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Measuring and Mapping Undernutrition and its Determinants among Under-five Children in Odisha

Rabiul Ansary[1] and Krishna Chandra Rath*[2]

Abstract: In the last two decades, Odisha experienced sustained high economic growth and subsequent reduction in incidence of poverty. Despite that, the prevalence of undernutrition among under-five children in Odisha remains comparable to many African countries. Literature firmly establishes that adequate nutrition plays a crucial role for the early childhood development. Thus, by considering the outcome of undernutrition (stunting, underweight, CIAF), this study looks at the factors influencing its regional variation across the districts of Odisha. This paper analyses nationally representative household datasets (National Family Health Survey, 2015–16) to discern the extent of undernutrition prevalence in Odisha. Undoubtedly, Odisha has performed better in this regard than economically well off states such as Gujarat, Haryana, and Maharashtra. However, present study found evidences of regional disparity among undernourished children in Odisha and its associated factors. Our analysis illustrates spatial homogeneity in mean prevalence of undernutrition across the districts. Children in the coastal plain region are better nourished compared to the children from highland and mountainous region. In tribal dominated districts children are more vulnerable to all forms of undernutrition. In western Odisha intra-district disparity is very high in all forms of undernutrition. Our findings reveal that wealth index, child's age, mother's educational status, mother's body mass index, religion, social groups, region of residence, food security and hygiene-sanitations are significant predictors of childhood undernutrition. This study suggests comprehensive region, districts and population specific interventions to achieve child related SDGs in Odisha by 2030.

Keywords: Economic growth, Undernutrition, Regional, Tribal, Coastal, SDGs.

Introduction

Balanced nutrition allows holistic development of children, while undernutrition robs their future and leaves behind a precarious adolescent and adulthood. Balanced nutrition has multi-dimensional effects, such as meet child growth standards, develop all sphere of life, increase life expectancy and escape from nutrition induced poverty cycles. Although, nutritional deficiency affects population across the age groups, children at the early age of their development remain at higher risk (Khan and Mohanty, 2018). Malnutrition is the largest factor contributing to the global burden of disease and accounts for around half of the infant deaths (Lopez, et al., 2006; Kotloff, et al., 2013). Studies on causes and determinants of malnutrition reported multiple intertwined causes (UNICEF, 1998; Reinbott and Jordan, 2016).

The immediate cause of malnutrition is inadequate food intake which has strong positive association between consumption expenditure of the household and child's malnutrition (Torlesse, et al., 2003; Mauludyani, et al., 2014). The underlying causes include lack of

* Corresponding Author
[1] Consultant, Social Policy, UNICEF-Raipur, Chhattisgarh, INDIA. Email: rabiulansary.ansary786@gmail.com
[2] Professor, P.G. Departments of Geography and Deputy Director Population Research Centre (PRC), Utkal University, Odisha.Email: kcrath65@gmail.com

education among parents, unhealthy environment, economic distress, institutional inadequacy and political instability leading to a lack of potential resource (Ahmed, et al., 2015). A large number of studies in developing countries suggest poverty, lack of access to resources and food unavailability causes pathways and inflates the level of malnutrition among the population, especially among the children (Kumar, et al., 2014). Similarly, studies on sanitation and hygiene practices found positive association between household level sanitation and linear growth among the children (Rahman, 2015). A field study in Bangladesh found child's sex, mother's body mass index, parental educational status, place of residence, region of residence, socioeconomic status, community status, religion and food security are significant factors of childhood malnutrition (Chowdhury, et al., 2016).

In developing countries Government implements various programs as part of national policy to eliminate malnutrition. Studies in developing countries reported WASH (Water, Sanitation, and Hygiene), Integrated Child Development Scheme (ICDS), Public Distribution System (wheat based Supplementary Nutrition), health insurance, community capacity development, and micro credit provision as the major interventions adopted to reduce malnutrition (Bain, et al., 2013; Khan and Raza, 2014; Semba, 2016).

In developing countries, child undernutrition is a serious public health issue and necessitates immediate interventions in the management of human resource problem. In last two decades, India experienced high economic growth and subsequent reduction of multidimensional poverty and head count poverty ratio. But the prevalence of undernutrition in India, especially in major states and more so in specific districts within a state remained as high as it is in many African countries (Drammeh, et al., 2019; Onyango, et al., 2019). Rapid economic growths of India certainly has enormous benefits, but it is by no means sufficient and sustainable if millions of children in the country are unhealthy and malnourished. The child undernutrition rates in India are among the highest in the world. India is still home of over 40 million stunted children and 17 million wasted children under five (Business Standard, 2018). Many studies also show that poor health and undernutrition in early childhood can have long-term effects to children's' height, school attendance, educational attainment, wages and productivity which in turn negatively affect the sustained growth of the country (Gillespie and Flores, 1999-2000). The disease burden due to child and maternal malnutrition in India is higher per person than in China. Malnutrition also continues to be one of the largest risk for health loss in India, which is higher among females, rural poor and low educated mothers.

World Health Assembly notified the desire to meet global nutrition targets (40% reduction in number of under-five stunted children, 30% reduction in low birth weight and 5% reduction in wasting) by the end of year 2022 and eradicate malnutrition by 2030. Reduction of undernutrition is the primary agenda among public health professionals, planners and policy makers in India. In India, one in every three children are stunted. NITI (National Institution for Transforming India) Aayog has come out with a national strategy to fight maternal and child malnutrition in 100 poor performing districts. The *Vision Khuposhan Mukat Bharat* (malnutrition free India) espouses to reduce all forms of malnutrition by 2022 and also indicates the government's commitment to fight maternal and child malnutrition.

Among the Empowered Action Group (EAG) States, Odisha has performed better compared to major economically well off states like Gujarat, Haryana, and Maharashtra where per capita income is almost double. The prevalence rate of stunted children in Odisha is 34.1% which is lower than Gujarat (38.3%) and Maharashtra (34.2%) (Ansary and Hooda, 2019).The government of Odisha has launched schemes like the Millets Mission and Iron plus Initiative to boost nutrition, especially among the children and the tribal population. United Nations International Children's Emergency Fund (UNICEF) participates in different state sponsored integrated project to improve the health and nutrition status, skill development and empower vulnerable communities. Odisha is the first state in India to implement *'Nutritional Budget'* to fight against malnutional. It is a multi-sectoral approach that deals with both nutrition specific (direct nutrition centric) and nutrition sensitive (indirect nutrition centric) schemes and interventions (Odisha Budget Report, 2020-21). Further in the financial year *(*2021-22) 'SDG *budget'* highlights the accountability, transparency and commitment of the state in *'leaving no one behind'* and integrate the agenda 2030 with its associated targets and goals. Odisha has to achieve the targets of 40% reduction in number of under-five stunted children, 30% reduction in low birth weight and 5% reduction in wasting by 2022 and eradicating malnutrion by 2030 (World Health Organisation, 2014). In this context this study is an attempt to understand the spatial heterogeneity and determinants of undernutrition among under-five children across the districts of Odisha.

Objectives

- To analyses the pattern and prevalence of undernutrition among under-five children in Odisha
- To study the district level disparity of undernutrition among under-five children in Odisha.
- To find out and discuss the determinants of undernutrition among under-five children in Odisha.

Data and Methods

This study utilises the latest National Health Family Survey datasets, namely the fourth round NFHS (2015–16). This nationally representative household survey provides national and state level information on fertility, infant and child mortality, maternal and child health, reproductive health, nutrition and quality of health and family planning services for females aged 15–49 years, males aged 15–54 years as well as various health related information on children below 5 years age. NFHS-4 gathered information of 259,627 children below the age of five years from 699,686 women. The primary sampling units are divided into two main strata; urban (wards/municipal localities) and rural (villages). They are drawn separately based on the relative sizes of the state and of the urban and rural populations within the state. In the present study information pertaining to the state Odisha is utilised. So, in the present attempt information of 111,106 children from Odisha is analysed.

Malnutrition may take the form of either undernutrition or over nutrition. In other words, it is simply the imbalance between nutrients that the body needs and the nutrients it receives. Present paper is designed to study the undernutrition measured by indicators such as stunting,

underweight and wasting. This study uses WHO (2010) standard to define variables like stunting, underweight and wasting. Children whose height-for-age (HAZ) index of Z-scores are below minus two standard deviations (-2SD) from the median of the reference population are considered stunted. The Children whose weight-for-age (WAZ) is below minus two standard deviations (-2 SD) are considered underweight. Wasting children are defined as whose weight-for-height (WAZ) is below minus two standard deviations (-2 SD) from the median of the reference population.

The main dependent variable or outcome variable in this study is the undernutrition (stunted, underweight, and CIAF) of children under-five years. The focus of this study is to analyse the factors associated with the likelihood of children being undernourished relative to those who are not. In our study we incorporate a number of covariates known to be associated with the likelihood of undernutrition; i.e., economic status, water and sanitation, social groups including religion, place of residence, Geographical regions, Maternal education, maternal age of birth, Body Mass Index, birth order, sex of the child, age of the child, status of immunization and score of government nutritional and health interventions programs. Socioeconomic status (SES) is well recognised as an important determinant of undernutrition; Hence, in this study we use the household wealth index prepared by the NFHSs as a proxy for economic status. This study uses the WHO weight classification for BMI calculation of mother (Below 18.5 Underweight; 18.5–24.9-Healthy weight; ≥25.0 overweight/obese). BMI is calculated as the weight in kilograms divided by the square of height in metres (i.e., kg/m2). In the category of schedule (Schedule caste and schedule tribes) and Non-schedule population (Other Backward Classes [OBC] and Unreserved [UR]) are considered. Based on the census of India 2011 criteria, Tribal dominated districts are those districts where the share of schedule tribe population is more than 50% to the total population of the district. In this study, a total nine districts (Mayurbhanj, Keonjhar, Sundargarh, Kandhamal, Gajapati, Koraput, Rayagada, Malkangiri and Nabarangpur) of Odisha are identified as tribal dominated districts. In term of physiographic division of Odisha state, coastal Odisha consists of following districts; Baleswar, Bhadrak, Ganjam, Jagatsinghpur, Kendrapara, Khordha and Puri (Chittibabu, et al., 2004). In this study WHO Drinking-water Quality and sanitation guideline (4th edition 2011) is followed to define the Improved and unimproved drinking water source and sanitation.

Apart from studying stunting and underweight, we also use an alternative indicator of undernutrition; the Composite Index of Anthropometric Failure-CIAF (Nandy and Svedberg, 2010). It measures and examines the relationship between ill health and malnutrition as well as different forms of malnutrition and poverty. The following equation is used for the inclusive estimate of Composite Index of Anthropometric Failure,

CIAF=(1-a)/(a+b+c+d+e+f)=(1-a)/1=1-a,

a- Children who do not suffer from any anthropometric failure
b- Children who have subnormal weight for height
c- Wasting and underweight
d- Wasting, stunting and underweight
e- Stunting and underweight
f- Stunting only

y- Children who are only underweight

To measure and study the regional disparity at the district level in mean prevalence of undernutrition, we used modified Sopher (1980) Disparity Index (DI) proposed by Kundu and Rao (1986). Kundu and Rao (1986) have shown that the Sopher index fails to satisfy the additive monotonicity axiom. This index measures disparity between two groups in their possession of a particular property in terms of the logarithm of the odds ratio. It is a well-accepted measurement technique to identify the disparity of same variable between two groups. The value of Index close to zero indicates perfect equality. In other words, higher the value of Index, the higher the extent of disparity and vice versa (Raju, 1991; Biswas, 2016). Therefore, Disparity Index which is used in this study is as follows,

DIKR = Log (X2 /X1) +Log (200 - X1) / (200 - X2)

Where, DIKR = Disparity Index (Kundu and Rao)
X2 = Mean percentage of urban/male/non-schedule and poorest stunted/underweight/CIAF pre-school children.
X1 = Mean percentage of rural/female/schedule and richest stunted/underweight/CIAF pre-school children.
i.e. X2 ≥ X1

Moreover, several sets of choropleth maps are prepared with the Arc-GIS (10.9) software to depict and present the variation in regional disparity at the district level. The class interval of index value in choropleth map uses the quintile method.

Binary Logistic Regression: To estimate the likelihood of undernutrition, Binary Logistic Model is used (Tarling, 2008). The dependent variable comprising different measures of undernutrition (coded as 1) and nourished (coded as 0) are taken. A set of socio-economic and demographic factors are used as independent/explanatory variables. According to the Model Specification and Variables Definition,

$$\text{Logit}\,(p) = \beta_0 + \beta_1 \mathrm{X}_1 + \beta_2 \mathrm{X}_2 \ldots\ldots \beta_\mathrm{n} \mathrm{X}_\mathrm{n} + E$$

p = Dependent variable (different measures of undernutrition coded as 1 and nourished coded as 0).
$ß_0$ = Constant; $ß_1$ = Coefficient of variable X_1; E = Error Term

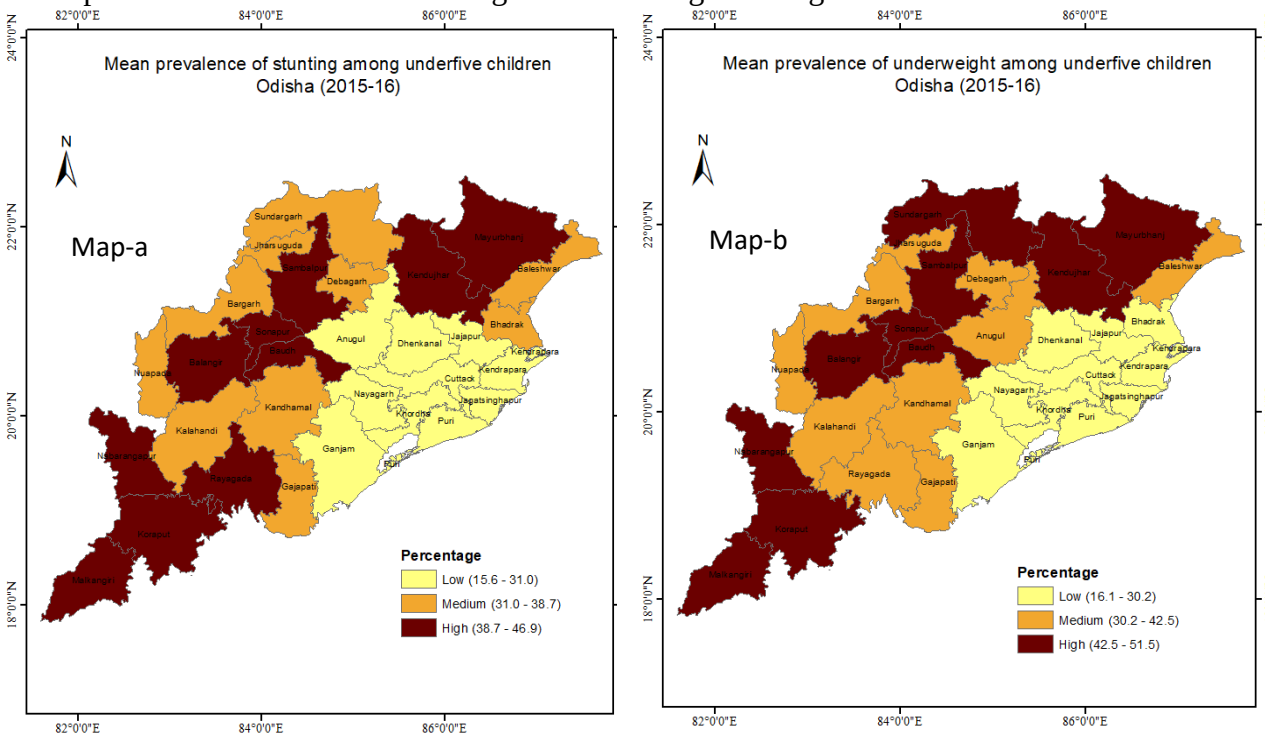
Analysis and Discussion

Regional pattern of undernutrition in Odisha

In the last two decades, the state Odisha experienced rapid economic growth and notable reduction in poverty level. But reduction of stunting, under-weight and wasting children was not commensurate. The analysis of National and Family Heath Survey (NFHS) data for Odisha suggest that the level of stunting children declined to 34.1% in 2015-16 from 50.8% in 1992-93. On the other hand, prevalence of underweight declined to 34.4% in 2015-16 from 50% in 1992-93. It is interesting to note here that over the last decade (2005-06 to 2015-16) mean prevalence rate of stunting among under-five children in Odisha declined to 34.1% from 43.9%, with

average annual reduction rate 0.98% which is much lower than the state average GDP growth rate. Over the same period, mean prevalence of underweight observed 5% change from 39.5% with registered average annual reduction rate 0.5%. The analysis of mean prevalence of stunting and underweight below-five children across the districts also highlighted contrasting geographical variations. Around half (47%) of the children in subarnapur district is stunted while lowest percentage is reported in Cuttack district (15.6%). Highest percentage of underweight children is found in the Malkangiri district, which is one of the districts of KBK region of Odisha where more than half of the (51.6%) children are underweight. IAn alternative indicator of malnutrition measures around 50% children in the state are suffering from Composite Index of Anthropometric Failure (CIAF). Highest percentage of CIAF is reported in the Nabarangapur district (67.3%) while lowest percentage is calculated in Cuttack district (24.6%).

Map 1: Mean Prevalence of stunting and underweight among under-five children in Odisha



It can be inferred from the district level 'Map 1 (a & b)' that overall lower mean prevalence of stunting and underweight are observed in the coastal districts of Odisha, which comes under the lowland/coastal plain agro-climatic zone[3], comprising nine districts (Baleshwar, Bhadrak, Jajapur, Kendrapara, Jagatsinghapur, Cuttack, Nayagarh, Khordha and Puri). The state can be broadly divided into two Agro-Climatic Zones (ACZ), i.e. Coastal plain Region and Highland Region (Govt. of Odisha, 2014). The highland region comprises 21 districts and accounts about 80 % of the area of Odisha and around 70% of the total below-five children are living here. Higher percentages of undernourished children are reported from the districts covered by plateau and high land area located in north, east and southern part of the state ('Map 1 [a & b]'). Interestingly these agro climatic zones are the abode of 'Particularly Vulnerable

3Based on soil structure, humidity, elevation, topography, vegetation, rainfall and other Agro- Climatic factors.

Tribal Groups' (PVTGs) of Odisha accounting for around one fourth (22.9%) of the total population.

Table 1 demonstrates the scenario of undernutrition by considering different covariates of Odisha. The results reveal that in rural area 35% children are *stunted,* while in urban area more than one fourth children of under-five age group are stunted. Rural-urban differences in mean prevalence of stunting are 8 percentage points. On the other hand, mean prevalence of *underweight* in rural and urban is 36% and 26% respectively. In term of mean prevalence of *CIAF*, children of urban area are in better position than children of rural area.

Based on the census of India criteria of regionalization, nine tribal dominated districts were identified in the state of Odisha and the prevalence of nutritional status is analysed. In the tribal dominated districts, the figure of stunted children is 42% while in the non-tribal dominated districts, the proportion of stunted children is as low as 31%. Around half of the children in tribal dominated area are underweight while this figure is only 30% in the non-tribal dominated districts. According to the latest 2011 census of India (Odisha), around 31% of the state's total children belonging to the age groups 0-4 years are residing in the tribal dominated districts. This indicates the severity of undernutrition in the tribal dominated districts of Odisha. In term of prevalence of stunting, among under-five children by geographical regions, it is the coastal region that fares better with 25% and 22% children are stunted and underweight respectively. In the highland region the percentage of stunting and underweight is 38% and 40% respectively (table 1). Moreover, more than half of the children (55%) in highland region are suffering from composite index of Anthropometric Failure (CIAF). In the coastal area only 37% children are suffering from CIAF.

Table 1: Mean prevalence of different measures of undernutrition among under-five children in Odisha (2015-16)

	Stunted		**Underweight**		**CIAF@**	
	Mean	CI (95%)	Mean	CI (95%)	Mean	CI (95%)
Wealth Index						
Poorest	0.48	0.46-0.50	0.48	0.46-0.50	0.65	0.63-0.67
Poorer	0.40	0.38-0.42	0.41	0.39-0.43	0.57	0.55-0.59
Middle	0.35	0.33-0.37	0.36	0.33-0.38	0.50	0.48-0.53
Richer	0.26	0.24-0.28	0.27	0.25-0.29	0.41	0.39-0.43
Richest	0.19	0.17-0.21	0.17	0.15-0.19	0.31	0.29-0.34
Toilet in HHs						
No toilet	0.39	0.38-0.40	0.40	0.39-0.41	0.56	0.55-0.57
Flush toilet	0.24	0.22-0.25	0.23	0.21-0.25	0.37	0.35-0.39
Pit latrine	0.25	0.21-0.28	0.24	0.20-0.27	0.37	0.33-0.41
Others	0.36	0.16-0.56	0.39	0.18-0.60	0.53	0.31-0.74
Source of drinking water						
Unimproved	0.35	0.32-0.38	0.36	0.33-0.39	0.49	0.46-0.52
Improved	0.34	0.33-0.35	0.35	0.34-0.36	0.50	0.49-0.51
Religion						
Hindu	0.34	0.33-0.35	0.35	0.34-0.36	0.50	0.48-0.51
Muslim	0.32	0.25-0.38	0.19	0.14-0.25	0.43	0.36-0.50
Christian	0.35	0.31-0.40	0.39	0.34-0.43	0.53	0.49-0.58
Other	0.48	0.21-0.76	0.44	0.16-0.72	0.48	0.21-0.76
Caste/ethnicity						
Schedule Tribe	0.46	0.44-0.48	0.49	0.46-0.50	0.64	0.63-0.66
Schedule Caste	0.36	0.34-0.38	0.35	0.33-0.37	0.52	0.50-0.55
OBC	0.30	0.28-0.32	0.30	0.28-0.32	0.45	0.43-0.47
General Class	0.20	0.18-0.22	0.19	0.17-0.22	0.31	0.29-0.34

Place of residence						
Urban	0.27	0.25-0.29	0.26	0.24-0.28	0.41	0.39-0.44
Rural	0.35	0.34-0.36	0.36	0.35-0.37	0.51	0.50-0.52
Region based on tribal population##						
Other than Tribal	0.31	0.29-0.32	0.30	0.29-0.31	0.45	0.44-0.46
Tribal	0.42	0.40-0.44	0.45	0.43-0.46	0.60	0.58-0.61
Geographical region						
High land Region	0.38	0.37-0.39	0.40	0.39-0.41	0.55	0.54-0.56
Coastal region	0.25	0.23-0.27	0.22	0.20-0.24	0.37	0.35-0.39
Maternal education						
No education	0.47	0.45-0.49	0.48	0.46-0.50	0.65	0.63-0.67
Primary	0.37	0.35-0.40	0.40	0.37-0.42	0.55	0.52-0.57
Secondary	0.28	0.27-0.29	0.27	0.26-0.29	0.42	0.40-0.43
Higher	0.17	0.13-0.20	0.15	0.12-0.18	0.29	0.25-0.33
Maternal age at first birth						
Less than 18 Years	0.41	0.38-0.44	0.42	0.38-0.44	0.56	0.53-0.59
18-30 years	0.33	0.32-0.34	0.34	0.32-0.35	0.49	0.48-0.50
More than 30 years	0.30	0.23-0.36	0.27	0.21-0.32	0.41	0.35-0.48
Place of delivery of Child						
Home	0.46	0.43-0.49	0.48	0.45-0.50	0.63	0.60-0.66
Institutional	0.32	0.31-0.33	0.32	0.31-0.33	0.47	0.46-0.48
Other	0.34	0.19-0.49	0.43	0.27-0.59	0.56	0.39-0.72
BMI of Mother						
Underweight	0.43	0.41-0.45	0.49	0.47-0.51	0.63	0.61-0.65
Healthy Weight	0.33	0.32-0.35	0.31	0.30-0.33	0.48	0.47-0.49
Overweight/Obese	0.18	0.16-0.20	0.17	0.15-0.19	0.28	0.26-0.31
Maternal birth order						
First order	0.30	0.29-0.31	0.31	0.29-0.32	0.44	0.43-0.46
Second order	0.33	0.31-0.34	0.32	0.30-0.33	0.48	0.46-0.49
third	0.42	0.40-0.45	0.43	0.40-0.45	0.61	0.58-0.63
fourth order	0.44	0.41-0.47	0.48	0.45-0.51	0.63	0.60-0.66
Sex of child						
Male	0.34	0.33-0.36	0.35	0.33-0.36	0.50	0.48-0.51
Female	0.34	0.33-0.35	0.34	0.33-0.35	0.49	0.48-0.50
Age of child						
Less than one year	0.23	0.21-0.25	0.28	0.26-0.30	0.51	0.48-0.53
1 year	0.39	0.37-0.41	0.34	0.32-0.36	0.53	0.51-0.55
2 year	0.36	0.34-0.38	0.35	0.33-0.37	0.49	0.47-0.51
3 years	0.37	0.35-0.39	0.36	0.34-0.38	0.48	0.46-0.51
4 years	0.34	0.32-0.36	0.37	0.35-0.40	0.46	0.44-0.48
Status of Immunization						
No (0)	0.39	0.35-0.42	0.39	0.36-0.43	0.54	0.50-0.57
Half (1-4)	0.26	0.23-0.30	0.31	0.26-0.34	0.54	0.50-0.58
Partially full (up to 7)	0.28	0.26-0.30	0.31	0.28-0.33	0.49	0.46-0.51
Full (8)	0.35	0.34-0.37	0.35	0.34-0.36	0.49	0.48-0.50
Disposal of child stool						
Disposed	0.30	0.28-0.31	0.31	0.30-0.33	0.45	0.43-0.47
Open	0.37	0.35-0.38	0.36	0.35-0.38	0.52	0.50-0.53
Other	0.38	0.30-0.47	0.31	0.23-0.40	0.56	0.47-0.65
Score of govt. nutritional and health interventions(maternal and child) #						
0	0.26	0.22-0.30	0.24	0.20-0.28	0.38	0.34-0.42
1	0.31	0.26-0.36	0.35	0.30-0.41	0.46	0.40-0.52
2	0.31	0.28-0.34	0.33	0.30-0.36	0.47	0.44-0.50
3	0.36	0.34-0.38	0.35	0.33-0.38	0.49	0.47-0.52
4	0.35	0.34-0.36	0.35	0.34-0.36	0.51	0.50-0.53

Note: Lower and upper limit of Confidence Interval (CI) at 5% significance level; and @= Composite Index of Anthropometric Failure (Nandy and Svedberg, 2012); #- During pregnancy and breastfeeding received benefits (Supplementary food, Health check-ups, Health and nutrition education) from anganwadi/ICDS centre; Child received benefits (food and check-up) from anganwadi/ICDS centre, last 12 months; Received immunizations through anganwadi/ICDS centre, last 12 months.

Household level characteristics are the most crucial factors in determining both health and nutrition of children. Household wealth index produced by the NFHS is used as a proxy for economic status to determine the nutritional outcome. In the study area, poorest families are more prone to being both stunted and underweight than the wealthier families. In the state, among the poorest families, around half of the children are stunted and underweight while among the richest families the figure is 19% and 17% respectively (table 1). Around half of the children in the richest economic status are suffering from CIAF as compared to a much higher value for the poorest economic status (65%). With the improvement in economic status mean prevalence of stunted, underweight, and CIAF of children under-five age are declining.

Access to safe drinking water and increased latrine coverage is often considered as effective measures for reducing exposure to faecal pathogens and preventing diseases, ultimately reducing malnutrition (Clasen, et al., 2014). The households using flush latrine in Odisha reported mean prevalence of stunted children as only 25%, while households without latrine reported stunted children as much as 39%. In prevalence of underweight, the households using flush latrine reported only 23% children are underweight, while 40% children are underweight in the households without latrine. The figure of CIAF among the children under-five years age is 56% in households without latrine and 37% among the households with flush toilet. Thus the study found increased latrine coverage as an effective measure to reduce malnutrition.

Mean prevalence of stunted and underweight among under-five children in Odisha across the religious groups exhibit little differences but shows noticeable differences by ethnicity. Among major religious communities in Odisha, the mean prevalence of stunting are as follows; Muslim 32%, Hindu 34% and Christian 35%. Lowest underweight prevalence rate is reported among children of Muslim religious groups (19%) and this figure is more than double among the children in Christian religion (table 1). In Odisha, only one fifth children from General caste[4] reported stunted children while this figure is around one half among the children in Schedule Tribe category (table 1). The percentage of stunted children among the SC and OBC population in the state is 36% and 30% respectively. Around half of the children of Scheduled Tribes population are underweight, while in the General caste this figure is only 19%. In multiple forms of anthropometric measures, the children of Schedule Tribe population are suffering a lot more than rest of the caste and class in Odisha (table 1). The mean prevalence of CIAF among the General caste children is around half of the prevalence rate among the Schedule Tribe children (64%).

Literature on nutrition status in developing countries found vital role of intra-household characteristics and nutrients available to children. One such characteristic is the maternal birth order. It refers to the sequence of birth of mother during her child bearing age. It can be inferred from table 1 that with the increase of birth order, percentage of all forms of undernutrition are increasing. Mothers with first order birth in Odisha reported 30% children as stunted and it increased to around 44% among maternal birth order fourth and more. On the other hand, 31% children are underweight among the mothers with first order birth, while mothers with fourth order birth reported around half of the children as underweight. Mothers with fourth birth order reported higher percentage in all anthropometric failure among their kids than mothers with first

[4] In Indian caste system whose representatives are socially and economically on average ahead of other Indians.

order birth (table 1). Mothers with first order birth reported 44% children are CIAF, while among the mothers with forth order child the mean prevalence is as high as 63%.

Sex of the child is another important intra-household determinant. Several studies found that due to societal preference and sex bias, mothers prefer to offer better nutrients to sons (Sen and Sengupta, 1983). It can be concluded from table 1 that in all measures of undernutrition by sex of the child no such differences exist in Odisha, which is different from the previous studies in developing countries. Age of the child is another determinant of nutritional outcome of under-five children. Breast feeding and supply and intake of complementary feeding practices to children in India are largely determined by the existing taboos emanating from socio-cultural and religious belief. It can be inferred from the table 1 that with increase in age, mean prevalence of stunted and underweight children under-five years' age is increasing in Odisha. Among the children aged less than one year, 23% reported stunted while this figure increased to 39% among the children of one-year age and above. Mean prevalence of underweight is around 28% among children less than one year and this figure is increasing continuously with increase of children's age and at the age of four around 37% children reported underweight. It is interesting to note that mean prevalence of CIAF is inversely associated with increase in age. To elaborate this point, CIAF in the less than one year is 51%, while this figure decline to 46% among the children with four years of age.

Mother's education, exposure to media, age at marriage and BMI of mother has a prominent influence on nutrition and child's health outcomes. It is found that in Odisha, children of educated mothers are more nourished than mother without education (Illiterate). In Odisha, among higher educated mothers, mean prevalence of stunting children is 17% and around half of the under-five children are stunted among the uneducated mother (table 1). Thus, the figure for stunting is increasing with decrease in maternal levels of education. On the other hand, mean prevalence of underweight among higher educated mothers is only 15%, while among the uneducated mothers the same is three times higher. Mean prevalence in all forms of anthropometric failure among uneducated mothers is more than five times higher than the children of higher educated mothers (2%) in the state. Studies in developed and developing countries found positive linear association between mother's education level and child's nutrition level (Webb and Block, 2004; Moestue, et al., 2007). Mother's education is increasingly recognised as one of the important factors which facilitates knowledge and awareness, proper feeding practices, and better hygiene. Further, it can be inferred from the table 1 that the figure of mean prevalence of CIAF among children in uneducated mothers is more than double that of CIAF among children in higher educated mothers (29%).

Age at marriage and age at first birth is another important maternal factor which determines the health of child. In Odisha, among mothers who gave birth before 18 years of age around, 41% children are stunted while this figure is only 30% among mothers with age at birth 30 years or more. In term of prevalence of underweight, it is highest among the mothers whose age at first birth is less than 18 years, while lowest among mothers with age at first birth 30 years or more. We can further conclude from table 1 that BMI of mother is also an important factor affecting child's health and nutrition. The results suggest that among underweight mothers, mean

prevalence of stunting children is higher (43%) than the healthy weight mothers[5] (33%). In Odisha among the underweight mothers, around half of the children are underweight while among the Overweight/Obese mothers, mean prevalence of underweight children is only 17%. Among the underweight mothers, 63% children are suffering from CIAF, while among the healthy weight mothers, mean prevalence is 5% and 48% respectively.

Governments in almost all countries are implementing various programs to eliminate childhood malnutrition. India is also trying hard to eliminate childhood malnutrition through implementing both centrally and state sponsored programs. Currently, most important sponsored programs in India and its states are providing supplementary food, health check-ups, immunizations and nutrition education to lactating mothers via anganwadi/ICDS centres. To study the effect of govt nutritional and health interventions during NFHS survey, following information including benefits received during pregnancy and breastfeeding (Supplementary food, health check-ups, health and nutrition education) from anganwadi/ICDS centre, benefits received by child (food and check-up) and immunizations from anganwadi/ICDS centre, during last 12 months were collected from mothers. To calculate the *'score of govt. services'* simple score method is adopted in this paper. The information of the intervention and services are collected, which are dichotomous in nature (yes-1 or No-0).

It is assumed that better the utilization of intervention services by mother, higher will be the score and better nutritional and health outcomes will be observed. But the result depicts a different story of govt. intervention services in Odisha. Here around 35% children are stunted although children and mother utalised all the four services during pregnancy and breastfeeding, while this figure is only 26% among those who did not utalise any services. Interestingly, mean prevalence of stunted child are increasing with the increased sore of utilization of govt. service. Similar pattern is observed among the underweight children. Among the underweight children, around one fourth did not utilize any services; while among those who utilized them, one third child are underweight (table 1). Similarly, same pattern is observed in the mean prevalence of CIAF among under-five children in Odisha, where increase in govt. services score reported higher percentage of CIAF than among lower score prevalence rate. By controlling the wealth index of the household, it is observed that better utilization of intervention services by mother have better nutritional and health outcome among the poorest wealth index population. Among the poorest households, those who utilized all four govt. services (score-4), only 42% are stunted than the households without utilization of any govt. nutritional intervention services (50%). The poorest households without utilization of govt. intervention services reported 52% children are underweight while households with full utilization of govt. intervention services reported this value as only 44.5%. Similar pattern is observed in mean prevalence of underweight and CIAF. In the study area, among the institutional delivery, only 32% children are stunted, while among the home delivery around half of the children are stunted. On the other hand, around half of the underweight children reported their place of delivery is home while in case of institutional delivery only 32% children are underweight. The result of status of child immunization and mean prevalence of malnutrition in the study area did not depict much difference. It can be inferred from table 1 that those who are not immunized, 39% of them are stunted; while those

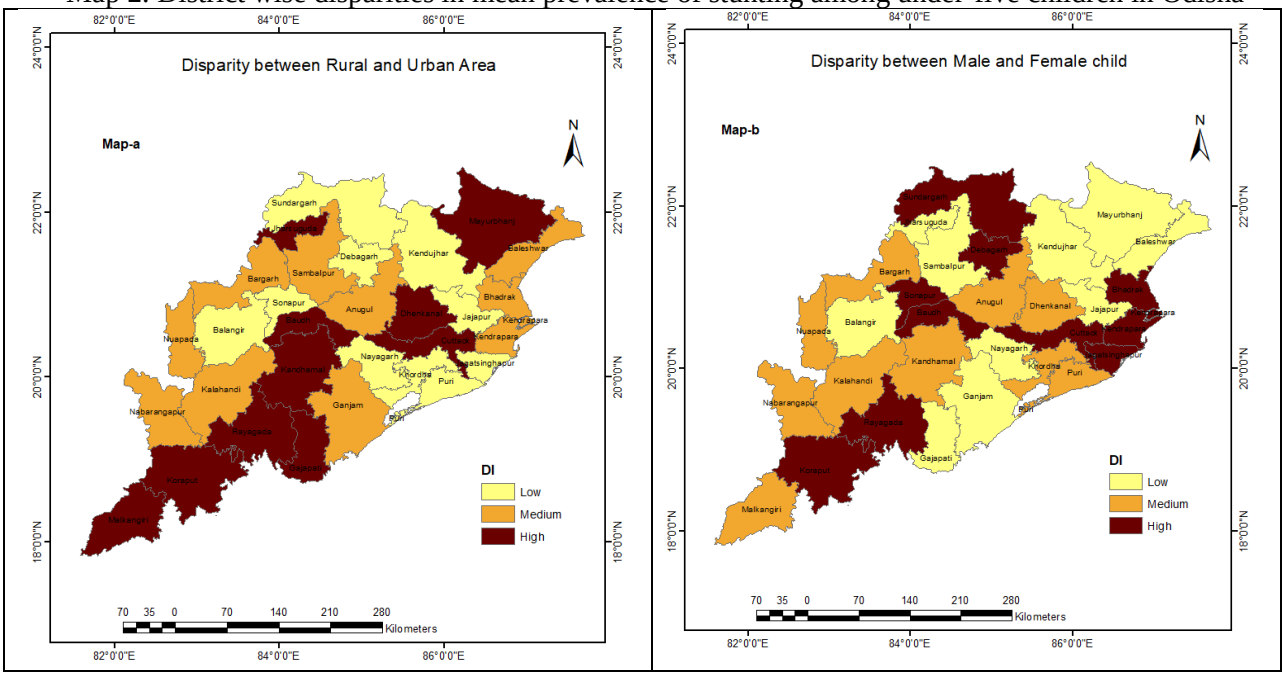
[5] World Health Organisation Standard (https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi)

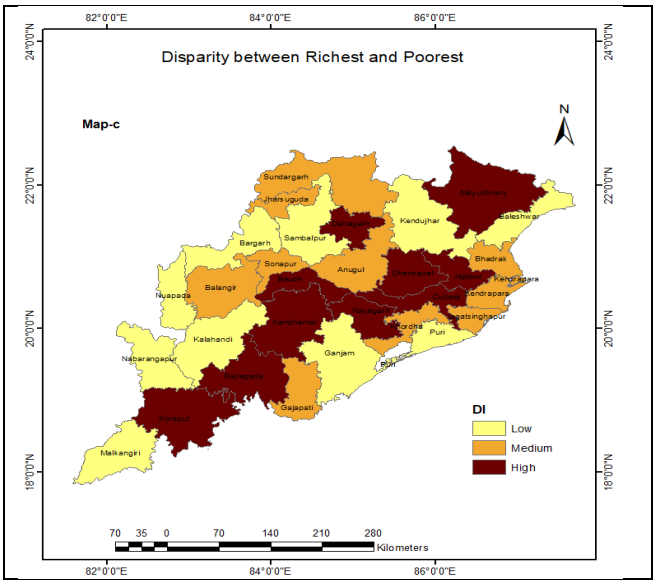
who are fully immunized, 35% are stunted. Similar result is found in other forms of undernutrition measures in Odisha.

District level Disparity Index (DI) of undernutrition

Despite exponential rise in gross state domestic product (GSDP) from a meager 2.45% in 1998–99 to about 8.08% in 2014–15, Odisha is still at the bottom in many critical social and human development parameters (Rajan, et al. 2013; Mahakur and Nayak, 2019). Persistent inter-district income disparities in Odisha and rising regional disparities turned out to be a serious challenge. The study from Mahakur and Nayak (2019), reported that higher economic growth benefitted the richer districts more than the poorer ones. Poor living standards, rural poverty ratio and deprivation are strikingly large in the tribal dominated districts. High GSDP growth rate also fails to reduce regional inequality and does not seem to trickle down into the laggard districts for them to catch up with the advanced districts. In this section we will discuss about the intra-district disparity in mean prevalence of different measure of undernutrition for policy intervention. Disparity Index suggested by Sopher (1980), and modified by Kundu and Rao (1986) is used to measure the disparity across the districts of Odisha. The value of DI is zero in case of perfect equality and greater the value, higher the extent of disparity (Raju, 1991). The results of all three measures of undernutrition (stunted, underweight and CIAF) disparity index indicate prevalence of high disparity in the districts located in the northern and south-western Odisha (map 2[a,b,c], 3[a,b,c] and 4[a,b,c]). It can be inferred from the 'map 1.a' that the district wise rural-urban disparities in mean prevalence of stunting among under-five children is highest in Dhenkanal (DI 0.73) and lowest in Khordha (DI 0.03). It is followed by the districts Kandhamal, Baudh, Rayagada, Koraputand Malkangiri. The result of disparity index by sex indicates highest male-female disparity is prevailing in Cuttack, a district in the costal plain. On the other hand, results indicate lowest disparity in the Gajapati district (map2.b).

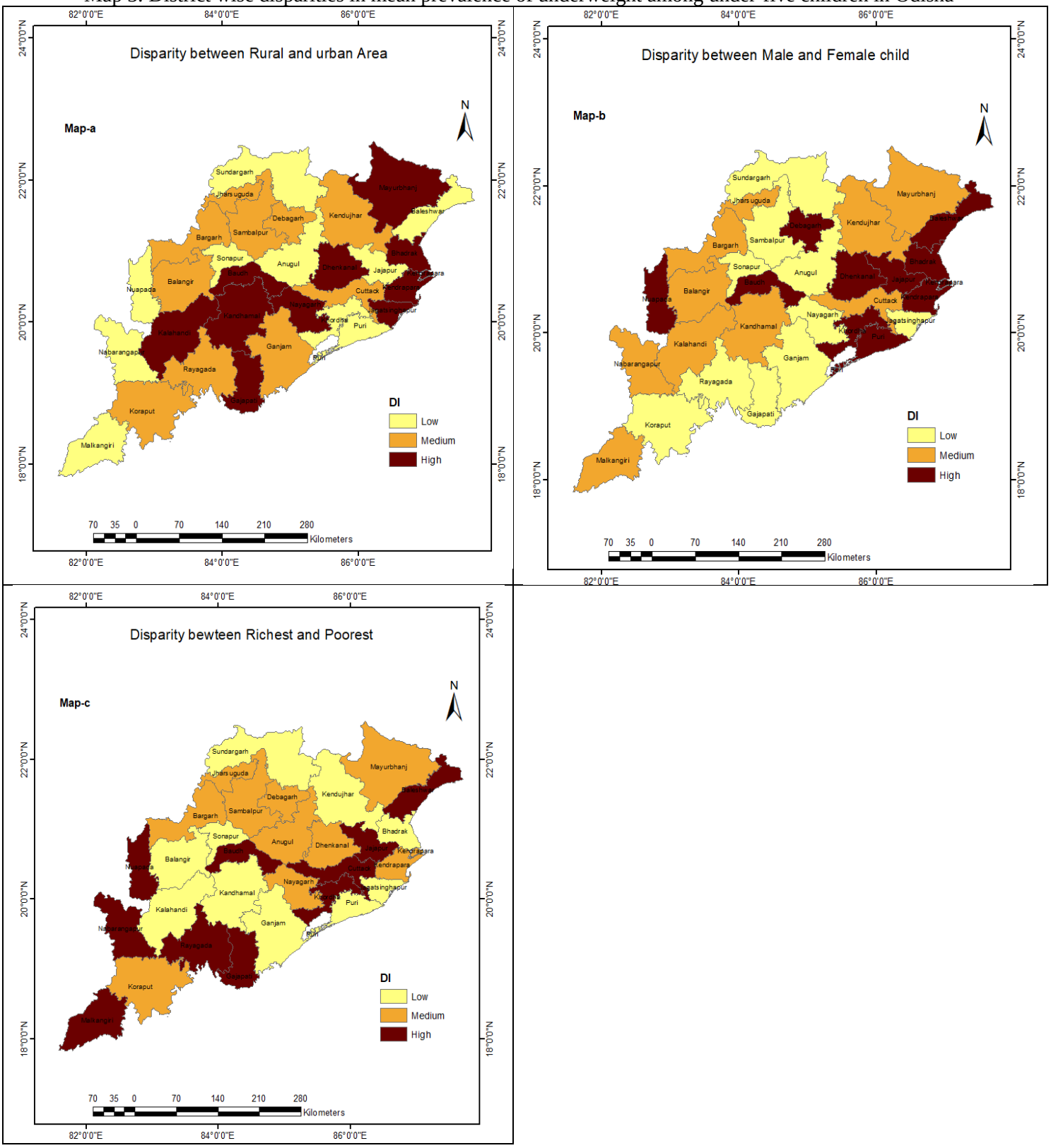
Map 2: District wise disparities in mean prevalence of stunting among under-five children in Odisha





It is interesting to note here that districts located in the southern (Ganjam and Nayagarh) and northern (Kendujhar and Mayurbhanj) part of the state, which are dominated by tribal population, reported lower male female disparity in mean prevalence of stunting among below-five children. The disparity of mean prevalence of stunting between the poorest and the richest wealth quintile under-five children across the districts in the state Odisha highlights significant regional differences. Lowest DI is observed in Baleshwar district (DI 0.01) while in most of the districts of central and western Odisha, except Malkangiri, value of disparity index is high. The value of disparity index for mean prevalence of stunting between poorest and richest wealth index is highest in the Dhenkanal district (DI 0.72). In terms of disparity in mean prevalence of underweight among under-five children by place of residence, sex of child and wealth Index of the household also shows differences across the districts in Odisha.

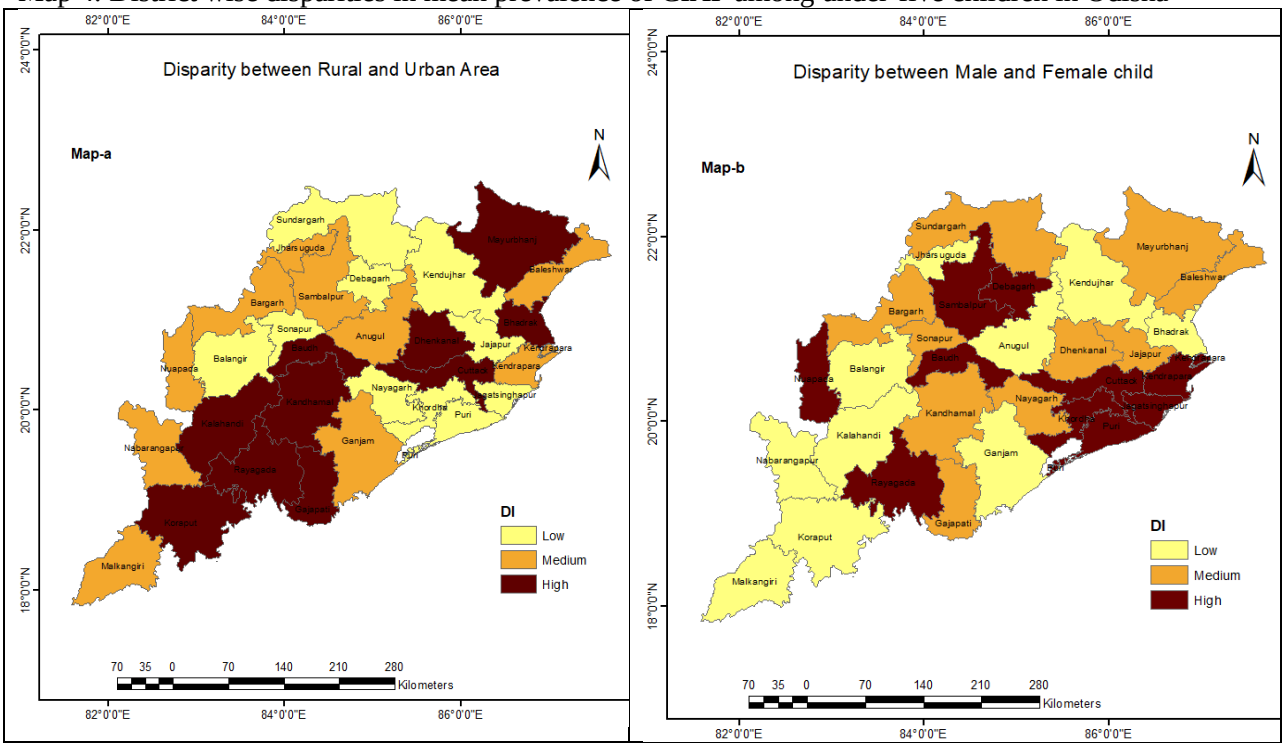
Map 3: District wise disparities in mean prevalence of underweight among under-five children in Odisha

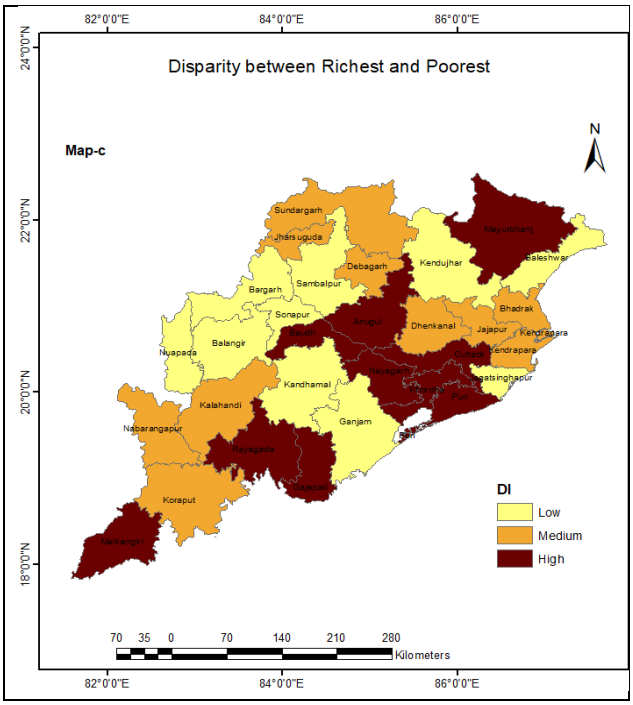


In the district Baudh highest disparity (DI 0.67) is observed in mean prevalence of underweight. It is followed by Kendrapara (0.54), Mayurbhanj (0.51) and Dhenkanal (0.39). It is interesting to note here that in most of the tribal dominated districts, rural-urban disparity in mean prevalence of underweight is considerable large compared to the non-tribal dominated districts in Odisha. Khordha one of the coastal districts, with with state administrative head quarter, reported lowest rural-urban disparity in mean prevalence of underweight. In other coastal districts, rural-urban disparity in mean prevalence of underweight is quite visible.

Disparity by sex of the child also found regional variation in the state. It can be inferred from 'map 3.b' that in the coastal districts disparity is highest as compared to the districts located in north and south-western Odisha. Sambalpur, one of the districts of north-western Odisha, reported lowest male-female disparity (DI 0.01) in mean prevalence of underweight. Other districts with low male-female disparity are Gajapati (0.01), Rayagada (0.01), Sundargarh (0.02) and Subarnapur (0.02). Intra-district highest male-female disparity in mean prevalence is noticed in the Kendrapara district with DI vale 0.22. It is followed by coastal districts of Puri, Jajapur and Khordha, where intra-district male female disparity in mean prevalence of underweight is highest. Intra-district disparity in mean prevalence of underweight among under-five children by wealth index across the districts observed differences in the state. The result indicates that in Cuttack district, highest poorest-richest disparities (0.93) in mean prevalence of underweight children exists. It is followed by the districts Rayagada (0.91), Baleshwar (0.76), and Khordha (0.64). In Odisha, lowest intra-district richest-poorest disparity index is calculated in Puri district with index value (0.06) which is also lowest in the coastal districts of Odisha.

Map 4: District wise disparities in mean prevalence of CIAF among under-five children in Odisha





In terms of disparity in mean prevalence of CIAF by place of residence, sex of child and wealth Index observed intra-district differences as well. Lowest rural-urban disparity index of CIAF in Odisha is calculated in Khordha district with index value 0.02 while highest index value is observed in Mayurbhanj district (map 4.a) in the north central plateau agro- climatic zone. It can further be inferred from 'map 4.a' that most of the rural-urban high disparity districts are located in the north eastern ghat high land agro-climatic zone. Sex of the child is one of the major social constraints that discriminate girl child in term of accessibility of food and intake of available household nutrition. Highest disparity in CIAF is observed in the coastal plain agro-climatic zone except Bhadrak district. Lowest intra-district male-female disparity is observed in the Jharsuguda (DI 0.01) and Kalahandi (DI 0.01). Mean prevalence of CIAF by wealth index indicates wide intra-district disparity in Odisha. Highest intra-district disparity is calculated in Cuttack district (DI 0.62) followed by Rayagada district (0.57). Most of the districts in coastal plain and west central table land agro climatic zone reported higher poorest-richest disparity in mean prevalence of CIAF. Lowest intra-district poorest-richest disparity in mean prevalence of CIAF is recorded in Kandhamal district (DI 0.03), followed by Jagatsinghapur district (0.09). Most of the districts in mid central table land agro climatic zone reported low poorest-richest intra-district disparity in mean prevalence of CIAF in the state Odisha.

Determinants of undernutrition among under-five children in Odisha

Child undernutrition is caused by a combination of socioeconomic and demographic factors. Although immediate determinants of child undernutrition is poor dietary intake, underlying determinants which influence child undernutrition are adequate cares for mothers, proper health environment, access to health services, income and intervention programs. Studies in developing countries found influence of socioeconomic, demographic and households' environment on child's nutrition level (Madise and Mpoma, 1997; Haddad, et al., 2003; Mamabolo, et al., 2006; Alderman et al., 2006; Ajieroh, 2009). In this study, household socioeconomic status, individual specific characteristics and nutrition intervention programs are

used to explain nutritional status of under-five children in Odisha. Household income is one of the crucial factors in determining childhood nutrition and health. This study uses the household wealth index produced by the NFHSs as a proxy for economic status/income. It can be inferred from table 2 that the average predicted likelihood of stunting at 95% confidence intervals for different wealth quintile is statistically significant. The categorical variables alongside wealth index are positively associated with a greater likelihood of different measures of undernutrition of children relative to the reference group of poorest children. The result indicates that there is 2.02 times greater risk of stunting among poorest children compared to the richest quintile children which is significant statistically. Thus, for example, children who is poorer, middle, and richer had 69%, 59% and 29% greater odds respectively of being stunted compared to reference category richest quintile children. Further the result indicates quantum increase in predicted likelihood of being underweight child if we are moving from higher socioeconomic status to lower status and the results are significant statistically (table 2). Predicted likelihood of CIAF also increases with decreasing socioeconomic status relative to the reference category richest quintile children and the result is statistically significant.

The likelihood of being stunted is 9% more among those who have no toilet and 10% among those who are using pit latrine relative to reference category using flush toilet; but the result is insignificant statistically. The likelihood of underweight children is high among those who are not using flush toilet relative to those who are using flush toilet. This study also noticed differences of nutritional outcome of under-five children in Odisha between use of improved and unimproved source of drinking water. It can be inferred from the table 2 that the likelihood of undernourished in a child is high among those who are using unimproved sources of drinking water relative to improved sources of drinking water which is statistically insignificant. Religion and ethnicity also plays an important role for the nutritional outcome of under-five children. The likelihood of stunting among children of Muslim religion are 100% higher relative to the children of Hindu religion and the result is also statistically significant. On the other hand, likelihood of stunting children among Christian and 'other religion' is lower than the reference category children and the result is statistically significant. Although the likelihood of underweight children among Muslims is 22% higher than the children of Hindu religion, the result is statistically insignificant. Among Muslim children the likelihood of CIAF is 120% higher than children of Hindu religion and also the result is statistically significant, whereas results indicate lower likelihood among children of Christian and other religious category (table 2). It can further be inferred from the table 2 that likelihood of different measures of undernutrition among Schedule Tribe children is higher than Schedule Caste children. On the other hand, likelihood of stunting and CIAF among children from unreserved category is 51% and 40% lower than SC children and the result is significant at 5% level. The effect of spatial difference on measures of undernutrition of under-five children, especially the likelihood of rural–urban difference is statistically insignificant in Odisha. Also, the effect of geographical difference on likelihood of undernutrition, especially across coastal and other than coastal districts, is observed, which are also significant statistically. The likelihood of underweight children in 'other than coastal district' is 100% higher than the children of coastal districts and the result is significant at 5% level. On the other hand, the likelihood of stunting, and CIAF children in 'other than coastal district' is 25%, 52% and 39% higher than the children in coastal district but the result is statistically insignificant.

Maternal characteristics generally try to provide every possible advantage to their children for better nutrition, health status and proper health care. The result of this study found determining role of maternal level of education in the likelihood of undernutrition of below-five children in Odisha. The likelihood of stunting and underweight in below-five children decreases with increasing levels of education of mother and the result is significant among underweight children (table 2). Among uneducated and primary educated mothers, the likelihood of underweight children is 74% and 68% greater relative to the higher educated mothers and the result is significant statistically at 5% level. On the other hand, likelihood of CIAF children among uneducated mothers is 49% higher relative to the reference group of higher educated mothers (table 2). Age of mother at first birth is another important determinant for children's health and nutritional outcome. The result of the present study found that the likelihood of undernutrition under-five children is higher among the mothers whose age at first birth is less than 18 years relative to the age at first birth 30 years or more, but the result is insignificant statistically. The study also found effect of Body Mass Index (BMI) of mother on the likelihood of undernutrition among below-five children in Odisha. Among 'underweight mothers' likelihood of stunting children is 27% higher than the healthy weight mother and the result is significant at 5% level. The likelihood of underweight children among underweight mothers is 75% higher compare to the healthy weight mother and the result is significant at 5% level. On the other hand, the likelihood of stunting, underweight and CIAF children among overweight/obese mother is 35%, 34% and 38% lower relative to the healthy weight mothers and the result is significant at 5% level.

The study also found that the likelihood of undernutrition decreases with the increase of institutional delivery and the result is significant statistically at 10% level. Childhood malnutrition is positively correlated to birth order i.e., higher order births present higher chances of yielding malnourished children (Siddiqui, et al., 2019). This study also found the likelihood of undernourished children rises with higher number of maternal birth order in Odisha. The likelihood of stunting children is 17% higher with maternal birth order three compare to the first order birth and result is significant at 10% level. Similarly, likelihood of CIAF among mother with third order birth is 27% higher relative to the mother with first order birth and the result is significant statistically at 5% level. Sex of the child is often considered as one of the important individual determinants for child nutritional outcome. Due to societal negligence, a girl child faces discrimination in availing better nutrition. The result of the present study found contrasting findings from the previous studies which found male children are always in better position for better nutrition. In Odisha among male children the likelihood of stunting, underweight and CIAF is higher relative to the female although the result is insignificant statistically. Age of the children is also another important determinant for nutritional outcome of children. With the increase in the age of children, along with breast feeding supplementary food is essential for holistic development; which is determined by social taboos and food cultures. This study found that with increase in the age of children likelihood of stunting and underweight is also increasing relative to the reference age of the children. The likelihood of stunting children at the age one year is 133% higher compare to the reference age of less than one year, which is statistically significant at 5% level. Similarly, the likelihood of underweight among children at the age of four years is 63% higher than the reference age of less than one year with the results being statistically significant at level 5%. Child immunization is one of the government child health intervention programs in India and its federal states with free of cost immunization of children to

an infectious disease. This has positive association with health and nutritional outcome. It can be inferred from the table 2 that among children without immunization, likelihood of undernutrition is much higher compare to the children with full immunization. It is interesting to note that odds of being CIAF are increasing with the increasing scores of utilizations of government nutritional and health intervention programs in Odisha.

Table 2: Determinants of undernutrition among under-five children in Odisha

	Model-I (stunted)		**Model-II (underweight)**		**Model-III (CIAF)**	
	N=8,911		**N=8,911**		**N=8,625**	
	OR	**CI (95%)**	**OR**	**CI(95%)**	**OR**	**CI(95%)**
Wealth Index Richest(Ref)						
Poorest	2.02**	1.60-2.55	2.02**	1.59-2.55	1.82**	1.46-2.28
Poorer	1.69**	1.36-2.10	1.92**	1.54-2.39	1.54**	1.26-1.89
Middle	1.59**	1.29-1.96	1.71**	1.38-2.10	1.43**	1.18-1.73
Richer	1.29**	1.06-1.56	1.50**	1.24-1.83	1.25*	1.05-1.49
Flush toilet(Ref)						
No toilet	1.09	0.94-1.26	1.07	0.93-1.24	1.10	0.96-1.26
Pit latrine	1.10	0.88-1.38	0.99	0.79-1.25	1.00	0.81-1.24
Others	0.82	0.34-1.99	0.75	0.30-1.84	0.71	0.30-1.71
Improved(Ref)						
Unimproved	1.05	0.90-1.22	1.10	0.94-1.28	1.04	0.90-1.21
Hindu(Ref)						
Muslim	2.00**	1.35-2.97	1.22	0.80-1.85	2.10**	1.44-3.06
Christian	0.78*	0.61-1.00	0.83	0.66-1.06	0.81*	0.64-1.03
Other	0.93	0.28-3.11	0.65	0.19-2.24	0.43	0.13-1.38
Schedule caste(Ref)						
Schedule Tribe	1.06	0.93-1.21	1.14*	1.00-1.31	1.08	0.94-1.23
OBC	0.92	0.81-1.05	1.06	0.93-1.20	0.92	0.81-1.04
UR	0.59**	0.49-0.72	0.77*	0.63-0.93	0.60**	0.50-0.71
Rural(Ref)						
Urban	1.01	0.86-1.17	1.08	0.92-1.26	1.02	0.88-1.19
Other than Tribal dominated dist. (Ref)						
Tribal dominated dist.	1.10	0.78-1.55	0.88	0.62-1.25	1.04	0.73-1.49
Coastal region®						
Other than coastal	1.25	0.83-1.89	2.00**	1.29-3.09	1.39	0.94-2.07
Education of mother (Higher)(Ref)						
No education	1.36*	1.01-1.84	1.74**	1.27-2.40	1.49**	1.13-1.96
Primary	1.18	0.87-1.60	1.68**	1.22-2.32	1.27*	0.96-1.66
Secondary	1.08	0.82-1.42	1.43*	1.06-1.92	1.11	0.87-1.42
Age at first birth more than 30 years(Ref)						
Less than 18 Years	1.20	0.84-1.70	1.28	0.90-1.83	1.21	0.86-1.70
18-30 years	1.17	0.85-1.62	1.24	0.89-1.73	1.22	0.89-1.67
Healthy Weight of mother(Ref)						
Unweight	1.27**	1.15-1.41	1.75**	1.58-1.93	1.55**	1.40-1.72
Overweight/Obese	0.65**	0.54-0.77	0.66**	0.55-0.79	0.62**	0.53-0.73
Institutional delivery(Ref)						
Home	1.14*	0.99-1.31	1.15*	1.00-1.32	1.07	0.92-1.23
Other	0.90	0.44-1.84	1.48	0.74-2.94	0.93	0.47-1.87

First order(Ref)						
Second order	1.01	0.91-1.13	0.96	0.86-1.07	1.08	0.97-1.20
Third	1.17*	1.02-1.36	1.16*	1.00-1.34	1.27**	1.10-1.47
Fourth order	1.10	0.93-1.29	1.18*	1.00-1.38	1.15	0.97-1.36
Female(Ref)						
Male	1.06	0.96-1.16	1.07	0.97-1.17	1.05	0.96-1.15
Less than one year(Ref)						
1 year	2.33**	1.93-2.82	1.26*	1.05-1.52	1.19	1.00-1.43
2 year	2.08**	1.72-2.52	1.59**	1.31-1.91	1.09	0.91-1.30
3 years	2.25**	1.85-2.73	1.64**	1.35-1.97	1.04	0.86-1.24
4 years	1.88**	1.55-2.28	1.63**	1.35-1.97	0.91	0.75-1.09
Full Immunization(Ref)						
No	1.06	0.88-1.28	1.10	0.91-1.32	1.11	0.92-1.34
Half	0.91	0.71-1.17	1.00	0.79-1.27	1.01	0.80-1.28
Partially full	0.92	0.78-1.08	0.86	0.73-1.01	0.87*	0.74-1.02
Disposed(Ref)						
Open	1.03	0.93-1.14	0.90*	0.81-1.00	1.00	0.90-1.11
Other	1.14	0.74-1.75	0.99	0.65-1.53	1.24	0.81-1.89
Govt. service (score zero)(Ref)						
1	1.02	0.71-1.48	1.23	0.85-1.77	0.97	0.69-1.37
2	1.04	0.79-1.38	1.14	0.86-1.51	1.11	0.85-1.44
3	1.27*	0.98-1.66	1.15	0.88-1.50	1.15	0.90-1.47
4	1.24	0.96-1.59	1.24	0.96-1.59	1.19	0.94-1.51

Note: Note: Asterisks denote level of statistical significance: ** P < 0.001; * P < 0.05.
OR denote Odd Ratio and CI denotes confidence interval.

Discussion

During fetal life, subsequent birth of children and in early infancy, growth is often impaired due to poor nutrition. It has perilous short and long-term consequences for individuals, households, communities, and nations making it a major human development problem. In Odisha, most of the women suffers from adult malnutrition and prevailing disease environment restrict absorption of the food, food insecurity and poor caring practices which in turn leads to impaired growth during infancy and early childhood development. A careful examination of pattern and levels in childhood undernutrition and its determinants in Odisha suggests that although overall performance has improved over time, rate of reduction of different measures of undernutrition is very low. No doubts among the EAG States, Odisha has performed better and even compared to other major states (Gujarat, Haryana, and Maharashtra) where per capita income is almost double; the prevalence rate of stunted children here is lower. The findings of this study suggest a clear spatial pattern in different measures of undernutrition (stunting, underweight, and CIAF) across the districts of Odisha. High level of undernourishment is found across some selected geographical regions. The clustering districts with high proportion of undernourished children is dominated by tribal population and highland track of agro-climatic zone, while districts dominated by non-tribal population and coastal plain agro-climatic zone is the home of low prevalence of different measures of undernutrition.

The result of disparity index (stunted, underweight and CIAF) indicates prevalence of high disparity in the districts located in the northern and south-western Odisha. The district wise rural-urban disparity in mean prevalence of stunting is highest in Dhenkanal district and lowest

in Khordha district. Intra-district disparity in underweight by wealth index across the districts also shows differences in the state. The analyses of determinants of undernutrition suggest statistically significant association (stunting, underweight, d and CIAF) with the factors such as wealth index, BMI status of mothers, maternal education, age of child and religion. The study confirms that districts with higher tribal population are at a higher risk of increased prevalence of stunting, underweight and CIAF. The likelihood of all forms of undernutrition among the poorest wealth index children is much higher than rest of the children. Previous studies in developing countries found that poverty is one of the major contributors to child undernutrition (Duncan, 2001). To reduce the overall burden of malnutrition in Odisha and achieve the SDGs, specific sustainable intervention should be prioritized in these identified tribal dominated districts. Households with improved sanitation reported lower likelihood of malnutrition in Odisha. It is well known that lack of improved sanitation leads to disease environment within the household and causes childhood diarrhea and other infectious diseases (Rahman, et al., 2015; Spears and Ghosh, 2013). Our findings suggest the positive linkage between women's educational attainment and different measures of child's nutrition which is consistent with previous studies (Mishra and Retherford, 2000). Maternal BMI status found association with all measure of nutritional indicators and the findings are consistent with previous studies. The result found greater likelihood of malnutrition among children with maternal BMI less than 18.5 kg/m^2.

Conclusion

This study found regional disparity of undernutrition among under-five children in Odisha and its associated factors. It illustrates spatial heterogeneity in mean prevalence of undernutrition among children across the districts in Odisha. The results demonstrate regional disparity in performance of nutrition. This study found children of coastal Odisha districts are better nourished compared to children from highland and forested districts. May be socio-cultural practices and food availability leads to better nourishment of children in coastal area. Similarly in tribal dominated districts, children are more vulnerable to all measures of undernutrition than the non-tribal dominated district. Overall in all measures of undernutrition intra-district disparity is very high in western Odisha districts. Logistic regression analysis showed that wealth index, child's age, mother's educational status, mother's body mass index, religion, region of residence, food security and hygiene and sanitations are significant factors of childhood undernutrition. It has been observed that children of poor families are more prone to being undernourished than those form wealthier families. Children of Odisha from ST backgrounds have a higher chance of being undernourished than other children. Although government of Odisha implemented state sponsored programs along with ICDS programs (supplementary food, health check-ups, and health and nutrition education) for children under the age of five, as well as pregnant and lactating mothers to eliminate undernutrition, mean prevalence and likelihoods of undernutrition continues to be high among who received benefits. The objectives of sustainable development can only be achieved when there exists dynamic linkages between economic growth, development and social, demographic and cultural transformation in real time and in a seamless manner. Finally, based on the findings, this study suggests that the state should come up with comprehensive region, district (tribal population dominated districts) and population specific (Particularly Vulnerable Tribal Groups) interventions to eliminate all forms undernutrition and achieve SDGs for under-five children in Odisha. Further, Government of Odisha may adopt child and family specific interventions (ILO

Social Protection Framework Area-1) for the vulnerable children (Poorer and poorest wealth index, ST and SC, uneducated mother, underweight mother, children of rural area, and households living environment) to fight against undernutrition.

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