
Energy: fuelwood for cooking	19.29	16.67	64.04	7.00	20.88	72.12	2.26	7.20	90.53	91.69	8.31	89.10	10.90
Community level characteristics													
Employment opportunities: mothers employed	13.79	18.55	67.66	3.87	17.02	79.11	0.24	3.39	95.81	91.29	8.71	88.70	11.30
mployment opportunities: mothers not employed	13.39	14.41	72.20	2.20	13.56	84.24	0.51	2.03	97.46	91.93	8.07	89.14	10.86
Water: surface, unprotected well & spring	19.98	17.11	62.91	6.98	21.41	71.61	1.82	6.31	91.87	92.39	7.61	90.06	9.94
Water: better sources	16.45	15.92	67.63	6.39	18.02	75.59	2.54	8.05	89.41	91.09	8.91	88.04	11.96
Regional and residential factors													
Rural	21.54	17.07	61.38	7.25	22.36	70.39	1.96	6.64	91.40	92.03	7.97	89.82	10.18
Urban	11.08	15.29	73.63	5.47	14.03	80.50	2.66	8.42	88.92	91.03	8.97	87.34	12.66
East	14.54	16.64	68.83	5.08	17.86	77.06	2.63	5.43	91.94	92.93	7.07	90.20	9.80
North	21.90	18.05	60.05	8.45	22.66	68.89	1.92	6.15	91.93	91.99	8.01	89.15	10.85
South	21.08	15.46	63.45	7.83	19.68	72.49	2.21	10.84	86.95	91.11	8.89	88.89	11.11
West	11.21	14.16	74.63	3.54	15.63	80.83	2.06	7.37	90.56	90.00	10.00	86.82	13.18

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AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
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PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 1: Malnutrition and child mortality by socio-economic characteristics (contd.)

Variable/Indicator	Height-for-Age Z-scores			Weight-for-Age Z-score			Weight-for-Height Z-scores			Child Mortality Incidence			
	< -3	-3 to < -2	≥ -2	< -3	-3 to -2	≥ -2	< -3	-3 to -2	≥ -2	Surviving infant	Deceased infant	Surving under5	Deceased under5
Macro level policy related characteristics													
Vaccination: children receiving vaccination	13.24	16.47	70.29	2.94	15.44	81.62	0.29	3.24	96.47	100.00	0.00	100.00	0.00
Vaccination: child not receiving vaccination	13.91	17.65	68.43	3.57	16.17	80.26	0.35	3.39	96.26	87.52	12.48	83.44	16.56
Professional assistance at deliveries	12.33	16.67	71.00	3.00	13.89	83.11	0.11	4.33	95.56	93.04	6.96	90.11	9.89
Professional assistance absent as deliveries	14.95	17.74	67.31	3.66	17.85	78.49	0.54	2.37	97.10	90.54	9.46	88.01	11.99
Communication: listening to radio	16.16	17.15	66.69	5.41	18.29	76.29	1.80	6.48	91.71	91.78	8.22	88.75	11.25
Communication: not listening to radio	20.62	15.67	63.71	8.25	21.34	70.41	2.68	8.14	89.18	91.63	8.37	89.16	10.84
Communication: having mobile phone	12.79	14.29	72.92	4.32	16.11	79.57	1.83	7.31	90.86	88.75	11.25	87.98	12.02
Communication: does not have mobile phone	20.16	17.33	62.51	7.56	20.98	71.46	2.33	7.18	90.49	89.16	10.84	89.37	10.63
Vegetable intake: part of diet previous day	12.61	17.66	69.73	3.06	15.95	80.98	0.14	3.42	96.44	95.01	4.99	93.32	6.68
egetable intake: not part of diet previous day	17.14	15.73	67.14	4.23	15.73	80.05	0.94	3.05	96.01	83.34	16.66	78.05	21.95
Breast feeding: child breast fed	13.78	17.38	68.84	3.48	15.76	80.77	0.3	3.36	96.35	93.82	6.18	91.46	8.54
Breast feeding: child not breast fed	12.42	15.53	72.00	1.86	17.39	80.75	0.62	3.11	96.27	74.37	25.63	68.84	31.16

Author's construct based on DHS 2008

DHS 2008 HAS A REF. NO?

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AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 13
No.5December 2013
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 2: Descriptive statistics of variables considered in the malnutrition model

Variable	Obs	Mean	Std. Dev.	Min	Max
Mothers attaining Primary Education	1830	0.759	0.428	0.000	1.000
Mothers attaining Primary Education	1830	0.108	0.310	0.000	1.000
Mothers attaining Higher Education	1830	0.133	0.340	0.000	1.000
Wealth poor households	1830	0.393	0.489	0.000	1.000
Household size	1830	7.110	3.054	2.000	20.000
Number of rooms in the household	1830	2.997	1.793	0.000	22.000
Whether stream or bush is used as toilet	1830	0.235	0.424	0.000	1.000
Age of mother	1830	29.305	6.886	15.000	49.000
Whether mothers employed	1830	0.678	0.468	0.000	1.000
Rural location	1830	0.666	0.472	0.000	1.000
Eastern regional location	1830	0.273	0.446	0.000	1.000
Northern regional location	1830	0.360	0.480	0.000	1.000
Southern regional location	1830	0.212	0.409	0.000	1.000
Western regional location	1830	0.155	0.362	0.000	1.000
Whether vitamin A given to children	1830	0.273	0.445	0.000	1.000
Whether vitamin A given to mothers	1830	0.767	0.423	0.000	1.000
Whether mothers adopt family planning method	1830	0.061	0.240	0.000	1.000
Vaccination of children	1830	0.372	0.483	0.000	1.000

Author's construct based on SLDHS2008

SLDHS = Sierra Leone Demographic and Health Survey
Obs.=observation;
Std. Dev.=Standard Deviation ;
Min.=Minimun ;
Max.=Maximum

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AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
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PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 3: Descriptive statistics for variables considered in the mortality model

Variable	Obs	Mean	Std. Dev.	Min	Max
Mothers attaining Primary Education	2507	0.764	0.425	0.000	1.000
Mothers attaining Primary Education	2507	0.114	0.317	0.000	1.000
Mothers attaining Higher Education	2507	0.122	0.327	0.000	1.000
Wealth poor households	2507	0.399	0.490	0.000	1.000
Household size	2507	7.380	3.223	2.000	20.000
Number of rooms in the household	2507	4.199	10.415	0.000	99.000
Whether stream or bush is used as toilet	2507	0.248	0.432	0.000	1.000
Age of mother	2507	29.180	6.822	15.000	49.000
Sex of child	2507	0.511	0.500	0.000	1.000
Whether mothers employed	2507	0.680	0.466	0.000	1.000
Rural location	2507	0.667	0.471	0.000	1.000
Eastern regional location	2507	0.251	0.434	0.000	1.000
Northern regional location	2507	0.356	0.479	0.000	1.000
Southern regional location	2507	0.237	0.425	0.000	1.000
Western regional location	2507	0.156	0.363	0.000	1.000
Whether vitamin A given to children	2507	0.249	0.432	0.000	1.000
Whether vitamin A given to mothers	2507	0.367	0.482	0.000	1.000
Whether mothers adopt family planning method	2507	0.061	0.239	0.000	1.000
Vaccination of children	2507	0.341	0.474	0.000	1.000
Postnatal care for mothers	2507	0.426	0.495	0.000	1.000
Postnatal care for children	2507	0.251	0.434	0.000	1.000
Height-for-age	2507	-1.789	1.875	-5.960	5.680
Weight-for-age	2507	-1.396	1.490	-5.270	5.790
Weight-for-height	2507	-0.697	1.473	-3.960	5.840

SLDHS = Sierra Leone Demographic and Health Survey
Obs.=observation;
Std. Dev.=Standard Deviation ;
Min.=Minimun ;
Max.=Maximum

Author's construct based on SLDHS2008.

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Volume 13
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PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 4: Malnutrition and mortality regression estimates

Variables	Seeming unrelated regression (SUR) model									Probit model					
	Height-for-age			Weight-for-age			Wieght-for-height			Infant Mortality			Under-Five Mortality		
	All	Rural	Urban	All	Rural	Urban	All	Rural	Urban	All	Rural	Urban	All	Rural	Urban
Individual & household characteristics															
Mothers attaining Primary Education	0.042	-0.013	0.233	-0.038	-0.165	0.214	-0.036	-0.141	0.111	-0.004	-0.014	0.019	0.004	-0.011	0.031
	(0.129)	(0.168)	(0.202)	(0.100)	(0.125)	(0.168)	(0.096)	(0.114)	(0.176)	(0.013)	(0.015)	(0.022)	(0.016)	(0.019)	(0.029)
Mothers attaining Higher Education	0.427*	0.167	0.571*	0.230*	-0.026	0.384*	-0.018	-0.159	0.063	-0.028*	-0.036*	-0.015	-0.028*	-0.032	-0.015
	(0.130)	(0.232)	(0.159)	(0.100)	(0.172)	(0.133)	(0.096)	(0.156)	(0.139)	(0.010)	(0.012)	(0.015)	(0.014)	(0.020)	(0.021)
Wealth poor households	-0.077	-0.058	-0.034	-0.007	-0.004	0.031	0.064	0.059	0.035	0.003	0.004	0.000	0.009	0.009	0.032
	(0.097)	(0.104)	(0.298)	(0.075)	(0.077)	(0.250)	(0.072)	(0.070)	(0.263)	(0.011)	(0.011)	(0.031)	(0.013)	(0.013)	(0.046)
Household size	-0.016	-0.004	-0.030	-0.031*	-0.009	-0.056*	-0.032*	-0.014	-0.053*	0.004*	0.004*	0.002	0.004*	0.004*	0.003
	(0.015)	(0.021)	(0.023)	(0.012)	(0.016)	(0.019)	(0.012)	(0.014)	(0.020)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
Number of rooms in the household	0.058*	0.033	0.106*	0.048*	0.022	0.094*	0.022	0.006	0.048	0.000	0.000	-0.001	0.000	0.000	0.001
	(0.026)	(0.034)	(0.041)	(0.020)	(0.025)	(0.034)	(0.019)	(0.023)	(0.036)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Whether streams or bush is used as toilet	-0.191**	-0.035	-1.226*	-0.080	0.012	-0.726*	0.062	0.062	0.063	-0.008	-0.006	-0.026	-0.004	-0.002	-0.041*
	(0.111)	(0.121)	(0.308)	(0.086)	(0.090)	(0.258)	(0.082)	(0.081)	(0.270)	(0.011)	(0.012)	(0.019)	(0.014)	(0.015)	(0.025)
Age of mother				0.003	0.007*	-0.007	0.004	0.009*	-0.008	0.000	0.000	0.001	0.000	0.000	0.001
				(0.003)	(0.004)	(0.007)	(0.004)	(0.005)	(0.009)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Sex of child										0.014**	0.004	0.034*	0.014	0.006	0.033*
										(0.008)	(0.010)	(0.014)	(0.010)	(0.012)	(0.017)
Community and regional charatcerisitcs															
Whether mothers were employed	0.083	0.012	0.295*	0.031	-0.035	0.170	-0.006	-0.033	0.012	0.006	-0.014	0.035*	0.010	-0.015	0.047*
	(0.089)	(0.114)	(0.140)	(0.068)	(0.085)	(0.115)	(0.065)	(0.076)	(0.119)	(0.009)	(0.013)	(0.014)	(0.011)	(0.015)	(0.018)
Rural location	-0.590*			-0.537*			-0.248*			0.004			-0.012		
	(0.107)			(0.083)			(0.080)			(0.011)			(0.014)		
Northern regional location	-0.200*	-0.158	-0.204	-0.465*	-0.360*	-0.707*	-0.451*	-0.344*	-0.778*	0.006	0.016	-0.014	0.012	0.019	-0.002
	(0.105)	(0.123)	(0.206)	(0.081)	(0.091)	(0.172)	(0.078)	(0.083)	(0.181)	(0.012)	(0.014)	(0.018)	(0.015)	(0.017)	(0.026)
Southern regional location	0.085	0.121	-0.021	-0.304*	-0.150	-0.662*	-0.453*	-0.297*	-0.791*	0.020	0.029	-0.004	0.011	0.027	-0.021
	(0.118)	(0.142)	(0.212)	(0.092)	(0.106)	(0.177)	(0.088)	(0.096)	(0.186)	(0.015)	(0.019)	(0.021)	(0.017)	(0.021)	(0.025)
Western area location	-0.164	-0.124	-0.083	-0.533*	-0.565*	-0.569*	-0.539*	-0.588*	-0.649*	0.045	0.108**	0.016	0.046*	0.115*	0.019
	(0.139)	(0.285)	(0.173)	(0.107)	(0.212)	(0.144)	(0.103)	(0.192)	(0.150)	(0.021)	(0.058)	(0.018)	(0.023)	(0.059)	(0.023)

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AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 13
No.5December 2013
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 4: Malnutrition and mortality regression estimates (contd.)

	Seemingly unrelated regression (SUR) model									Probit model					
	Height-for-age			Weight-for-age			Wieght-for-height			Infant Mortality			Under-Five Mortality		
	All	Rural	Urban	All	Rural	Urban	All	Rural	Urban	All	Rural	Urban	All	Rural	Urban
Macro level policy related characteristics															
Whether Vitamin A given to child	-0.026	-0.027	0.017				0.020	0.035	-0.029						
	(0.075)	(0.084)	(0.149)				(0.057)	(0.065)	(0.112)						
Vitamin A supplement for mothers										-0.047*	-0.051*	-0.037*	-0.055	-0.056	-0.053
										(0.009)	(0.010)	(0.014)	(0.011)	(0.012)	(0.018)
Vegetables in the diet of mothers and children	0.231*	0.288*	0.164	0.128*	0.214*	0.000**	0.031	0.103	-0.091						
	(0.094)	(0.116)	(0.156)	(0.073)	(0.086)	(0.130)	(0.070)	(0.079)	(0.138)						
Mothers adopting family planning	-0.162	0.334	-0.815	-0.096	0.189	-0.474				0.015	0.047	-0.013	0.018	0.030	0.005
	(0.167)	(0.230)	(0.239)	(0.100)	(0.137)	(0.143)				(0.021)	(0.035)	(0.021)	(0.024)	(0.035)	(0.034)
Whether children ever received vitamin A	0.126	0.156	0.052	0.178*	0.225*	0.034	0.134*	0.169*	0.016						
	(0.088)	(0.107)	(0.157)	(0.064)	(0.076)	(0.115)	(0.066)	(0.073)	(0.135)						
Mothers receiving postnatal care										0.009	-0.009	0.041*	0.013	-0.003	0.043
										(0.009)	(0.011)	(0.018)	(0.011)	(0.013)	(0.022)
Children receiving postnatal care										-0.030*	-0.030*	-0.026*	-0.047	-0.044	-0.049
										(0.010)	(0.012)	(0.015)	(0.011)	(0.014)	(0.018)
Nutritional status (outcome															
Height-for-age										0.023*	0.020*	0.020*	0.027	0.022	0.036
										(0.006)	(0.007)	(0.010)	(0.007)	(0.008)	(0.012)
Weight-for-age										-0.031*	-0.030*	-0.020	-0.037	-0.033	-0.041
										(0.010)	(0.012)	(0.016)	(0.011)	(0.013)	(0.021)
Wieght-for-height										0.024*	0.025*	0.011	0.030	0.026	0.032
										(0.008)	(0.009)	(0.013)	(0.009)	(0.010)	(0.016)
Constant	-1.005*	-1.694*	-1.037*	-0.399*	-1.261*	0.126	0.279	-0.312	0.963*	-1.714*	-1.520*	-2.202*	-1.523	-1.437	-1.934
	(0.175)	(0.218)	(0.265)	(0.165)	(0.192)	(0.298)	(0.181)	(0.203)	(0.349)	(0.249)	(0.287)	(0.488)	(0.224)	(0.273)	(0.413)
R-square/Pseudo R-	0.058	0.014	0.074	0.075	0.033	0.097	0.043	0.037	0.068	0.073	0.085	0.124	0.066	0.067	0.108
Chi-square/wald-test	113.380*	17.170	49.560*	148.910*	45.230*	69.090*	82.630*	47.720*	44.710*	63.510*	56.510*	57.610*	72.780	51.590	52.930
No. of obs.	1830	1219	611	1830	1219	611	1830	1219	611	2507	1673	834	2507	1673	834

Source: Author's construct based on Sierra Leone DHS 2008

*Significant at 1 and 5%; ** significant at 10%

DHS=demographic and Health Survey

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 13
No.5December 2013
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 5: Projected reductions in malnutrition and child mortality due to changes in selected variables

Variables	National	Rural	Urban
Malnutrition (Underweight models)			
Mothers with higher education increased to 50% from 13.33%	13.11%	0.73%	9.57%
Mothers with higher education increased to 70% from 13.33%	18.36%	1.10%	13.45%
Mothers with higher education increased to 90% from 13.33	22.69%	1.37%	16.89%
Household size reduced by 30% (mean of 5) from 7.11 sample value	7.53%	1.83%	17.79%
Household size reduced by 43.74% mean of 4) from 7.11 sample value	11.06%	2.65%	25.86%
All mothers and children have vegetables in their diet	3.40%	4.57%	0.00%
Infant mortality (probit model)			
Mothers with higher education increased to 50% from 13.33%	0.007	0.007	0.001
Mothers with higher education increased to 70% from 13.33%	0.010	0.010	0.002
Mothers with higher education increased to 90% from 13.33	0.013	0.013	0.002
Household size reduced by 30% (mean of 5) from 7.11 sample value	0.009	0.011	0.005
Household size reduced by 43.74% mean os 4) from 7.11 sample value	0.013	0.016	0.007
All mothers receive Vitamin A	0.033	0.040	0.025
All children receive postnatal care	0.026	0.028	0.022
Under-five mortality (probit model)			
Mothers with higher education increased to 50% from 13.33%	0.007	0.006	0.002
Mothers with higher education increased to 70% from 13.33%	0.010	0.008	0.002
Mothers with higher education increased to 90% from 13.33	0.012	0.011	0.003
Household size reduced by 30% (mean of 5) from 7.11 sample value	0.010	0.011	0.009
Household size reduced by 43.74% mean os 4) from 7.11 sample value	0.014	0.015	0.013
All mothers receive Vitamin A	0.038	0.042	0.039
All children receive postnatal care	0.039	0.039	0.044

Author's construct

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