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A robustness check to Multiple Overlapping Deprivation Analysis (MODA) methodology. The case of Nigeria

Teju Fagbeja and Victor Cebotari

Abstract

This study is the first to employ a robustness check to the Multiple Overlapping Deprivation Analysis (MODA) methodology. Using Nigerian MODA as the baseline study, we introduced three sets of parametric changes to the analysis: a change in poverty cut-offs (*k*); adjustments of indicators in dimensions, and inclusion of new dimensions as *per* the relevance for the national context. The rank correlation coefficient method is adopted to test for the robustness of MODA using Kendall Tau rank and Spearman rank correlation coefficients. The analysis is conducted for children aged 0-17 and for children of different age groups (0-4, 5-11, and 12-17), and across four profiling variables: regions, wealth index, education level of household head, and education level of mother. Findings show that rankings of dimensions across the four profile variables are overall stable when parametric changes apply. The adjustment of indicators in dimensions resulted in a slight increase in the deprivation headcount for housing for all age groups, and for water for children 12-17 years old. Minor decreases in headcounts were observed for sanitation, water, housing, health, and nutrition for children 0-4 years old; for information, sanitation, water, and education for children 5-11 years old; and for sanitation and education for children 12-17 years old. The multidimensional deprivation rate increased compared to that of the baseline Nigeria MODA (53.9%) when the poverty cut-off (*k*) was changed from three to two dimensions (78.7%), when indicators were adjusted in dimensions (58.2%), and when new dimensions of child labour, physical development, and HIV/AIDS were added to reflect specifics in the national context (65.8%). These results vary across regions, with the northern part of the country showing higher deprivation rates. This study confirms the robustness of MODA methodology to parametric changes, and highlights the importance of contextualising the evidence in the national realm.

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A robustness check to Multiple Overlapping Deprivation Analysis (MODA) methodology. The case of Nigeria

Teju Fagbeja[1] and Victor Cebotari[2]

Introduction

Children make up about a third of the world's population, yet make up more than half of the world's poor (Newhouse, Suarez Becerra, & Evans, 2016). Poverty is defined as a "pronounced deprivation in well-being" and also multidimensional in its nature (Haughton & Khandker, 2009). The United Nations also recognizes poverty as being multidimensional, and the first Sustainable Development Goal (SDG) aims to reduce poverty in all its dimensions (United Nations, 2015).

Central to poverty eradication are the concepts of identification and aggregation (Roelen & Gassmann, 2008) because they help to answer two key questions: "Who are the poor?" and "How poor are the poor?". For a long while, poverty measures and analyses have been carried out using the money-metrics approaches based on income and consumption. According to Achille & Gianni (2006):

> *Traditionally, poverty has been defined as a lack of income and has been associated with the study of personal income…the poverty concept has considerably evolved during the last three decades. New definitions have emerged…These new approaches underline the multidimensional and the vague aspects imbedded in the poverty concept.* (p. 139)

There have also been arguments to focus on child poverty as distinct from poverty in general. Roelen & Gassmann (2008) argued that children, not being economic actors by themselves, are not in control of how monetary resources are distributed within households, making them more vulnerable. Moreover, children have peculiar needs that are different from those of adults, and these needs, when unfulfilled, have farther-reaching implications for children

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compared to adults. Also, childhood poverty, being a strong predictor of adult poverty, gives a compelling case for addressing childhood deprivation as a way to fight poverty in the long-term.

Of recent, poverty, in general, has been increasingly measured by methods that capture its multidimensional nature. Even more recently, there has been a lot of emphasis on using a similar approach to child poverty. Morgan (2018) argues for more child-focused social protection programs from two points of view. First, the need to, in practical terms, uphold the rights of children ratified in the UN Convention of the Rights of the Child; then, from an "investment" point of view – children are human resources with higher potential for good "return on investment" (United Nations, 1989).

The call for child-sensitive poverty reduction initiatives underscores the need for child-focused poverty metrics. A study by de Neubourg et al. (2018), explains why household level monetary measurements of poverty may not adequately capture child poverty, and argues that poverty analysts would need to make assumptions on the proportionate distribution of resources within the household, of which children are not in control. Also, attempting to extrapolate household level deprivations to measure child deprivations fails to consider the specificity of the needs of children and can lead to either over- or under-estimation of child deprivations. It is more desirable, therefore, to measure multidimensional child poverty at the individual child level.

The UNICEF's Multiple Overlapping Deprivation Analysis (MODA) tool is an innovative method to measure multidimensional poverty of children. Studies by de Neubourg et al. (2012) and de Milliano & Plavgo (2014) describe the unique characteristics of MODA. It builds on the Bristol methodology, which counts deprivations experienced by children, according to seven basic human needs: access to clean water, sanitation, shelter, education, information, food, and health. In this approach, children living in a household without access to one of these are deprived, and those deprived of two or more of these basic needs are identified as absolutely poor (Gordon et al., 2003). The MODA methodology also builds on existing multidimensional poverty measures, including the Multidimensional Poverty Index (MPI) of the Oxford Poverty and Human Development Initiative (OPHI) (Alkire, 2007).

Under the MODA methodology, the child is the unit of analysis and not the household, as MODA seeks to understand the way each child experiences poverty directly. For this reason, the methodology gives priority to individual-level indicators rather than household-level indicators, since there may be differences across children of the same age and children in the same household. Household-level indicators can be used when they have a direct bearing on child well-being, for instance, the source of drinking water. Furthermore, MODA employs a life-cycle approach to measuring poverty, as to capture the changing needs across the childhood (De Milliano & Plavgo, 2014, p. 8).

Another significant feature of MODA methodology is its rights-based approach to identifying the dimensions[3] in which a child is deprived. This all-or-none, called the union approach, implies a child is deprived in a dimension if s/he is deprived in any of the indicators making up the dimension in question. The rationale to the approach is that it helps identify children deprived in any of the indicators belonging to the same dimension. The indicators are reflectors of a violation (or fulfilment) of the child's rights to well-being in that dimension, rather than a measure of the level of deprivation within the dimension (De Neubourg, De Milliano, & Plavgo, 2014).

MODA allows the deprivations to be disaggregated in different ways, including the split across different characteristics of the children. This shows how the composition of multidimensional poverty changes with features like geography, ethnic groups, and other individual or household characteristics. According to UNICEF Office of Research - Innocenti (n.d.), MODA provides:

> *A clearer picture of which dimensions of poverty children are experiencing, providing enhanced analytics to guide programming and policy responses. MODA is a practical and flexible tool that allows rigorous measurement of multidimensional child poverty in different contexts, as well as in-depth monitoring of SDG target 1.2.*

The selection of parameters in MODA, as in all multidimensional measurements of poverty, is subject to some limitations (discussed in the literature review section below), and policy recommendations may be sensitive to changes in parameters.[4] As Alkire et al. (2015) note, a ranking[5] of poverty comparisons may change when one or more parameters are altered, and this calls into question the robustness of multidimensional poverty measures.

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[3] A dimension refers to a broad area of basic need e.g. health, nutrition, education, sanitation, housing etc (De Neubourg, de Milliano, & Plavgo, 2014, pp. 10-13).
[4] Parameters can refer to dimensions, indicators, weights assigned to them, and cut-offs to determine who is poor.
[5] Ranking refers to the ordering of entities (e.g. countries, regions etc) from least poor to poorest by virtue of the poverty index used (i.e. headcount ratio or adjusted headcount ratio).

In the most recent Nigeria MODA (UNICEF, 2021 forthcoming), the researchers presented the magnitude and intensity of multidimensional poverty among childen.[6] Further, the study provided comprehensive profiles of multiply-deprived Nigerian children and made relevant recommendations based on findings. The MODA analysis not only measures the proportion of children suffering from multiple deprivations in various basic needs but also identifies the different dimensions in which children are deprived. The study also shows how dimensions contribute, both simultaneously and severally, to child poverty in Nigeria. Notably, the profiles of multiply-deprived children are identified based on region (state of residence), geography (urban *versus* rural), gender, and other profiles.

The proposed study aims to perform a robustness check on MODA by using the Nigerian case. The choice of Nigeria is based on the quality of available data and the diversity of its population as being the most populated country in Africa. In 2018, Nigeria had an estimated 98.7 million persons under 18 years, a figure behind only China and India (UNICEF, 2019). These figures make in Nigeria of high relevance to global efforts to eradicate child poverty and poverty in general.

Using the Nigeria MODA as the baseline study, the analysis aims to unpack the changes in parameters of Nigeria MODA and how these changes influence the size and scale of results. In doing so, the study will apply three changes in parameters of the baseline Nigeria MODA. First, the analysis will apply a change in poverty cut-off,[7] while holding other parameters constant. Second, the analysis will change and adjust the indicators in dimensions, as to better measure the observed vulnerabilities. Finally, the analysis will add new dimensions to better fit the measurement of deprivations in the national context.

These adjustments will determine the robustness of the baseline study and of MODA as a methodological tool. The study will also generate new insights into the multidimensional deprivations in the Nigerian child populations, and provide additional policy perspectives to eradicating child poverty in the country.

In the coming sections, the study will provide a review of existing literature on multidimensional poverty, MODA, and the robustness measures of poverty studies. The review is followed by a detailed description of the methodology, and by data analysis. After that, the

[6] Defined according to the UN Convention of the Rights of the Child as persons below the age of 18 years (United Nations, 1989).

[7] The minimum number of dimensions in which a child has to be deprived to be considered multidimensionally poor (De Neubourg et al., 2012, p. 25).

study presents and discusses the findings. The study concludes with a summary of key points, a mention of the study constraints, and a list of recommendations.

Background

Multidimensional perspectives of child deprivation

The increasing shift in perspective of human well-being from an income or consumption point of view to alternative views has been influenced to no small extent by the theoretical framework of the Capability Approach, developed by Amartya Sen and Martha Nussbaum (Deneulin & Shahani, 2009). The Capability Approach (CA) is an alternative framework, in welfare economics, for assessing human well-being and development. It advocates that, rather than measure well-being in terms of utility maximisation (proxied by the money-metric measures), social arrangements should be evaluated in terms of the "freedoms" people have to live the lives that they value. Sen referred to these freedoms as "functionings" (Deneulin & Shahani, 2009, p. 32), which are realised through "agency", which is the ability to pursue and achieve whatever goals or values a person regards as essential (Sen, 1985). According to Sen (1999), economic indices like Gross National Products (GNP) or household incomes are means to expanding these freedoms, the realisation of which is also dependent on other determinants like health and education facilities, democratic, and civil rights. It logically follows that freedoms and functionings, which are the end goal of development, have to be directly measured to appreciate the actual levels of human development, and the real impact of development programmes. Further, Sen describes the mutually reinforcing nature of the interconnected individual freedoms and the milieu of institutions within which they can thrive or die:

> *What people can positively achieve is influenced by economic opportunities, political liberties, social powers, and the enabling conditions of good health, basic education, and the encouragement and cultivation of initiatives. The institutional arrangements for these opportunities are also influenced by the exercise of people's freedoms, through the liberty to participate in social choice and in the making of public decisions that impel the progress of these opportunities* (Sen, 1999, p. 25)

Nussbaum (2011), also argues for the inadequacy of nations' GDPs as a measure of their people's well-being, and prefers to call the CA as "Capabilities" approach, to emphasise the plurality of quality of life (health, education, security, etc.) which should not be reduced to a singular metric. Nussbaum emphasises the importance of an individual approach to defining and evaluating capabilities rather than using total or average measures of well-being.

Also, Alkire & Santos (2014), identify several shortcomings of money-metric measures of poverty. These include non-uniformity in the pattern of consumption, inconsistent prices in goods, social income not accounted for, i.e., services, such as water, health, and the challenges of verifying the intra-household distribution of income. Another problem they identify is that people who experience poverty describe their state as comprising of deprivations, in addition to low income. A proper poverty measurement should not exclude these deprivations.

In defining capabilities, choices and freedoms, there is the challenge of how these should be appraised, especially considering the impracticality of measuring individual capabilities, which would differ from person to person due to the inherent heterogeneity of human beings (Fukuda-Parr, 2003). As noted by Robeyns (2003), Sen's CA does not specify what capabilities should be measured and leaves it to normative and value judgments, which depend on personal worldviews. Nussbaum (2011), on the other hand, proposes a list of "central capabilities" choosing not to leave the CA so open-ended even though there is still the need to translate her list into more detailed and specific lists to suit country and cultural contexts. Robeyns (2003) would argue that Sen's CA is more socially-oriented and, therefore, more relevant to social arrangements and understandably requires more fair and consistent democratic procedures to draw up the list (Robeyns, 2003, p. 69). Alkire (2007) also argues against having an authoritative list of poverty dimensions showing central domains and capabilities, as this would sideline public participation and may not always be fit-for-purpose. Alkire (2007) highlights five methods of selecting dimensions used by researchers, either alone or in combination:

1. *Existing data or convention*: This selects dimensions (or capabilities) based mostly on convenience or a convention that is taken to be authoritative, or because these are the only data available with the required characteristics.
2. *Assumptions*: Dimensions are selected based on implicit or explicit assumptions about what people do value or should value.
3. *Public consensus*: This is exemplified by the universal human rights, the SDGs, and UNCRC, among other public ratifications at international, regional, national, and subnational levels.
4. *Ongoing deliberative participatory processes*: Based on the idea of periodically eliciting the values and perspectives of stakeholders.

5. *Empirical evidence regarding people's values*: Based on expert analyses of people's values from empirical data, or data on consumer preferences and behaviours, or studies of the values that are most conducive to mental health or social benefit.

There is a second challenge of how the above methods can be implemented. The CA is only as useful as it can practically evaluate well-being; otherwise, it remains an unusable "framework." Comim, Qizilbash, & Alkire (2008, p. 157) acknowledge the apparent contradiction of assigning "quantitative" measures to human capabilities as it appears to narrow down those spaces, ignoring types of information that cannot be translated into concrete metrics. The authors, nevertheless, highlight a useful protocol that can permit quantitative measurements of capabilities without jeopardising informational spaces:

i) clarification of concepts;
ii) specification of dimensions that will be chosen as the focal point of analysis;
iii) choice of categories to represent the scales in which the evolution of dimensions would be assessed; and,
iv) organisation of results.

The demonstration of this protocol can be observed in the first attempt to measure capabilities by Mahbub ul Haq (1995) in the preparation of the first annual Human Development Report (HDR) in 1990.

1. *Clarification of concepts*: Haq (1995) clearly defined the concept of human development as *human-centered,* as opposed to *economy-centered*. Conventional measures of human development (e.g. GDP, GNP) are a means to an end – the expansion of human capabilities, which, if not realised, would reflect negatively on a nation's development. Further, Haq (1995, p. 47) identified specific capabilities that should be evaluated as the basic concept of human development to enlarge people's choices. These are living long, knowledge acquisition, comfortable standard of living, gainful employment, clean air, and freedom of community participation. The HDR uses the first three.
2. *Specification of dimensions*: The choices could be quantified or measured, and the critical factor is to identify variables besides income variables that proxy these choices. Moreover, identified variables should not be highly correlated. For instance, when infant and child mortality are highly

correlated with life expectancy, as in the case of the first HDR, the former had to be discarded as a variable for long life. In the maiden HDR, the three dimensions were specified as follows: life expectancy, adult literacy, and mean years of schooling (for knowledge), and per capita income (living standard) [8] (Haq, 1995, p. 49).

3. *Choice of categories*: This refers to the choice of scales that would reduce the variables identified into indicators with a common denominator, and is achieved by gauging the values measured for each variable as a relative distance from standardised value for the indicator(s) for that variable. Minimum and maximum values are defined for the actual observed values of each of the three variables. For example, "if the minimum observed life expectancy is 40 years and the maximum 80 years, and a country's life expectancy is 50 years, its index value for life expectancy is 0.25. Similarly for the other variables." (Haq, 1995, p. 50).
4. *Organisation of results*: This refers to a systematic way of displaying measurement results and is exemplified in the Human Development Index (HDI), which is a composite index resulting from the previous steps in this protocol, used to measure development progress across countries. As will be shown later, this is the mainstay of many multidimensional poverty measures and analyses.

Global and national multidimensional poverty studies, deriving from the CA framework have gained traction in the last decade. The introduction of a Human Poverty Index (HPI) in 1997 was a complement, rather than a substitute for the HDI. It was based on the "deprivational" perspective of human development, as opposed to the "conglomerative" perspective of it, which the HDI represented (Anand & Sen, 1997). If well-being is recognised as possession of capabilities, it stands to reason that poverty is deprivation in these capabilities. Also, since capabilities are multidimensional, poverty must be so treated. Today, a central feature of most multidimensional poverty measures is the construction of the composite multidimensional poverty index (MPI).[9] The MPI derives from the Alkire-Foster (AF) counting approach, itself a direct extension of the Foster-Greer-Thorbecke (FGT) approach.[10] The MPI is also called the

[8] Income was used as a proxy for a bundle of goods and services needed for the best use of human capabilities.
[9] MPI as a concept should not be confused with the Global MPI as a specific method, which uses 3 dimensions (health, education and living standard) and 10 indicators.
[10] A family of decomposable poverty metrics where changes can be made to the weight assigned to the income level of the poor, and changes resulting from rising average incomes, and can also be separated from changes in the distribution of income (Foster, Greer, & Thorbecke, 1984).

adjusted headcount ratio (depicted as M_0). Alkire et al. (2015) identify the unique properties of M_0 that make it suitable for multidimensional poverty measures. These are its ability to use ordinal or binary data rigorously, its decomposability by population sub-groups, providing insights into disparities, and its ability to be broken down by dimensions and indicators. M_0 can show the composition of poverty on aggregate and for each sub-group. It is also decomposable into sub-indices: the headcount ratio (*H*), and the intensity of deprivation (*A*). The H represents the percentage of the population who are poor, while *A* is the percentage of deprivations suffered on average by each person, and it reflects the intensity of poverty. The multidimensional headcount ratio is denoted as:

$$M_0 = H \times A$$

While MODA draws on the AF approach, its main focus is not the construction of a composite index. Moreover, as already mentioned, MODA seeks to understand child deprivations by identifying dimensions in which children are deprived, thereby informing policy decisions on which sector(s) to prioritise (De Neubourg et al., 2012). It also analyses how these deprivations in different dimensions overlap and reveal which children are worst deprived. Understanding of multiple overlapping deprivations would imply a multisectoral approach to addressing deprivations, rather than treating identified deprivations as stand-alone problems.

MODA studies

Studies in MODA have been done over the past decade to support national and international efforts to understand better and tackle child deprivation. There are currently three types of MODA: Cross country (CC) MODA, EU-MODA, and National MODA (N-MODA). The CC-MODA is used for cross-country comparisons in low and middle-income countries that have standardised surveys like the Demographic and Health Survey (DHS) or the Multiple Indicator Cluster Survey (MICS). EU-MODA is used for comparison of the living conditions of children across European states, using sophisticated panel data from the EU Statistics on Income and Living Conditions (EU-SILC). The N-MODA is done within a national context where peculiarities of a country are to be considered when measuring child deprivation. The EU-MODA and some of N-MODA studies also include two extra levels of analysis: income poverty and the overlaps between income poverty and multidimensional deprivation (Chzhen & De Neubourg, 2014; UNICEF Lesotho, 2018).

As part of an EU-MODA, Chzhen and colleagues (2014) analysed child deprivation and its relationship to monetary child poverty across three diverse EU countries (United Kingdom (UK), Romania, and Finland) in pre-school age children. The dimensions used were nutrition, clothing, early childhood education, and care (ECEC), child development, information, and housing. The study used both unidimensional and multidimensional cut-offs. In the former, a child is considered deprived if s/he is deprived in at least one dimension, and in the latter, the child is deprived if s/he is deprived in two or more dimensions. Romania had the highest deprivation rates in each of the dimensions, with the most substantial differences between Romania and the other two countries observed in housing, information, and child development. The highest deprivation rates were observed in housing, with 86% in Romania, 33% in the UK, and 15% in Finland. When Housing was decomposed into indicators, it was found to be driven by multiple housing problems in the UK (25%) and Finland (9%), and by overcrowding in Romania (72%).

Furthermore, pre-school age children in Romania were more likely to be deprived than their counterparts in the UK and Finland at every cut-off. 93% of pre-school children in Romania were deprived in one or more dimensions out of six, compared with 55% in the UK and 37% in Finland. In terms of the intensity of deprivation, Romanian children who were deprived in at least one dimension had 3.1 deprivations, on average. In contrast, the UK and Finland children in the same category had 1.5 and 1.2 deprivations, respectively. Since Romania had both a higher H and A at each cut-off, it also had a higher M_0. The analysis further decomposed M_0 into the shares contributed by each dimension, to give insight into their relative importance in each country. It showed that ECEC and housing contributed most to the M_0 in Finland, compared to housing and information in the UK and Romania. For the three countries, the study showed that income-poor children tend to be significantly more likely to be deprived in each dimension than non-poor children. Nearly all of those who live in income-poor households are deprived in at least one dimension, and similar household characteristics are associated with a higher likelihood of being both poor and deprived (Chzhen et al., 2014, p. 19).

A CC-MODA was conducted by de Milliano & Plavgo (2014) across thirty countries in sub-Saharan Africa to analyse the number and the combinations of deprivations that children experience, as well as sector-by-sector analyses. As it was a cross-country comparative study, the indicators and thresholds were standardised to allow for comparability. The study revealed that 247 million (67%) of all the 368 million children in the thirty countries suffer from two to five deprivations. The findings were compared with both the international $1.25 a day and national poverty measures and showed a weak correlation between monetary and multidimensional child poverty. However, there was a stronger correlation between multidimensional child deprivation and GDP per capita. Unlike the findings of Chzhen et al. (2014) in Europe, De Milliano & Plavgo (2014) reached a different conclusion, even though the studies were conducted in the same year. In the African study, monetary poverty and multidimensional deprivation were found to be conceptually different complementary poverty measures, with advantages to measuring both simultaneously, especially when measuring child poverty. The study also ranked all the 30 countries from the least poor to the poorest using the multidimensional headcount ratio, which showed Ethiopia as the most deprived country and Gabon the least deprived. The study recommended further country-specific research to investigate the correlation between national poverty rates and multidimensional child deprivation. The ongoing WCAR CC-MODA as of 2020 (from which the current case of Nigeria MODA derives), follows up on the above presented CC-MODA.

Several N-MODA studies have been conducted, especially in the Sub-Saharan African context. In a study by (UNICEF Zimbabwe, 2016), the findings showed that most (90.1%) children experienced at least one deprivation, 59.6% experienced at least two deprivations, while 27.6% experienced between three and five deprivations. The highest deprivation rates were in the Sanitation dimension across all the age groups, especially for children from 24 months to 17 years, with more than seven out of ten children being deprived. The indicators toilet type, and sharing of toilet facilities were the main contributors to the high deprivation rates in this dimension. Because these high rates were constant across all provinces, the study suggested that sanitation was a national challenge.

On the other hand, the Water dimension showed the highest level of disparities among provinces, as over 50% of children in all age groups in Matabeleland North and Masvingo provinces were deprived in the water dimension. In comparison, the metropolitan provinces of Bulawayo and Harare had deprivation rates ranging from 1-10% depending on the age group. This finding was consistent with the distribution of the 2013 outbreak of water-borne diseases in Zimbabwe, where Matabeleland North and Masvingo were among the provinces that recorded the highest number of sicknesses and deaths.

The study also revealed that 25% of children under five years were stunted (under the dimension physical development) and tended to be deprived in other dimensions as well, with only 3.4% of the 30.3% of children aged 24–59 months deprived in the physical development dimension having deprivation in that dimension only. For all dimensions and age groups, the deprivation rates (H and M_0) were higher in rural areas for both simple and multiple deprivation analysis. However, the average intensity of deprivation across the deprived children was not different, implying that the deprived children in all provinces had, on average, the same number of deprivations. Also, analysis of how the different dimensions contributed to M_0 was revealing: the water, and information dimensions contributed more to M_0 in rural areas, while education contributed more in urban areas. While the water, and information dimensions contributed relatively more to M_0 for children living in poor households, education was the highest contributor to M_0 in non-poor households.

The study also analysed the overlap between poverty based on wealth and deprivations and found that 45% of children were both poor and deprived; 18% were poor but non-deprived, while 15% were non-poor but deprived. Also, deprivation affected the children in all wealth quintiles, especially for children below five years; 19% of children aged 0–23 months in households in the richest wealth quintile were deprived in two or more dimensions simultaneously. Hence according to the study, a relatively high standard of living of households does not necessarily protect children from deprivations. This finding is in line with the 2014 CC-MODA conducted for Sub-Saharan Africa. The study, therefore, recommended that joint policies targeting both poor and non-poor households should be implemented to tackle both poverty and deprivation (UNICEF Zimbabwe, 2016, p. xii).

In the N-MODA conducted for Rwanda (UNICEF Rwanda, 2018), the study identified 39% of all children 0-17 in Rwanda as being multidimensionally poor (k=3). While gender disparity was not observed in deprivation rates among the under-5s, it came to the fore in the older age group, with boys being more deprived in primary education compared to girls. Also, children who were stunted as well as children living in households with the following characteristics tended to experience more deprivations: households with a case of child mortality in the past five years; female-headed households; households with mothers having lower education level.

Analysis of overlapping deprivations revealed 55% of under-5s and 32% of children aged 5-17 years suffered from at least three simultaneous deprivations with the nutrition, health, and sanitation dimensions having the most significant overlap for children aged 0-23 months (26.6%). In contrast, the age group 24-59 months had the most significant overlap in the health, water, and sanitation dimensions (19.9%). The most significant overlap for the 5-14 years age group included the health, water, and housing dimensions (20.4%), while for the 15-17 years age group education, water, and housing overlap was most significant (21.5%). The distinction between monetary poverty and multidimensional child deprivations was consistent with other African MODA studies: 13% of children aged 5-17 years were multidimensionally deprived despite living in monetarily non-poor households while 27% of children living in monetarily poor households were not multidimensionally poor. The study recommended equity-focused multisectoral approaches with particular attention to investments in health, sanitation, and school infrastructure in rural areas, improved education programs, and support for households to offer improved diet to children aged 6-23 months. Recommendations also targeted children in Southern and Western provinces, identified as the most vulnerable. Additionally, the study recommended support for female-headed households, single mothers, and households with heads having little or no education.

In the 2019 N-MODA of Mozambique, Ferrone, Rossi, & Brukauf (2019) demonstrated that 81% of Mozambican children were multidimensionally deprived and that those in the rural areas were more vulnerable. The report also ranked provinces of Niassa, Zambezia, and Cabo Delgado, as the highest deprived areas. The dimensions that more frequently overlapped in Mozambique were housing, health, and WASH, with one-third of children simultaneously deprived in these three dimensions. Also, children from poor households were more likely to be deprived, and 36% of deprived children were from non-poor households. The findings were again consistent with previous studies, which suggested that monetary and multidimensional measures of poverty complement each other.

The MODA analysis conducted by Statistics South Africa, (2020) for South Africa was based on data collected from the Living Conditions Survey (LCS) of 2014/15 and had seven dimensions: Housing, protection, nutrition, health, information, WASH (comprising drinking water source, sanitation, and waste disposal), and education/child development. The study, which adopted a poverty cut-off of *k*=3, found 62.1% of children aged 0–17 years are multidimensionally poor, with children aged 5-12 years having the highest rate at 63.4%. In comparison, children aged 0-4 years had the lowest multidimensional poverty rate at 59.9%. On average, the multidimensionally poor children suffer from 4 out of 7 deprivations across all age groups, and over 80% of all children experienced at least two deprivations. Consistent with similar studies in the Sub-Saharan African setting, multidimensional child poverty was higher in rural areas (88.4%) than urban areas (41.3%). The South African MODA study further demonstrated a highly-positive correlation between multidimensional poverty and money-metric poverty. The multidimensional poverty rate for money-metric poor children was almost twice that of non-monetarily poor children across all age groups. Also, 40% of all children were both multidimensionally and monetarily poor, 20% were only multidimensionally poor,10% were money-metric poor, and 30% were neither multidimensionally nor monetarily poor.

The need for a robustness check

While these studies demonstrate the uniqueness and versatility of MODA as a powerful advocacy tool through the insights it gives into multidimensional child poverty, there is a drawback in MODA based on its use of a composite index. Unidimensional (including monetary) and multidimensional poverty measures often include the ranking of entities based on the values of their indices (M_0 and H). These studies also build a profile of the poor based on specific characteristics. Ranking of countries (in cross-country or regional studies), states or regions (within a country), and other pairwise comparisons like urban/rural, male/female provide insights into characteristics of the deprived. They are also useful for intertemporal comparison of poverty measures. As already noted, the CA has faced the challenge of the selection of capabilities. A natural offshoot of this is the arbitrariness that characterizes the specification of parameters when building a composite index, i.e., the determination of weights and poverty cut-offs to determine if there are deprivations and poverty, or not. Multidimensional poverty indices can take on different values when one or more of these parameters are altered. According to Permanyer (2011), the choice of weights of indicators or dimensions, which could be a reflection of ethical or normative considerations, can change entity rankings, which have important policy implications, for example, the allocation of resources for poverty reduction programmes. According to Permanyer & Hussain (2017, p. 868), while these poverty measures can potentially give exact assessments of existing poverty levels, their construction is based on a wide range of debatable assumptions.

According to Greco and colleagues (2018, p. 63), the process involved in building composite indices for multidimensional poverty measures is not clear and reasonably justified to everyone. They argue that the Organisation for Economic Co-operation and Development (OECD) ten-step checklist (OECD, 2008) – developed to establish a standard guideline to coherently and transparently build composite indices – while affording a better understanding of the theoretical framework to developing the final composite index, does not insulate the methodological framework from error. This error is the inherent arbitrariness and the intrinsic dependence on value judgments in choosing dimensions, indicator weights, and cut-offs.

Robustness (sensitivity) checks are a way to ensure the integrity of the rankings obtained from composite indices. It shows how parametric changes either confirm or invalidate a ranking based on initially used weights and cut-offs for indicators and dimensions. Even though parametric changes are as ambiguous and value-dependent as the initial parameters (Batana, 2008), when these changes are made, and rankings are more or less consistent, the initial studies are accepted as accurate and valid. In a study by Alkire and colleagues (2010) to investigate how robust the MPI rankings of the 2010 UNDP OPHI report are to a range of "plausible" changes in weights assigned to dimensions, the following dimensions were adopted: Education, with years of schooling[11] and school attendance[12] as indicators; Health, with nutrition[13] and child mortality[14] as indicators; and Living standards, with cooking fuel[15], sanitation[16], water[17], electricity[18], floor[19], and assets[20] as indicators. Robustness checks were done by estimating the MPI using three additional weighting scenarios different from the standard MPI weighing structure[21], as follows:

(i) Scenario 1: 50% to health and 25% each to education and living standards,
(ii) Scenario 2: 50% to education, and 25% each to health and living standards, and
(iii) Scenario 3: 50% to living standards and 25% each to health and education.

Robustness of country rankings to these changes was performed using four different methods:

1. *Calculation of the correlation coefficients* between each pair of rankings (a pair is the "baseline" scenario of equal weighting and an alternative scenario) using three different methods: Pearson's correlation coefficient, Spearman's rank correlation coefficient, and Kendall's rank correlation coefficient.[22]
2. *Estimation of the concordance* between all four rankings - i.e. the initial ranking and the three rankings resulting from changes in the weighting structure. This was done using three indices of intra-group rank concordance: the Kendall and Dickinson-Gibbon (KDG), the multi-rank version of Spearman's coefficient (by Kendall, KS) and the multiple-rank concordance index of Joe (J). These indices range from 0 (no correlation) to 1 (complete correlation).

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[11] Household deprived if no member had completed 5 years of schooling.
[12] Deprived if any school-aged child is not attending school in years 1 to 8.
[13] Deprived if an adult has a BMI less than18.5, or a child has a z-score for weight for age less than -2 standard deviations from the median of the reference population.
[14] Deprived if a child had died in the family.
[15] Deprived if household cooks with dung, wood, or carbon.
[16] Deprived household's sanitation facility is not improved (according to MDG guidelines).
[17] Deprived if household had no access to safe drinking water (according to MDG guidelines).
or safe drinking water was more than 30 min walking from home roundtrip.
[18] Deprived if household had no electricity.
[19] Deprived if household had dirt, sand, or dung floor.
[20] Deprived if household lacked one of the following: radio, TV, telephone, bicycle, motorbike, refrigerator, and does not own a car or truck.
[21] The standard Global MPI assigns equal weight to each of the three dimensions (1/3 or 33.3%) and each indicator within a dimension is equally weighted: two for health (1/6 each), two for education (1/6 each) and 6 for living standards (1/18 each).
[22] The Kendall and Spearman correlation coefficients, used in this study, are discussed in the Methodology section.

3. *Calculation of the percentage of pairwise comparisons* that were robust by comparing the MPI estimates for all possible pairs of countries across all four different weighting scenarios.
4. *Checking for "large rank changes"* - i.e. countries whose ranks changed by ten places or more.

While the changes in indicator weights affected poverty estimates, all four approaches suggested robustness of the initial rankings. The correlation coefficients for Scenario 1 were 0.991 for Pearson, 0.984 for Spearman and 0.903 for Kendall; Scenario 2, 0.995 for Pearson, 0.981 for Spearman and 0.909 for Kendall; Scenario 3, 0.989 for Pearson, 0.989 for Spearman and 0.916 for Kendall. For the concordance estimation, all the indices showed a high correlation: the KDG, 0.981, KS, 0.975, and J, 0.983. The test of the pairwise comparison showed that in 88% of the total possible pairs, one country has higher poverty than the other regardless of the weighting system. The last approach which looked at the countries that changed rank ten places or more showed only 5 of the 60 bottom countries (with MPI from 0.05 to 0.64) changed ranks by ten or more places in all the alternative scenarios. In the top 44 countries (MPI 0-0.05), 14 countries changed ranks by ten or more places, but the study considered this insignificant considering the very narrow gap of the MPI scores (0 to 0.05).

The robustness of the above study to changes in indicators, and also to indicator and dimensional (poverty) cut-offs (*z* and *k,* respectively) was analysed and reported by Alkire & Santos (2014). They made parametric changes on five different levels and calculated the MPI scores for each change:

1. Nutrition indicators, weight-for-height, and height-for-age replaced the baseline indicator weight-for-age. Also, the baseline reference population from WHO was replaced with a different reference population which had a broader ethnicity coverage.
2. Child mortality indicator (baseline) was replaced with under-5 mortality.
3. Child school attendance was removed under the education dimension - i.e. only years of education was retained.
4. The consideration for time to the source of safe drinking water was excluded from the water dimension.
5. Higher deprivation cut-offs were used for water (requiring piped water), sanitation (requiring a flush toilet), and floor (considering a household having a palm bamboo/wood plank floor to be deprived).

The results showed rank robustness on all the scenarios and for all the correlation coefficients. For example, the Kendall correlation coefficients between the baseline MPI, and the MPIs using the alternative indicators for nutrition with a different reference population, were all above 0.91. For the mortality indicator (available for 52 countries), the rank correlation was 0.867. Across all specifications, all Kendall correlations were above 0.86, while all Spearman's rank correlations were above 0.96. Also, all correlations were significant at the 5% level, suggesting that the MPI rankings are highly robust to these changes in the deprivation cut-offs (Alkire & Santos, 2014, p. 265).

For the test of the robustness of country rankings to changes in values of *k*,[23] alternative values of *k* = 20% and *k* = 40% were used. The rationale for using *k* = 20% was that some households could have some deprivations by choice or due to indicator inaccuracies or data errors. However, when households have deprivations in more than one indicator, they are likely poor. Since the highest weight any indicator could take on is 1/6 (16.7%), the lower threshold should exceed this value. The rationale for 40% was that anything above that was unreasonable. The robustness across the three possible MPIs with different values of *k* – 20%, 33.33% (baseline), and 40% – was calculated using the three pairwise comparison methodologies. It showed that 93% and 96% of the pairwise country comparisons that were significant in the baseline MPI, remained significant, implying that one country is unambiguously less poor than another irrespective of the values of *k* used.

Nigeria MODA

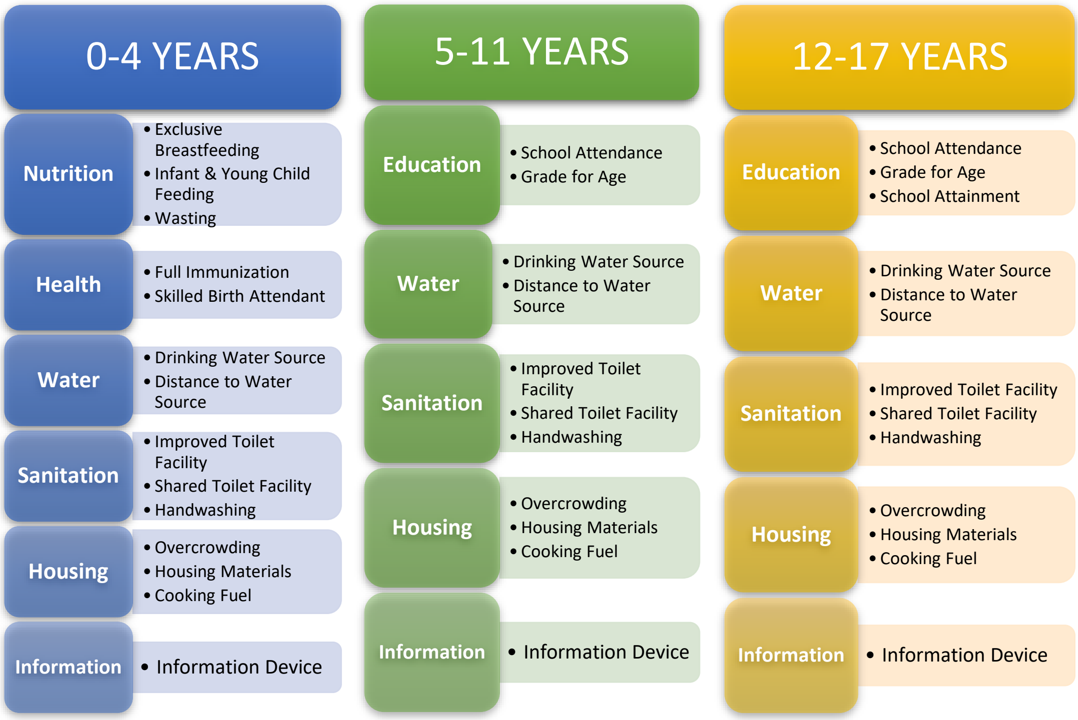
Literature is rather sparse on the robustness of multidimensional poverty measures in general. A search for literature on the robustness of child multidimensional poverty studies did not yield any find. This is the first study that aims to conduct sensitivity checks on the MODA approach of measuring child deprivation, by taking Nigeria as a case study.

The Nigeria MODA study has been conducted in 2020 by UNICEF and a team of SPRI researchers (UNICEF, 2021 forthcoming). It derives data from the 2016-17 MICS (National Bureau of Statistics and UNICEF, 2017). However, immunisation data for some states were obtained from the National Immunisation Coverage Survey (NICS). The data contained 25,713 households and 89,033 children (0-17 years). In line with the lifecycle approach, three age groups were used: 0-4 years, 5-11 years, and 12-17 years. The dimensions and indicators

[23] Standard value of *k* in Global MPI studies is 33.3%.

used in the baseline Nigeria MODA include six dimensions for the 0-4 years age group and five dimensions for each of the other age groups, are shown in Figure 1.

Figure 1: Dimensions, Indicators, and Age-groups in Nigeria MODA Study



Source: UNICEF (2021, forthcoming)

Since MODA adopts a union approach to indicator cut-off (*z*), the values of M_0 and *H* are not a weighted average of indicator weights. Also, *k* is not expressed as a percentage, but as the number of dimensions in which a child is deprived. In this N-MODA study, a value of 3 is used, meaning that a child is considered to be multidimensionally deprived if s/he has three or more deprivations. The report identified 53.9% of Nigerian children (0-17 years) as multidimensionally poor,[24] with only 6.9% not deprived in any dimension. 50% of all the children were deprived in two to three dimensions. The average deprivation rate was 3.7 dimensions out of 5 to 6 dimensions. Multidimensional poverty was highest in the 0-4 year age group (60%), followed by the 12-17 year age group (52.6%), and the 5-11 year age group (50%). Disaggregation by rural/urban showed that 65.7% of children in the rural regions were multidimensionally poor compared to 29.7% of children in the urban region. Notably, the adjusted headcount ratio (M_0) was the same for age groups 0-4 years and 12-17

[24] Based on multidimensional headcount ratio (*H*). The adjusted deprivation headcount ratio (M_0) was 37% and the percentage of deprivation suffered by the multidimensionally poor (*A*) was 68.8%.

years, due to the higher average intensity of deprivations among the deprived in the 12-17 years age group (Table 1).

Table 1: Multi-dimensional Deprivation Indices (H, A and M0, k=3), by age-group

Multi-dimensional Deprivation Headcount (H), %. K=3	Age-Group 0-4 years	60.0
	Age-group 5-11 years	50.0
	Age-group 12-17 years	52.6
Average intensity among the deprived (A), %, k=3	Age-Group 0-4 years	63.7
	Age-group 5-11 years	71.7
	Age-group 12-17 years	71.7
Average No. of deprivations among the deprived, k=3	Age-Group 0-4 years	3.8
	Age-group 5-11 years	3.6
	Age-group 12-17 years	3.6
Adjusted Deprivation Headcount Ratio (M0), k=3	Age-Group 0-4 years	0.38
	Age-group 5-11 years	0.36
	Age-group 12-17 years	0.38

Source: UNICEF (2021, forthcoming)

To analyse which dimensions contributed the most to the adjusted deprivation headcount ratio, the study decomposed M_0 by age group. The findings showed, for example, that the dimensions housing and sanitation were most relevant to M_0 for children aged 5-11 years old, contributing 26.5%. This decomposition was further disaggregated urban/rural, revealing the information dimension as being twice as important to M_0 in rural areas compared to urban areas (7.2% and 3.5%, respectively).

The study also analysed, per age group, possible combinations of overlapping deprivations between three dimensions (three-way overlap). In the 12-17 years age group, about 25% of children deprived in education, sanitation, and housing, respectively, experienced deprivation in 3 or more other dimensions. The proportion of children deprived in one dimension only ranged from 0% (information) to 8.5% (sanitation). Furthermore, 25% of the children in this age group were also simultaneously deprived in education, water and sanitation; 50.8% were simultaneously deprived in both education and sanitation; 1.9% were deprived in water only, and 10.8% were deprived in neither education, water or sanitation.

When the states were ranked by multidimensional poverty headcount ratio (*H*), Sokoto, Kebbi and Zamfara states had the highest (80.4%, 74.9%, and 74% respectively) while Edo and Lagos states ranked the lowest (19% and 17.3% respectively). Households with more members, with non-educated heads and also belonging to the lowest Wealth quintile, were more likely to have multidimensionally poor children. Also, stunted and underweight children

(0-4 years) were more likely to be multidimensionally poor. For this age group, gender differences were not statistically significant, unlike the 12-17 years age group, where boys were more likely to be multidimensionally deprived. Children involved in economic labour (5-17 years) were more likely to be deprived. Girls between ages 15-17 years who were married or became pregnant had a higher rate of multidimensional poverty (79.3% and 78%, respectively), compared to their peers who were not (45.4% and 46.9%, respectively).

The report also analysed deprivation rates by each indicator and dimension for the age groups. The analysis revealed that 95% of children aged 0-5 months were not exclusively breastfed; 83.9% of children aged 6-23 months did not attain the recommended meal frequency and diversity standard; 75% of children aged 0-23 months old were not fully immunized, and a skilled birth attendant did not deliver 60%.

In the analysis by dimensions in which children were deprived, 33% and 73% of children 0-4 years were deprived in nutrition and health, respectively; 45.4% and 61.7% of children 5-11 years and 12-17 years, respectively were deprived in education. Moreover, 79.2%, 78.8%, and 75% of children aged 0-4 years, 5-11 years and 12-17 years, respectively, were deprived in sanitation, while between 64.3% and 71.2% of all children suffered housing deprivation. In information, deprivation rates ranged from 10.8% to 12.8% across the age groups.

The insights generated from the Nigeria MODA study formed the basis of several policy recommendations by UNICEF. These recommendations promoted cost-effective interventions that spanned across sectors, taking into account the dimensions covered and, more importantly, the indicators that were used per dimension. The recommendations included the promotion of the school feeding programme, group handwashing, and strengthening of the birth registration system. Policies to adopt best feeding practices, enhance community-based infant and young child feeding, and scale-up of community management of acute malnutrition were also recommended, as one in three of 0-4 years children was deprived in the nutrition dimension. Based on a high proportion of children deprived in health across all the age groups, the study recommended that primary healthcare be strengthened, equity-based Maternal and Newborn Child Health Weeks (MNCHW) be promoted at community levels and the information system for tracking vaccinations be strengthened.

The robustness check of MODA is informed by the need to observe the changes in results when additional indicators and dimensions tailored to the national context of Nigeria are used. For instance, the prevalence of HIV/AIDS is historically higher in urban areas and more affluent states (Bashorun, et al., 2014), and it would be appropriate to check how the inclusion of context specific dimensions affect the state rankings, as well as other results. This study aims to contribute to knowledge in terms of robustness analysis of MODA-based studies. Additionally, it will generate complementary insights into the dimensions and intensity of deprivations suffered by Nigerian children.

Method

Approach

The mainstay of robustness analysis of this study is the altering of the parameters that influence the value of multidimensional poverty estimates. Following the approach by Alkire et al. (2015), there are two broad methods that can be used to test the robustness of poverty measures when parameters are altered: i) test for the robustness of pairwise comparison,[25] and ii) test for the robustness of overall poverty rankings.[26]

This study does not use the Stochastic dominance approach. Instead, it limits robustness checks to the analysis of rankings of *H,* based on profiles that have more than two entities, since two-entity profiles will benefit more from the Stochastic dominance approach. For the same reason, robustness checks on overlapping deprivations are not covered in this study. However, because new dimensions are introduced, the study compares changes in the contributions at the dimension level with the original study. Therefore, checks for the robustness of rankings are conducted for the following profiling variables: state, wealth index, education level of household head, and education level of the mother.

For the robustness checks, the study uses *H,* the same poverty index on which the ranking and profiling in the original study were based. Also, the union approach to indicator cut-off is unchanged in keeping with the right-based approach to child poverty. This study acknowledges that the parametric changes are not entirely insulated from the same arbitrariness that is attributed to multidimensional studies which necessitate robustness checks in the first place. In widening the extent to which existing dimensions may be altered

[25] Testing for the robustness of pairwise comparison uses the concept of Stochastic dominance (Alkire et al., 2015, p. 235), borrowed from dominance analysis in unidimensional poverty measurements. It is based on changes made to poverty cut-off *k* and is a form of robustness with highly stringent dominance conditions (Alkire, et al., 2015, p. 234). This technique provides reliable dominance results but is not appropriate when the number of pairwise comparisons is large.

[26] Robustness test for overall poverty rankings assesses the extent of preservation of the ordering of entities when parameters are changed. Robustness can then be determined in different ways. One method is by the proportion of pairwise comparisons that maintain the same orderings with the original one after parameters are changed. Another method is to compute rank correlation coefficients between original rankings of entities and the alternative rankings obtained when parameters are changed.

(by changing indicators) and creating new dimensions, the study consults the scope of usable dimensions and indicators as recommended by the UNICEF Office of Research - Innocenti.[27] Besides, the study adopts the following guidelines to ensure the parametric changes are as rigorous as possible:

a. *Use of an alternative poverty cut-off (k):* The baseline MODA adopted a value of 3 for *k* across the three age groups. As such, a child was considered multidimensionally deprived if s\he suffered deprivations in three or more dimensions. The choice k=3 is normative and arbitrary. Therefore, as a check for the robustness of the profile rankings of *k*=3, an alternative value of 2 is used. A robustness check at *k*=4 is not feasible because of the severity of vulnerability at the cut-off point.
b. *Use of child-level indicators and dimensions*: Where possible, this study introduces child-level indicators to existing and new dimensions. For instance, the variables underweight and stunting, which were not part of the original Nigeria MODA, are included in this study as child-level indicators.
c. *Adaptation to country context*: More country-specific dimensions that were not part of the original MODA study are added to this analysis. For example, HIV/AIDS status will be included as a dimension, since Nigeria is second only to South Africa globally in the number of children living with HIV/AIDS (UNICEF, 2020).
d. *Collinearity tests of indicators:*[28] Collinearity tests ensure that different indicators are not overlapping, while measuring the same mechanisms. These tests guard against indicators within a dimension becoming redundant, a situation that unnecessarily increases the complexity of measurement.

Attempts at parametric changes, especially at indicator level, are, however, met with some limitations. For instance, in dimension sanitation, the indicators used in the original MODA were exhaustive of the recommended range of indicators. In dimension water, the only unused indicator - protected water source available for less than eight hours per day or 20 days a month - is not available in the MICS dataset. For the dimension of information, the other suggested indicator, participation in community events or conversations, is not available in the dataset, hence the dimension with its existing indicators, is left unchanged. Under the health dimension, some indicators like the use of insecticide-treated nets are not used, because they may not be uniformly relevant across the Nigerian context. A new dimension,

[27]View at https://www.unicef-irc.org/files/upload/documents/MODA_List-of-indicators.xlsx
[28] This is done using Stata; a mean variance inflation factor (VIF) of more than 4 implies collinearity.

Child violence, could not be used due to a high number of missing values across relevant indicators.

The methodological approach to parametric changes is accomplished by creating three alternative scenarios to the original study (baseline scenario):

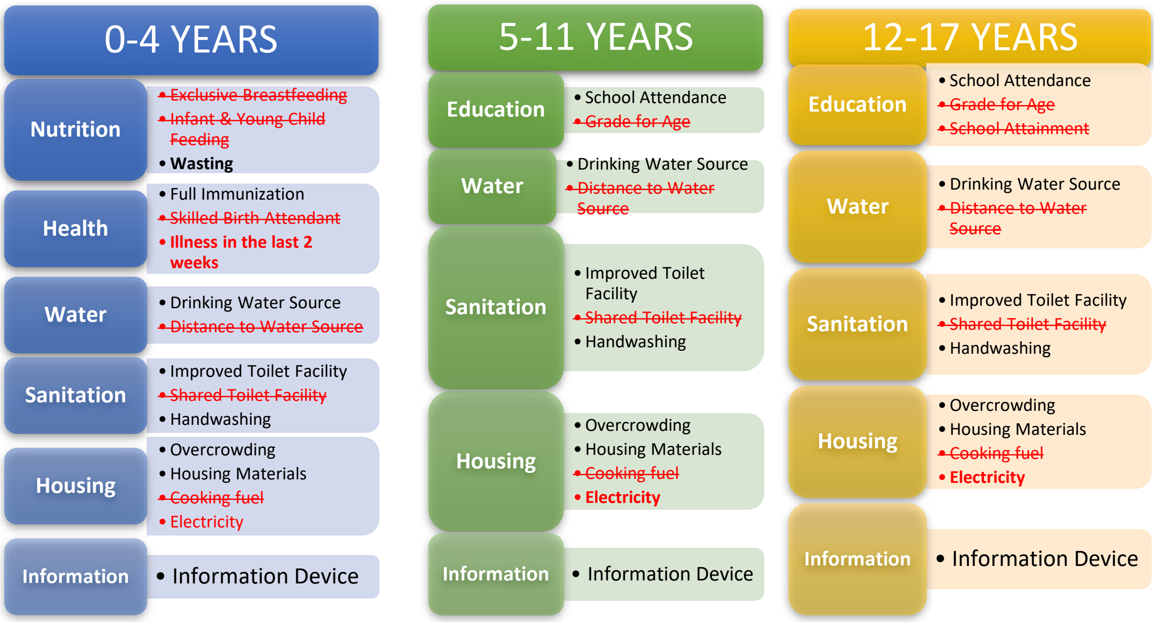
Scenario 1: Change in cut-off (*k*) while keeping other parameters constant (see Figure 1): It checks the consistency of the rankings at $k = 2$, based on the profiles state, wealth index, education level of household head, and education level of mother, with the original profile rankings.

Scenario 2: Changes at indicator level while keeping original dimensions and *k* unchanged (Figure 2): Using available data, indicators are substituted where possible (e.g. dimensions health, and housing), or otherwise dropped when they have the least headcount ratio. In the dimension sanitation, shared toilet facility has the lowest headcount ratio across the age group and is therefore dropped, leaving improved toilet facility, and handwashing. For the Housing dimension, which cuts across age groups, electricity replaces cooking fuel, which has the lowest headcount ratio in the dimension across all the age-groups. Even though electricity is a household-level indicator, its relevance to the Nigerian context warrants its inclusion. For the dimension water, the indicator distance to water source is dropped on account of its lower headcount ratio (across the age groups) compared to the other indicator drinking water source, which is retained as the sole indicator for the dimension.

In the dimension health (age group 0-4 years), the child-level indicator illnesses in the last two weeks replaces the indicator skilled birth attendant, which has a lower deprivation headcount ratio than vaccinations (full immunization). In nutrition, the indicators exclusive breastfeeding (which applies only to 0-5 months) and infant and young child feeding (which applies to 6-23 months) are dropped, leaving wasting, which covers 0-4 years.

In the education dimension for age group 5-11 years, the indicator grade-for-age is dropped, having a lower headcount ratio (19.3%) compared to the other indicator, school attendance (35.8%), which is retained as the sole indicator for this dimension. For the education dimension in the age group 12-17 years, grade-for age is dropped as it has a lower count (21.2%) than the other two indicators (school attendance (36.4%) and grade-for-age (39.9%)). Grade-for-age, even though having a higher deprivation rate than school attendance, is also dropped to have the same indicator with age group 5-11 years. The robustness check is performed at $k = 3$.

Figure 2: Changes made at Scenario 2 (depicted in red)



Scenario 3: Inclusion of new dimensions to Scenario 2 with *k* unchanged (Figure 3): This scenario builds on Scenario 2 by including dimensions considered relevant to the Nigerian context that were excluded in the original MODA study. The child-level and country-relevant indicators underweight (weight for age) and stunting (height for age) were excluded from the original MODA because they could not be assigned to either dimension health or nutrition, but were used as profiling variables. For the robustness check, a new dimension physical development is created across the three age groups to accommodate these indicators, However, because they are collinear (VIF = 4.35), underweight is dropped, and stunting is used as the sole indicator for this dimension. Also, to ensure country relevance, the national values for stunting are used, rather than the WHO values (National Bureau of Statistics and UNICEF, 2017).

A new dimension HIV/AIDS, measured by comprehensive knowledge on HIV, is included. It should be noted that the single indicator for the HIV dimension comprises several variables on different knowledge areas of HIV/AIDS. For ages 0-14, this indicator is household level, as children in this age group are not directly assessed for the comprehensive knowledge of HIV. For ages 15-17 years, however, the indicator is child-level.

Notably, the original MODA has six dimensions for age group 0-4 years, and five for age groups 5-11 years and 12-17 years. This situation makes the application of the cut-off *k* of 3 non-uniform across the age groups, making older children disproportionally disadvantaged as they have fewer dimensions on which poverty the cuts-offs can be applied. As a way to correct for this, and also for further robustness checks, a new dimension, child economic labour, is introduced to these older age groups, with farming and income-earning activities as indicators.

Figure 3: Robustness check (k=3) using new dimensions and indicators (in red fonts)

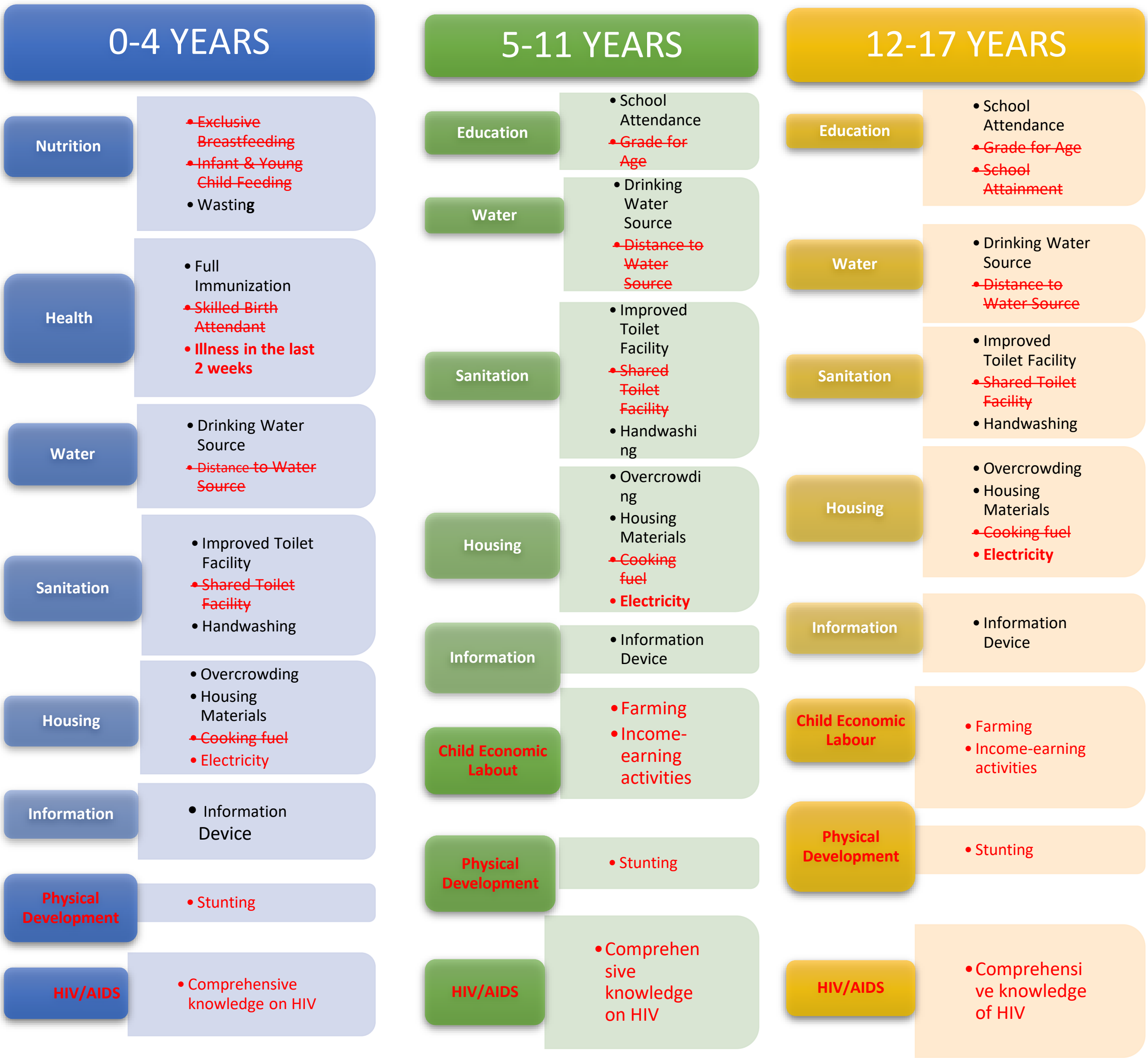


Table 2 details the variables used in the datasets for new indicators to old dimensions as well as new dimensions and indicators, and criteria used to determine deprivation by indicators.

Table 2: New indicators and dimensions in the alternative scenarios

Age group	**Dimension**	**Indicator(s)**	**Note**
All	Housing	Electricity	Child deprived if household has no electricity
	Physical development	Stunting (Height for age)	Child deprived if s/he has a height-for-age value less than two standard deviations below the median of Nigerian reference value
0-4 years	Health	Illnesses in the last two weeks	Child deprived if s/he has had either cough, fever or diarrhoea in the last two weeks
5-11years & 12-17 years	Child economic labour	Farming	Child deprived if engaged in work on plot, farm, food garden, looking after animals
		Income earning activities	Child deprived if engaged in: i. Helping in a family or relative's business or running own business; ii. Production or selling of articles, handcrafts, or clothes; iii. Any other activity for income
0-14 years	HIV	Household knowledge on HIV	Child deprived if no one in the household does not have comprehensive knowledge. Comprehensive knowledge is when respondent responds correctly to 8 of the following 11 questions on HIV/AIDS: i. Ever heard of HIV/AIDS; ii. Can be avoided by having one uninfected partner; iii. Can be contracted by supernatural means; iv. Can be avoided by using the condom correctly all the time; v. Can be contracted from a mosquito bite vi. Can be contracted by sharing food with someone who is infected; vii. Healthy looking person may have HIV/AIDS; viii. Can be transmitted from mother to child during pregnancy; ix. Can be transmitted from mother to child during delivery; x. Can be transmitted from mother to child during breastfeeding; xi. Drugs to infected woman can prevent transmission to baby.
15-17 years	HIV	Child knowledge on HIV	Child deprived if s/he does not have comprehensive knowledge. Comprehensive knowledge is when respondent responds correctly to 8 of the 11 questions listed previously

Rank robustness

The study adopts a rank correlation coefficient method using the Kendall Tau (or Kendall (R^{τ}) and Spearman (R^{ρ}) rank correlation coefficients (Alkire et al., 2015). Rank correlation coefficients will be computed for ranking by multidimensional headcount ratio *H* of the 37 states of Nigeria, the five quintiles of the Wealth index, the three categories of the Education level of household head, and the three categories of the Education level of the child's mother.

The Kendall rank correlation coefficient is computed as the difference in the number of concordant and discordant pairs divided by the total number of pairwise comparisons. A pair is concordant if the comparisons between two objects are the same in both the initial and alternative specification, and vice-versa. The Kendall correlation ranges from -1 to +1. The Kendall rank correlation coefficient has an intuitive interpretation: a Kendall Tau correlation coefficient of 0.90 means that 95% of the pairwise comparisons are concordant (i.e., 5% are discordant (95% minus 5% equals 0.90)).

The Kendall rank correlation coefficient is expressed as:

$$R^{\tau} = \frac{\#\text{Concordant Pairs} - \#\text{Discordant Pairs}}{m(m-1)/2}$$

m = number of observations (number of subgroups)

Rank correlation for Spearman is defined based on pairwise comparisons of the orderings of subgroups (e.g., states) by multidimensional deprivation headcount ratio (*H*), that is, the rankings obtained from the MODA and the ones obtained from an alternative parametric specification. The Spearman correlation coefficient also ranges from -1, which implies that two rankings are perfectly negatively associated, to +1, which implies a perfectly positive association.

The Spearman rank correlation coefficient is expressed as:

$$R^{\rho} = 1 - \frac{6\sum_{\ell=1}^{m}\left(r_{\ell} - r'_{\ell}\right)^2}{m(m^2-1)}$$

where,

m = number of observations (number of subgroups)

r_{ℓ}= the rank attributed to subgroup ℓ in original (MODA) specification

r'_ℓ= the rank attributed to subgroup ℓ in the alternative specification

The set of ranks across m population subgroups is denoted by r = (r1, r2, . . .,rm)

Data Analysis

Description of Data

The Nigeria MICS 2016-17 is the fifth round of its kind and was conducted by the National Bureau of Statistics (NBS) in collaboration with United Nations Children's Fund (UNICEF) as part of the global MICS exercise aimed primarily to collect data on the main indicators related to human development. It contains data on indicators related to child mortality, child and maternal nutrition, child health, reproductive health, water and sanitation, child development, literacy and education, child protection, knowledge of HIV and AIDS, access to mass media and use of information and communication technology, among others. The survey provides estimated disaggregation of Nigeria by states, geopolitical zones, sex, age, residence (urban and rural), mother's education, and wealth quintiles. For the first time, the MICS includes water quality testing and provides data on the quality of drinking water consumed at the household level.

The Nigeria MISC 2016-17 contains both household and individual-level data and a sample size of 37,440 households out of which 35,747 households were visited, 34,289 found to be inhabited, and 33,901 were successfully interviewed, representing a household response rate of 98.9%. In the interviewed households, 36,176 women (age 15-49 years) were identified, and 34,376 were successfully interviewed, giving a response rate of 95% within the interviewed households. A sub-sample of 17,868 households was drawn to identify 16,514 men (age 15-49 years), out of which 15,183 eligible men were successfully interviewed, corresponding to a response rate of 91.9%. In sampled households, 28,578 children under age five were identified, and questionnaires were completed for 28,085 of them, corresponding to a response rate of 98.3%.

Robustness Checks

Using Stata, the dataset is prepared to generate the baseline and alternative scenarios to compute the multidimensional headcount ratios for all children (0-17 years) as well as for the different age groups.[29] Notably, for all children at the national level, the multidimensional headcount ratios in all three alternative scenarios are higher than the ratio at baseline, which

[29] See Annex A for the complete computation of headcount ratio for all scenarios, age groups and profiles

is computed as 53.9%. In Scenario 1, lowering the value of *k* to 2 increases the proportion of Nigerian children who are multiply-deprived to 78.7%. In Scenarios 2 and 3, 58.2% and 65.8% of children, respectively, are multidimensionally deprived. The trend of *H* being highest in Scenario 1, followed by Scenario 3 and then Scenario 2, is also observed across all profiles and all age groups.

The study also computes *H* across the four profiles for all children, and in all age groups. This analysis is followed by determining whether the rankings based on computed multidimensional headcount ratios (*H*) in the original study are robust to the range of proposed parametric changes in each of the alternative scenarios. The robustness checks are accomplished by calculating the correlation between rankings based on the four profiles as mentioned earlier, using the Kendall Tau and Spearman correlation coefficients.[30]

Scenario 1: Change in cut-off (*k*) while keeping other parameters constant

Table 3 shows the findings both for the Kendall Tau and Spearman correlation coefficients for the state rankings, which is a crucial profiling variable that depicts how children are multidimensionally deprived by region (states) and the other profiling variables. The correlation coefficients show that the baseline rankings by *H* are highly robust to the change in cut-off (*k*) from three to two.

Table 3: Computations of the Spearman and Kendall coefficients for different profile rankings at k=2, adjusted for ties

Based on region (states) (N=37)		
	Kendall Tau (R^{τ})	**Spearman (R^{ρ})**
0-17 years	0.880	0.978
0-4 years	0.874	0.972
5-11 years	0.871	0.973
12-17 years	0.904	0.985
Based on Wealth Index *(N=5)*		
0-17 years	1.000 (p=0.0275)	1.000
0-4 years	1.000 (p=0.0275)	1.000
5-11 years	1.000 (p=0.0275)	1.000
12-17 years	1.000 (p=0.0275)	1.000
Based on Education level of household head *(N=3)*		
0-17 years	1.000 (p=0.296)	1.000
0-4 years	1.000 (p=0.296)	1.000
5-11 years	1.000 (p=0.296)	1.000
12-17 years	1.000 (p=0.296)	1.000
Based on Education level of mother *(N=3)*		
0-17 years	1.000 (p=0.296)	1.000
0-4 years	1.000 (p=0.296)	1.000
5-11 years	1.000 (p=0.296)	1.000
12-17 years	1.000 (p=0.296)	1.000

Source: Author's calculations using Nigeria MICS 5 2016-17

[30] Where the p-values are omitted, it means a p-value of 0.000 was obtained.

Under the profile region which tests the robustness of the state rankings, for all ages (0-17 years) the Kendall Tau coefficient is a statistically significant value (p=0.000) of 0.88, inferring 88% similarity in the total pairwise comparisons of the baseline (*k*=3) and the alternative(*k*=2) scenarios. In other words, 94% of state rankings are concordant with the original ranking at *k*=3, and 6% are discordant (Alkire, et al., 2015, p. 239).

Figures 4 and 5 show the changes in pairwise rankings from region to region for children aged 0-17 years and 0-4 years, respectively. For all children, the most significant[31] changes in

Figure 4: Rank robustness of multidimensional headcount ratio (H), in all children by region, to changes in deprivation cut-off, k, from 3 (baseline) to 2 dimensions.

Source: Author's calculations using Nigeria MICS 5 2016-17

Rank	Base Scenario	0-17 years	Scenario 1
1	Lagos		Edo
2	Edo		Anambra
3	Imo		Imo
4	Ekiti		Abia
5	Rivers		Rivers
6	Abia		Lagos
7	Anambra		Ekiti
8	Osun		Delta
9	Ogun		Osun
10	Delta		Ogun
11	FCT Abuja		FCT Abuja
12	Bayelsa		Kwara
13	Enugu		Akwa Ibom
14	Kwara		Ondo
15	Akwa Ibom		Enugu
16	Ondo		Bayelsa
17	Oyo		Oyo
18	Kogi		Kogi
19	Cross River		Cross River
20	Benue		Kaduna
21	Kaduna		Plateau
22	Nasarawa		Benue
23	Ebonyi		Niger
24	Niger		Nasarawa
25	Plateau		Ebonyi
26	Kano		Kano
27	Borno		Katsina
28	Adamawa		Borno
29	Katsina		Adamawa
30	Bauchi		Bauchi
31	Yobe		Taraba
32	Taraba		Gombe
33	Jigawa		Kebbi
34	Gombe		Zamfara
35	Zamfara		Yobe
36	Kebbi		Sokoto
37	Sokoto		Jigawa

Figure 5: Rank robustness of multidimensional headcount ratio (H) in children 0-4 years by region, to changes in deprivation cut-off, k, from 3 (baseline) to 2 dimensions.

Source: Author's calculations using Nigeria MICS 5 2016-17

Rank	Baseline scenario	0-4 years	Scenario 1
1	Rivers		Rivers
2	Lagos		Lagos
3	Anambra		Edo
4	Ekiti		Anambra
5	Edo		FCT Abuja
6	FCT Abuja		Ekiti
7	Imo		Osun
8	Osun		Imo
9	Kwara		Delta
10	Ogun		Kwara
11	Abia		Abia
12	Delta		Ogun
13	Enugu		Enugu
14	Bayelsa		Akwa Ibom
15	Kogi		Bayelsa
16	Akwa Ibom		Ondo
17	Ondo		Kaduna
18	Oyo		Kogi
19	Kaduna		Cross River
20	Benue		Oyo
21	Cross River		Plateau
22	Nasarawa		Niger
23	Plateau		Benue
24	Niger		Nasarawa
25	Ebonyi		Kano
26	Borno		Katsina
27	Kano		Ebonyi
28	Adamawa		Bauchi
29	Yobe		Adamawa
30	Katsina		Kebbi
31	Jigawa		Borno
32	Kebbi		Taraba
33	Bauchi		Gombe
34	Taraba		Yobe
35	Gombe		Zamfara
36	Zamfara		Sokoto
37	Sokoto		Jigawa

[31] Defined by the author as deviation from the original ranking by more than 3 positions up or down in rank.

rankings include Lagos, the least poor state at *k*=3 moving from position 1 down to position 6 at *k*=2; Anambra moving up the ranks from position 7 to 2. The others are changes by four places, including Bayelsa from 12th down to 16th; Plateau from 25th up to 21st; Yobe 31st down to 35th; and Jigawa from 33rd to 37th (Figure 4).

The Spearman coefficient gives a higher and equally statistically significant value of 0.978, which suggests that 97.8% of pairwise comparisons are robust to changes. Overall, both the Kendall and Spearman coefficients suggest that the overall state rankings of multidimensional poverty headcount ratios are highly robust to the alteration of poverty cut-off. For the age group 0-4 years, the R^{τ} is 0.874, implying that the state rankings are concordant with the original ranking (Table 3). An R^{ρ} of 0.972 suggests that 97.2% of the original ranking is highly robust to the change in poverty cut-off. The coefficients are statistically significant (p=0.000).

Figure 5 shows changes in rankings for children aged 0-4 years, with only 5 states moving more than three positions on the rankings: Jigawa from 31st to 37th position, becoming the poorest state; Borno and Yobe down in ranking by five places from 26th to 31st and 29th to 34th respectively; and Bauchi up the rank from 33rd to 28thand Katsina from 30th to 26th. Of the remaining 33 states, four maintained their ranks, nine moved by one rank, 16 by two ranks, and 3 by three ranks.

For the age group, 5-11 years, the R^{τ} and R^{ρ} suggest 87.1% and 97.3% robustness respectively and are statistically significant at p=0.000 (Table 3). Figure 6 shows 6 states moving more than three positions on the rankings: Lagos down to 7th position from being the least poor state; Bayelsa from 11th to 16th; Edo, FCT Abuja, and Plateau moving four ranks up from 5th to 1st, 14th to 10th and 25th to 21st respectively, and Jigawa from 32nd to 36th. Of all states, 10 have their ranks unchanged, while 6 have changes one rank, 13 two ranks, and 2 states moved by three ranks (Figure 6).

The highest robustness for Scenario 1 is seen in the age group 12-17 years, with both the R^{τ} and R^{ρ} being statistically significant (p=0.000) at 0.904 and 0.985, respectively (Table 3). As shown in Figure 7, only 2 states (change ranks by more than three positions Kebbi – 35th to 31st and Adamawa – 25th to 29th), while 10 states retain their rankings, 10 change by one level, 10 by two ranks, and four by three ranks.

For the other three ranking profiles – Wealth index, Education level of household head, and Education level of mother, both the R^T and R^ρ are 1 for all categories of age group, suggesting

Figure 6: Rank robustness of multidimensional headcount ratio (H) in children 5-11 years by region, to changes in deprivation cut-off, k, from 3 (baseline) to 2 dimensions

Source: Author's calculations using Nigeria MICS 5 2016-17

5-11 years

Rank	Baseline Scenario	Scenario 1
1	Lagos	Edo
2	Imo	Imo
3	Ekiti	Abia
4	Abia	Anambra
5	Edo	Ekiti
6	Anambra	Delta
7	Rivers	Rivers
8	Osun	Lagos
9	Delta	Osun
10	Ogun	FCT Abuja
11	Bayelsa	Ogun
12	Enugu	Enugu
13	Akwa Ibom	Kwara
14	FCT Abuja	Akwa Ibom
15	Oyo	Ondo
16	Kwara	Bayelsa
17	Ondo	Oyo
18	Kogi	Kogi
19	Cross River	Cross River
20	Nasarawa	Kaduna
21	Benue	Plateau
22	Kaduna	Nasarawa
23	Ebonyi	Ebonyi
24	Niger	Benue
25	Plateau	Niger
26	Kano	Kano
27	Borno	Katsina
28	Adamawa	Borno
29	Katsina	Bauchi
30	Bauchi	Adamawa
31	Taraba	Taraba
32	Jigawa	Gombe
33	Yobe	Zamfara
34	Gombe	Kebbi
35	Zamfara	Yobe
36	Kebbi	Jigawa
37	Sokoto	Sokoto

Figure 7: Rank robustness of multidimensional headcount ratio (H) in children 12-17 years by region to changes in deprivation cut-off k from 3 (baseline) to 2 dimensions

Source: Author's calculations using Nigeria MICS 5 2016-17

12-17 years

Rank	Baseline Scenario	Scenario 1
1	Edo	Abia
2	Lagos	Imo
3	Imo	Edo
4	Abia	Anambra
5	Anambra	Lagos
6	Rivers	Delta
7	Ogun	Rivers
8	Delta	Ogun
9	Ekiti	Osun
10	Osun	Ekiti
11	Ondo	Ondo
12	Akwa Ibom	Akwa Ibom
13	Kwara	Kwara
14	Oyo	FCT Abuja
15	Enugu	Enugu
16	FCT Abuja	Bayelsa
17	Bayelsa	Oyo
18	Cross River	Cross River
19	Kogi	Kogi
20	Benue	Kaduna
21	Kaduna	Benue
22	Nasarawa	Kano
23	Niger	Niger
24	Kano	Plateau
25	Adamawa	Nasarawa
26	Plateau	Ebonyi
27	Ebonyi	Borno
28	Katsina	Katsina
29	Borno	Adamawa
30	Gombe	Zamfara
31	Bauchi	Kebbi
32	Zamfara	Gombe
33	Yobe	Bauchi
34	Taraba	Taraba
35	Kebbi	Yobe
36	Jigawa	Sokoto
37	Sokoto	Jigawa

100% robustness of the rankings based on these profiles (Table 3). This finding implies that the study should fail to reject the Null Hypothesis that the rankings based on these profiles are independent across the scenarios. However, given that the sample size is small (N=3), plus the corresponding p-value of 0.000 for the R^ρ in all age groups, the rankings are considered highly robust.

Scenario 2: Changes at indicator level while keeping original dimensions at *k*=3

The summary of the Kendall and Spearman coefficients for the rankings obtained when indicators are altered is shown in Table 4 below.

The figures suggest a high robustness of the multidimensional headcount ratio to changes across the profiles. Under the profile region, the state rankings for all ages (0-17 years) are highly robust. The R^{τ} has a statistically significant value (p=0.000) of 0.960, which suggests that 96% of pairwise comparisons are robust to the changes at the indicator level. The R^{ρ}, at 99.6% (p=0.000), implies nearly perfect robustness.

Table 4: Computations of the Spearman and Kendall coefficients for different profile rankings with changes at indicator level and k=3, adjusted for ties

Based on region (states) (N=37)		
	Kendall Tau (R^{τ})	**Spearman (R^{ρ})**
0-17 years	0.960	0.996
0-4 years	1.000	1.000
5-11 years	0.967	0.996
12-17 years	0.892	0.978
Based on Wealth Index *(N=5)*		
0-17 years	1.000 (p=0.0275)	1.000
0-4 years	1.000 (p=0.0275)	1.000
5-11 years	1.000 (p=0.0275)	1.000
12-17 years	1.000 (p=0.0275)	1.000
Based on Education level of household head *(N=3)*		
0-17 years	1.000 (p=0.296)	1.000
0-4 years	1.000 (p=0.296)	1.000
5-11 years	1.000 (p=0.296)	1.000
12-17 years	1.000 (p=0.296)	1.000
Based on Education level of mother *(N=3)*		
0-17 years	1.000 (p=0.296)	1.000
0-4 years	1.000 (p=0.296)	1.000
5-11 years	1.000 (p=0.296)	1.000
12-17 years	1.000 (p=0.296)	1.000

Source: Author's calculations using Nigeria MICS 5 2016-17

Figure 8 presents the rank robustness for scenario 2 for all children. While 14 states retained their exact pairwise ranking, 22 states only changed ranking by one or two positions. Only Rivers state moves by more than two positions, from the fifth least poor to the second least poor. Hence there is no significant change in rankings.

For the age group 0-4 years (Figure 9), the coefficients suggest a perfect preservations of the ranks, in that all 37 states retain their original positioning. The R^{τ} and R^{ρ} values are 1.000 and coefficients are statistically significant (p=0.000) (Table 4).

Figure 8: Rank robustness of multidimensional headcount ratio (H) in all children by region, to changes at indicator level at k=3

Source: Author's calculations using Nigeria MICS 5 2016-17

Rank	Base scenario (0-17 years)	Scenario 2
1	Lagos	Lagos
2	Edo	Rivers
3	Imo	Imo
4	Ekiti	Edo
5	Rivers	Ekiti
6	Abia	Anambra
7	Anambra	Abia
8	Osun	Ogun
9	Ogun	Osun
10	Delta	FCT Abuja
11	FCT Abuja	Delta
12	Bayelsa	Kwara
13	Enugu	Bayelsa
14	Kwara	Enugu
15	Akwa Ibom	Akwa Ibom
16	Ondo	Kogi
17	Oyo	Ondo
18	Kogi	Oyo
19	Cross River	Cross River
20	Benue	Benue
21	Kaduna	Kaduna
22	Nasarawa	Nasarawa
23	Ebonyi	Niger
24	Niger	Ebonyi
25	Plateau	Plateau
26	Kano	Kano
27	Borno	Adamawa
28	Adamawa	Borno
29	Katsina	Katsina
30	Bauchi	Yobe
31	Yobe	Bauchi
32	Taraba	Jigawa
33	Jigawa	Taraba
34	Gombe	Gombe
35	Zamfara	Zamfara
36	Kebbi	Kebbi
37	Sokoto	Sokoto

Figure 9: Rank robustness of multidimensional headcount ratio (H) in children 0-4 years by region, to changes at indicator level at k=3

Source: Author's calculations using Nigeria MICS 5 2016-17

Rank	Baseline Scenario (0-4 years)	Scenario 2
1	Rivers	Rivers
2	Lagos	Lagos
3	Anambra	Anambra
4	Ekiti	Ekiti
5	Edo	Edo
6	FCT Abuja	FCT Abuja
7	Imo	Imo
8	Osun	Osun
9	Kwara	Kwara
10	Ogun	Ogun
11	Abia	Abia
12	Delta	Delta
13	Enugu	Enugu
14	Bayelsa	Bayelsa
15	Kogi	Kogi
16	Akwa Ibom	Akwa Ibom
17	Ondo	Ondo
18	Oyo	Oyo
19	Kaduna	Kaduna
20	Benue	Benue
21	Cross River	Cross River
22	Nasarawa	Nasarawa
23	Plateau	Plateau
24	Niger	Niger
25	Ebonyi	Ebonyi
26	Borno	Borno
27	Kano	Kano
28	Adamawa	Adamawa
29	Yobe	Yobe
30	Katsina	Katsina
31	Jigawa	Jigawa
32	Kebbi	Kebbi
33	Bauchi	Bauchi
34	Taraba	Taraba
35	Gombe	Gombe
36	Zamfara	Zamfara
37	Sokoto	Sokoto

The age group 5-11 years also shows high robustness in rankings with the R^{τ} and R^{ρ} at 0.967 and 0.996 (p=0.000), respectively (Table 4). According to Figure 10, 22 states retain their positions, 12 states move only one rank, 2 states by two ranks, and only 1 state (Oyo) moves by three ranks.

Figure 10: Rank robustness of multidimensional headcount ratio (H) in children 5-11 years by region, to changes at indicator level at k=3

Source: Author's calculations using Nigeria MICS 5 2016-17

5-11 years

Rank	Baseline Scenario	Scenario 2
1	Lagos	Lagos
2	Imo	Imo
3	Ekiti	Ekiti
4	Abia	Abia
5	Edo	Edo
6	Anambra	Anambra
7	Rivers	Rivers
8	Osun	Osun
9	Delta	Ogun
10	Ogun	Delta
11	Bayelsa	Bayelsa
12	Enugu	Enugu
13	Akwa Ibom	FCT Abuja
14	FCT Abuja	Akwa Ibom
15	Oyo	Kwara
16	Kwara	Ondo
17	Ondo	Kogi
18	Kogi	Oyo
19	Cross River	Cross River
20	Nasarawa	Nasarawa
21	Benue	Benue
22	Kaduna	Kaduna
23	Ebonyi	Ebonyi
24	Niger	Niger
25	Plateau	Plateau
26	Kano	Kano
27	Borno	Katsina
28	Adamawa	Adamawa
29	Katsina	Borno
30	Bauchi	Jigawa
31	Taraba	Bauchi
32	Jigawa	Yobe
33	Yobe	Taraba
34	Gombe	Gombe
35	Zamfara	Zamfara
36	Kebbi	Kebbi
37	Sokoto	Sokoto

Figure 11: Rank robustness of multidimensional headcount ratio (H) in children 12-17 years by region, to changes at indicator level at k=3

Source: Author's calculations using Nigeria MICS 5 2016-17

12-17 years

Rank	Baseline Scenario	Scenario 2
1	Edo	Rivers
2	Lagos	Edo
3	Imo	Imo
4	Abia	Abia
5	Anambra	Ogun
6	Rivers	Lagos
7	Ogun	Osun
8	Delta	Delta
9	Ekiti	Ekiti
10	Osun	Anambra
11	Ondo	Kwara
12	Akwa Ibom	Akwa Ibom
13	Kwara	FCT Abuja
14	Oyo	Bayelsa
15	Enugu	Ondo
16	FCT Abuja	Cross River
17	Bayelsa	Oyo
18	Cross River	Kogi
19	Kogi	Enugu
20	Benue	Benue
21	Kaduna	Nasarawa
22	Nasarawa	Kaduna
23	Niger	Niger
24	Kano	Kano
25	Adamawa	Adamawa
26	Plateau	Katsina
27	Ebonyi	Plateau
28	Katsina	Ebonyi
29	Borno	Borno
30	Gombe	Yobe
31	Bauchi	Zamfara
32	Zamfara	Taraba
33	Yobe	Gombe
34	Taraba	Bauchi
35	Kebbi	Kebbi
36	Jigawa	Jigawa
37	Sokoto	Sokoto

In the age group 12-17 years, the R^{τ} and R^{ρ} are 0.892 and 0.978, respectively (p=0.000) (Table 4). The R^{τ}, while relatively low in comparison with the other age groups and the corresponding R^{ρ}, still suggests high robustness for this age group. According to Figure 11, significant rank changes include Rivers state moving five ranks from the sixth least poor to the least poor region. Furthermore, Anambra is down by five ranks from 5th to 10th, while Lagos, Ondo, and Enugu are down four ranks from 2nd to 6th, 11th to 15th, and 15th to 19th, respectively.

Of the remaining 32 states, 13 retain their positions and 12 change positions by one or two ranks, while 7 states change ranks by three positions (Figure 11).

The R^{τ} and R^{ρ} are the same in this scenario for the other three ranking profiles – Wealth index, Education level of household head, and Education level of mother – as they are in Scenario 1. As shown in Table 4, the p-values are also the same for the different age categories for all corresponding profiles across the two scenarios. For the high p-value of 0.296 for the profiles Education level of household head and Education level of mother, the study offers the same explanation provided for the same observation under Scenario 1.

Scenario 3: Inclusion of new dimensions to Scenario 2 with *k* unchanged

Table 5 summarises the respective R^{τ} and R^{ρ} for the robustness check across age groups and profiles for Scenario 3, where simultaneously, new dimensions are introduced and existing indicators altered. The correlation coefficients suggest generally high robustness ranging from 0.784 and 0.936 (Kendall Tau and Spearman respectively) in the age group 0-4 years to 0.856 and 0.964 (Kendall Tau and Spearman respectively) for all children (0-17 years) for the state rankings. For the other profiles, the coefficients suggest perfect rank correlations (1.000) as in the previous scenarios.

Table 5: **Computations of the Spearman and Kendall coefficients for different profile rankings with the inclusion of new dimensions and k=3, adjusted for ties**

Based on region (states) (N=37)		
	Kendall Tau (R^{τ})	**Spearman (R^{ρ})**
0-17 years	0.856	0.964
0-4 years	0.793	0.936
5-11 years	0.841	0.957
12-17 years	0.826	0.947
Based on Wealth Index *(N=5)*		
0-17 years	1.000 (p=0.0275)	1.000
0-4 years	1.000 (p=0.0275)	1.000
5-11 years	1.000 (p=0.0275)	1.000
12-17 years	1.000 (p=0.0275)	1.000
Based on Education level of household head *(N=3)*		
0-17 years	1.000 (p=0.296)	1.000
0-4 years	1.000 (p=0.296)	1.000
5-11 years	1.000 (p=0.296)	1.000
12-17 years	1.000 (p=0.296)	1.000
Based on Education level of mother *(N=3)*		
0-17 years	1.000 (p=0.296)	1.000
0-4 years	1.000 (p=0.296)	1.000
5-11 years	1.000 (p=0.296)	1.000
12-17 years	1.000 (p=0.296)	1.000

Source: Author's calculations using Nigeria MICS 5 2016-17

Figure 12: Rank robustness of multidimensional headcount ratio (H) in all children by region, to changes at both indicator and dimension levels at k=3

Source: Author's calculations using Nigeria MICS 5 2016-17

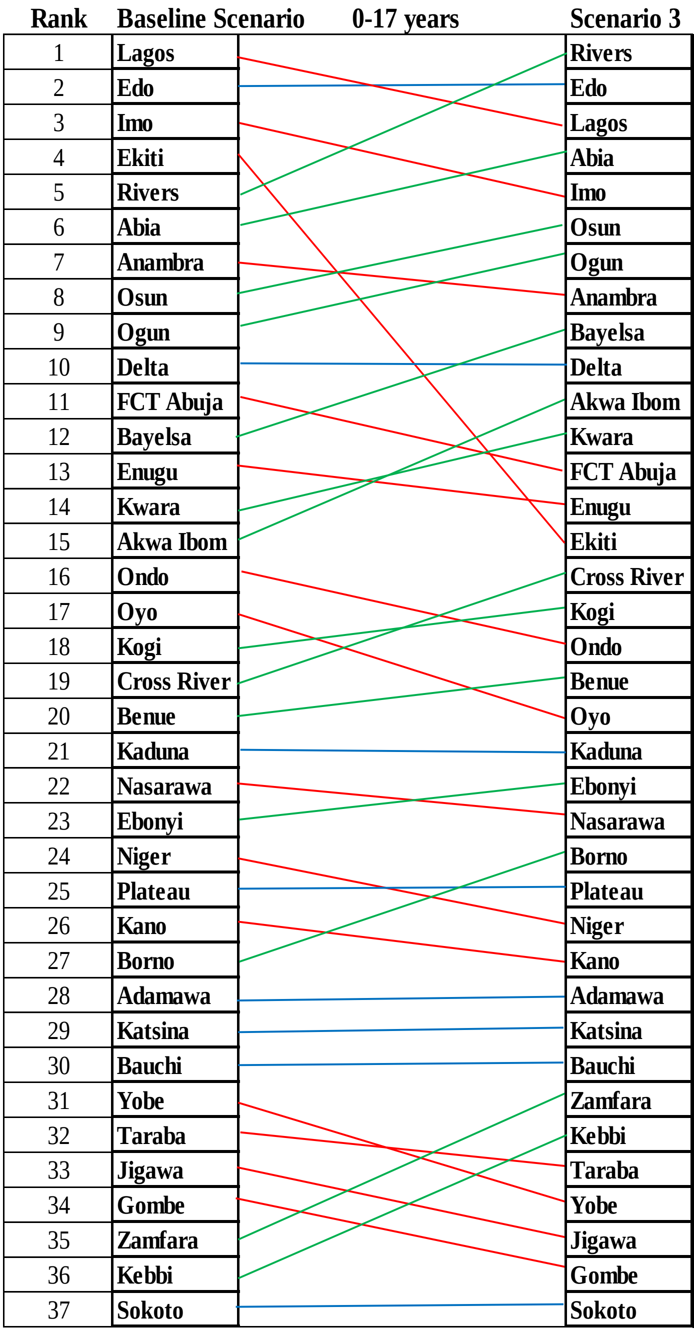
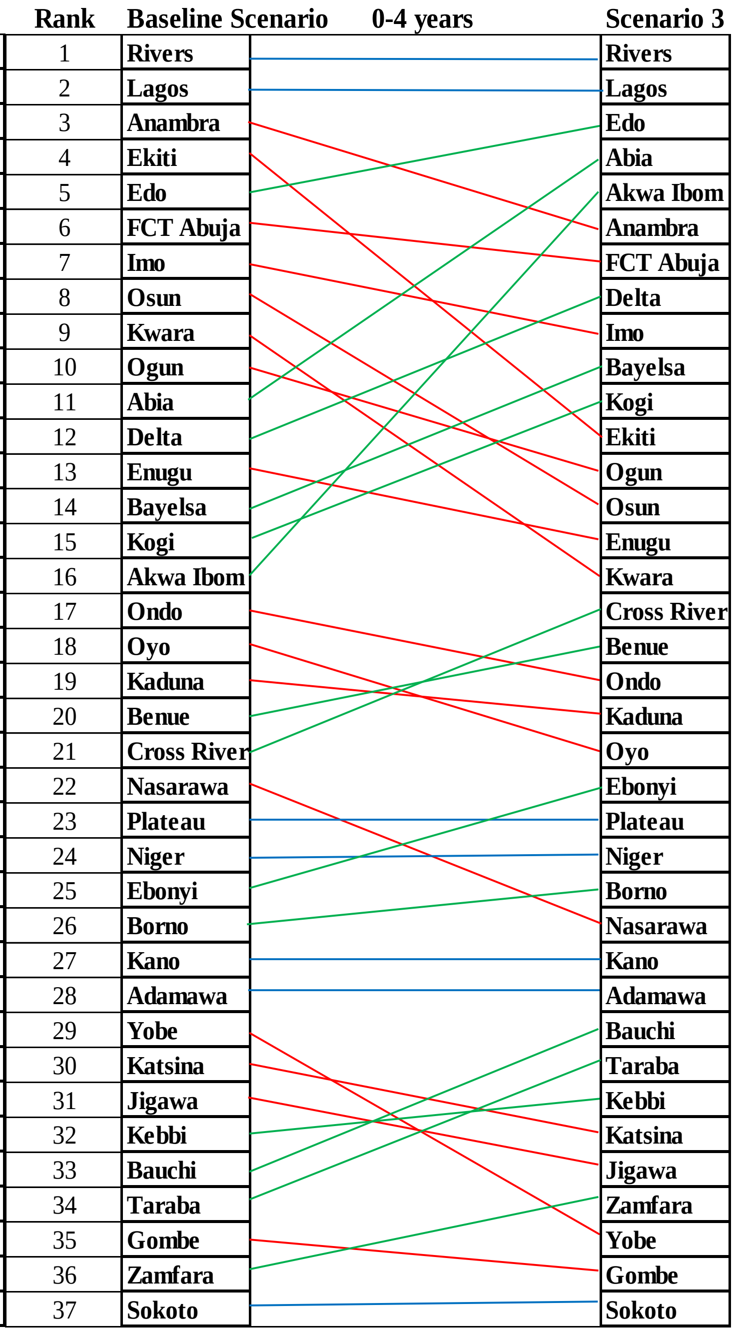


Figure 13: Rank robustness of multidimensional headcount ratio (H) in children 0-4 years by region, to changes at both indicator and dimension levels at k=3

Source: Author's calculations using Nigeria MICS 5 2016-17



The region profile has R^{τ} and R^{ρ} of 0.856 and 0.964 (p=0.000) for children of all ages, implying 85.6% and 96.4% robustness by the two scoring criteria. Figure 12 compares the ranking with the baseline scenario for all children. Of all states, 5 significantly change ranks: Ekiti from 4th to 13th; Rivers, Akwa Ibom, Zamfara and Kebbi moving up four ranks from 5th to 1st, 15th to 11th, 35th to 21st and 36th to 32nd respectively. Of the remaining states, 8 maintain their ranks, 8 move by one rank, 11 by two ranks, and 5 states move three ranks.

For the age group 0-4 years, R^{τ} and R^{ρ} are 0.793 and 0.936 (p=0.000) (Table 5). The recorded Kendall correlation coefficient is the lowest score across all the age groups, scenarios, and profiles in this study, and it implies that most of the state rankings are concordant with the baseline ranking and a small proportion of rankings are discordant.

As shown in Figure 13, the most significant changes in ranks for the age group 0-4 are for Akwa Ibom who moved up the rank with eleven places from 16th to 5th, and Ekiti who moved down eight ranks from 4th to 12th. Notable changes have been observed also for Abia (up seven places), Kwara (down seven places), Osun and Yobe (down six positions), Bauchi and Taraba (up four ranks), Delta, Bayelsa, Kogi, and Cross River (up 4 positions), and Nasarawa (down four ranks). Of the remaining 23 states, 7 maintained their ranks, 5 states move by one rank, 6 by two ranks, and 4 states by three ranks.

The age group 5-11 records values for R^{τ} and R^{ρ} at 0.841 and 0.957 (p=0.000), respectively (Table 5). Figure 14 shows that 7 states significantly change ranks, and they are Ekiti (down twelve positions), Kwara (up five ranks), Enugu and Zamfara (up four ranks), Delta, Oyo, and Taraba (down four ranks). Of the remaining states, 9 maintain their ranks (including Lagos retaining its position as the least poor state), 6 states move by one rank, 6 by two ranks, and 9 by three ranks.

In the age group 12-17, R^{τ} and R^{ρ} are 0.826 and 0.947 respectively (p=0.000) (Table 5). As per Figure 15, significant changes in ranks include Anambra (dropped ten places), Ekiti (down by seven places, Gombe (down by six ranks), Rivers, FCT Abuja and Bayelsa (up by five ranks), Enugu (down by five ranks), Osun, Kwara, Cross River, and Yobe (up by six ranks), and Oyo and Ebonyi (down by four positions). While 8 states do not change ranks, 8 move by one rank, 5 by two ranks, and 3 by three ranks (Figure 15).

The findings for profiles Wealth index, Education level of household head, and Education level of mother are the same as in the previous scenarios.

Figure 14: Rank robustness of multidimensional headcount ratio (H) in children 5-11 years by region, to changes at both indicator and dimension levels at k=3

Source: Author's calculations using Nigeria MICS 5 2016-17

5-11 years

Rank	Baseline Scenario	Scenario 3
1	Lagos	Lagos
2	Imo	Edo
3	Ekiti	Abia
4	Abia	Rivers
5	Edo	Imo
6	Anambra	Osun
7	Rivers	Ogun
8	Osun	Enugu
9	Delta	Anambra
10	Ogun	Bayelsa
11	Bayelsa	Kwara
12	Enugu	Akwa Ibom
13	Akwa Ibom	Delta
14	FCT Abuja	Ondo
15	Oyo	Ekiti
16	Kwara	FCT Abuja
17	Ondo	Cross River
18	Kogi	Kogi
19	Cross River	Oyo
20	Nasarawa	Benue
21	Benue	Ebonyi
22	Kaduna	Kaduna
23	Ebonyi	Nasarawa
24	Niger	Borno
25	Plateau	Plateau
26	Kano	Kano
27	Borno	Niger
28	Adamawa	Adamawa
29	Katsina	Katsina
30	Bauchi	Bauchi
31	Taraba	Zamfara
32	Jigawa	Yobe
33	Yobe	Jigawa
34	Gombe	Kebbi
35	Zamfara	Taraba
36	Kebbi	Gombe
37	Sokoto	Sokoto

Figure 15: Rank robustness of multidimensional headcount ratio (H) in children 12-17 years by region, to changes at both indicator and dimension levels at k=3

Source: Author's calculations using Nigeria MICS 5 2016-17

12-17 years

Rank	Baseline Scenario	Scenario 3
1	Edo	Rivers
2	Lagos	Edo
3	Imo	Imo
4	Abia	Lagos
5	Anambra	Abia
6	Rivers	Osun
7	Ogun	Ogun
8	Delta	Delta
9	Ekiti	Kwara
10	Osun	Akwa Ibom
11	Ondo	FCT Abuja
12	Akwa Ibom	Bayelsa
13	Kwara	Ondo
14	Oyo	Cross River
15	Enugu	Anambra
16	FCT Abuja	Kogi
17	Bayelsa	Ekiti
18	Cross River	Oyo
19	Kogi	Benue
20	Benue	Enugu
21	Kaduna	Kaduna
22	Nasarawa	Nasarawa
23	Niger	Kano
24	Kano	Niger
25	Adamawa	Adamawa
26	Plateau	Borno
27	Ebonyi	Plateau
28	Katsina	Katsina
29	Borno	Yobe
30	Gombe	Zamfara
31	Bauchi	Ebonyi
32	Zamfara	Bauchi
33	Yobe	Kebbi
34	Taraba	Jigawa
35	Kebbi	Taraba
36	Jigawa	Gombe
37	Sokoto	Sokoto

Comparison of Multidimensional Headcount Ratio by Dimensions (Base scenario versus Scenario 3)[32]

The Nigeria MODA study, as part of sectoral analysis, investigated the deprivation rates by each dimension for the three categories of age group[33]. In Scenario 3, new dimensions are

[32] Rank robustness using Kendall Tau and Spearman correlation coefficients is not done here because the pairs are unequal between the baseline scenario and Scenario 3.
[33] See Annex B for full listing of deprivation headcount ratios by dimensions for all age groups in all regions.

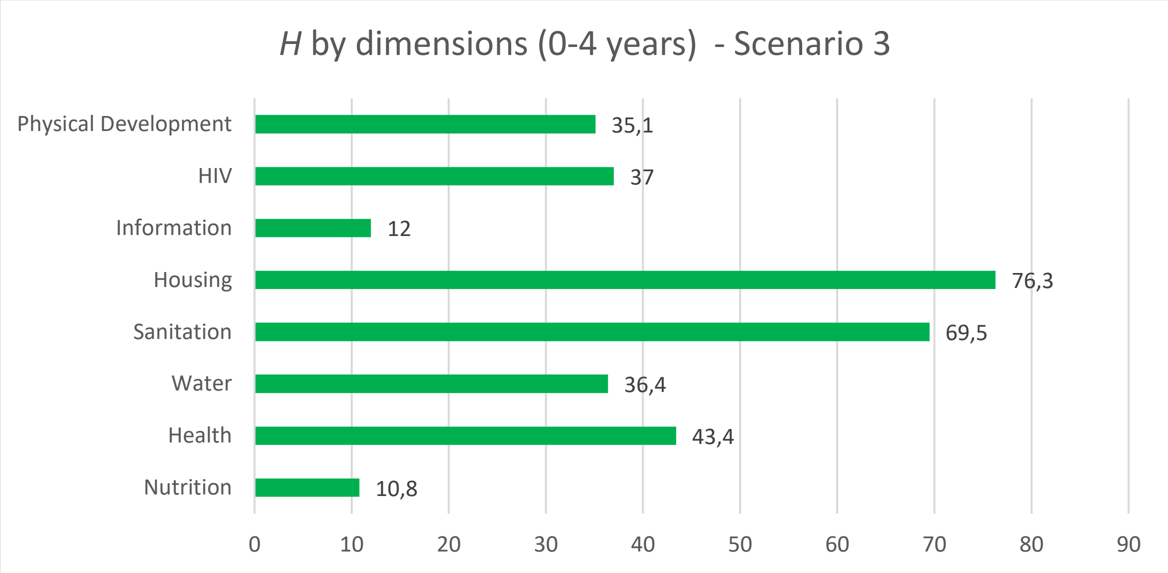
introduced in addition to existing dimensions (except for the Information dimension),[34] which was already modified in Scenario 2 through changes at the indicator level. The new dimensions that were introduced are HIV, physical development, and child economic labour. The study finds that 37% of children 0-4 years, 39.1% of children 5-11 years and 43% of children 12-17 years are deprived in the dimension of HIV. In dimension physical development, 35.1%, 39.3%, and 40.4% of children 0-4 years, 5-11 years, and 12-17 years, respectively, are deprived, while 40.1% of children 5-11 years and 47.9% of children 12-17 years are vulnerable to child economic labour. These findings underscore the significance of broadening the dimensions for national multidimensional poverty studies. They also highlight the importance of multidisciplinary and multisectoral approaches to fighting child poverty. The study also investigated how the changes introduced change in values of *H* for existing dimensions (except for the dimension Information which remains unchanged). All changes in deprivation headcount are statistically significant at p=0.000.

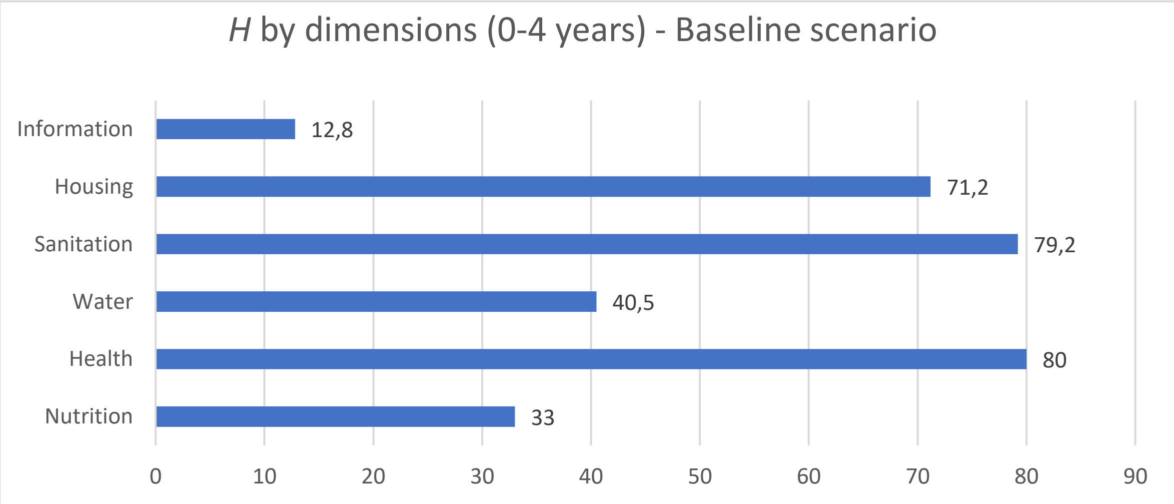
Figures 16, 17, and 18 depict the changes in both the absolute and relative contributions of each dimension in response to the parametric changes in Scenario 3. In the original study, 80% of children 0-4 years are deprived in Health[35] (Figure 16). This proportion becomes 43.4% in Scenario 3 when the indicator skilled birth attendance is replaced with the indicator illnesses in the last two weeks (Figure 16). This finding suggests that less Nigerian children of 0-4 years suffer from illness than not having skilled birth attendance during delivery. The dimension sanitation shares the same indicators across the age groups and is also a household level indicator. Across all age groups, the values of *H* are statistically lower in Scenario 3 than in the base scenario of Nigeria MODA. This outcome reflects the effect of dropping the indicator shared toilet facility without replacement, which reduces the overall multidimensional headcount ratio of the dimension sanitation across all the age groups.

In the case of the dimension housing, where availability of electricity replaces the indicator cooking fuel, the headcount ratio increases significantly in Scenario 3 for all the age groups (Figures 16, 17, and 18). This implies that indicator Electricity contributes more to multidimensional deprivation than Cooking fuel.

[34] The variations in the headcount ratios in dimension Information across both scenarios for age groups 0-4 years and 5-11 years are reported by Stata as statistically not significant.
[35] The Nigeria MODA study reported 73.3% as headcount deprivation rate for the dimension health, but it was for age group 0-23 months.

Figure 16: Deprivation headcount ratio (H) by dimensions across Baseline scenario and Scenario 3 (0-4 years)



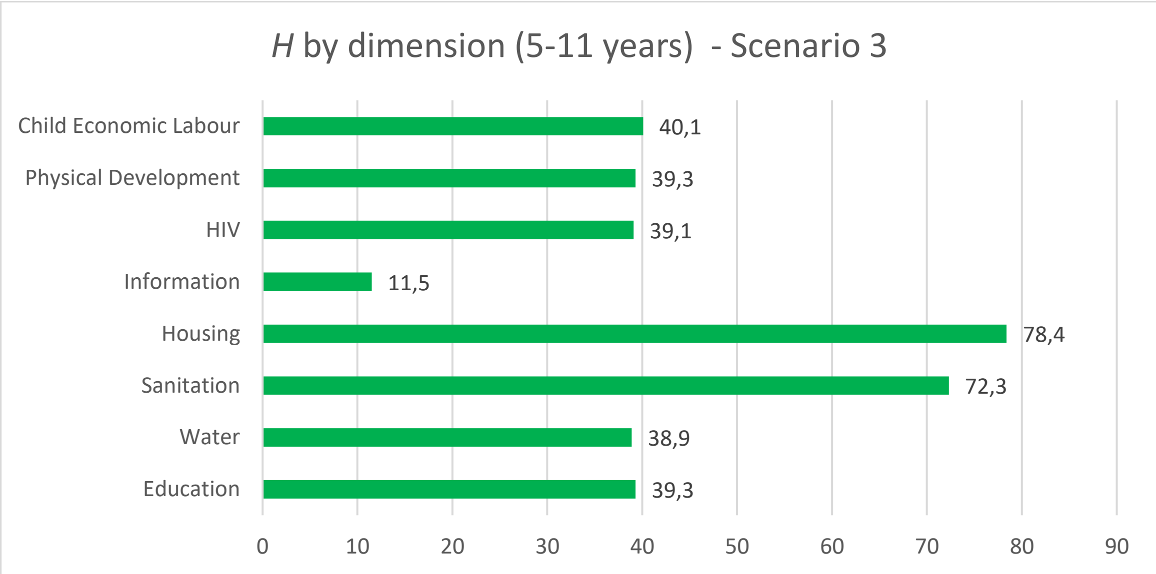


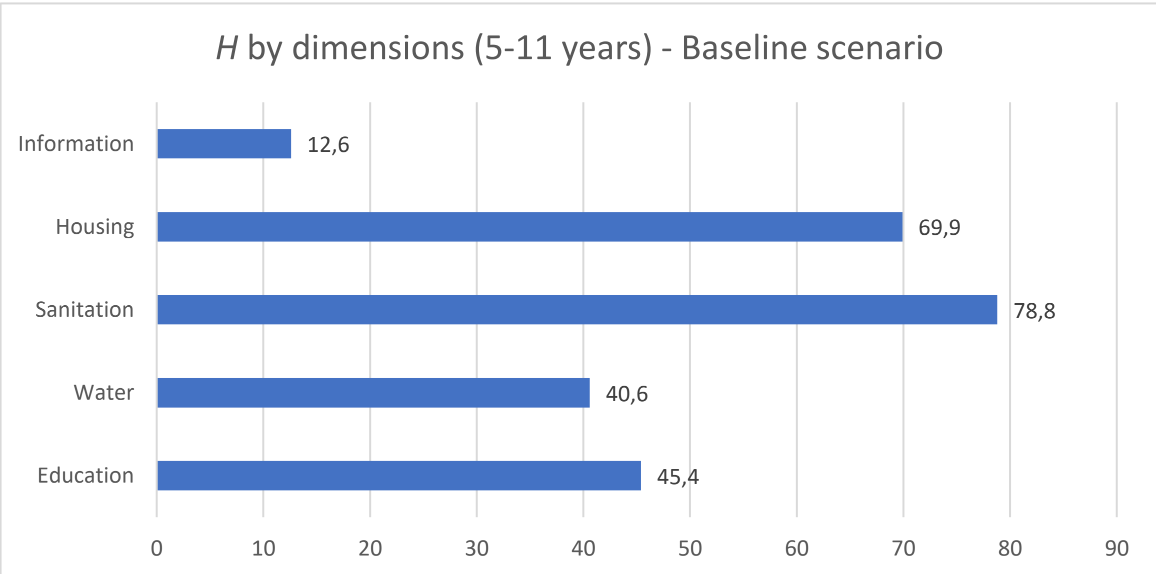
Source: Author's calculations using Nigeria MICS 5 2016-17

In the dimension Water where the indicator distance to water source is dropped, and drinking water source is retained as the only indicator (Scenario 3), the headcount ratio also falls across all the age groups (Figures 16, 17, and 18). The same applies to nutrition (0-4 years), where the only indicator in Scenario 3 (wasting) gives a headcount ratio of 10.8%, a much lower value than the 33% obtained in the baseline scenario. Expectedly there is no change in the *H* value for the dimension information across all the age groups as the indicator is not altered across the scenarios (Figures 16, 17, and 18).

In the age group 5-11 years, where the dimension education is altered in Scenario 3 by dropping the indicator grade-for-age without replacement, the multidimensional headcount ratio falls from 49.4% to 39.3% (Figure 17). A similar effect occurs in the age group 12-17 years, where two indicators, grade-for-age and gchool attainment, are dropped, leaving school attendance as the sole indicator for the dimension (Figure 18). The deprivation headcount by the dimension education is reduced from 61.7% in the baseline scenario to 42.2% in Scenario 3.

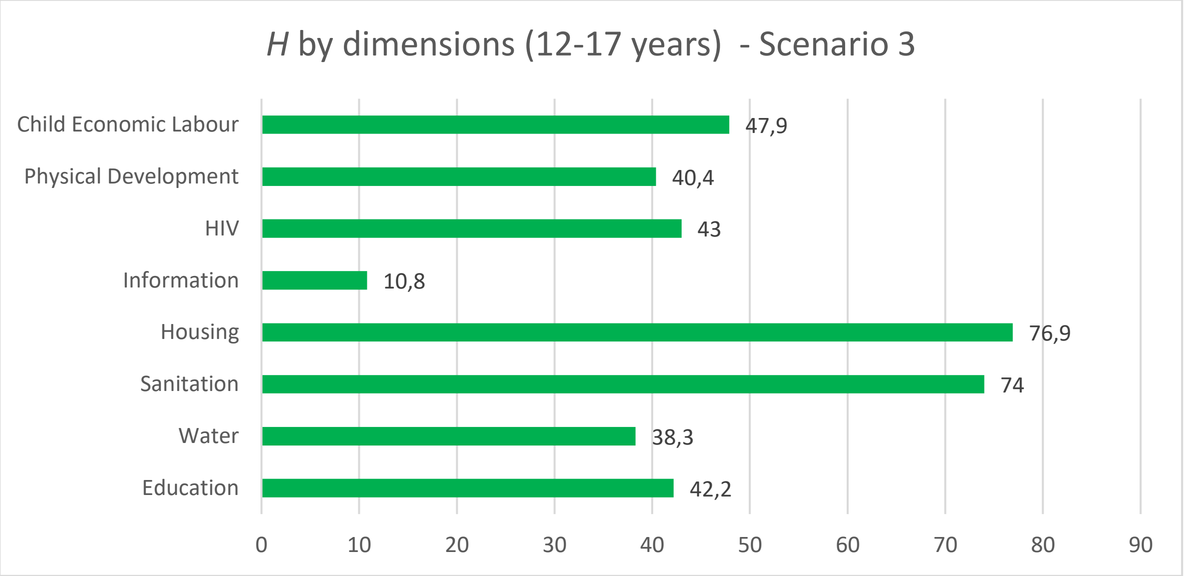
Figure 17: Deprivation headcount ratio (H) by dimensions across Baseline scenario and Scenario 3 (5-11 years).

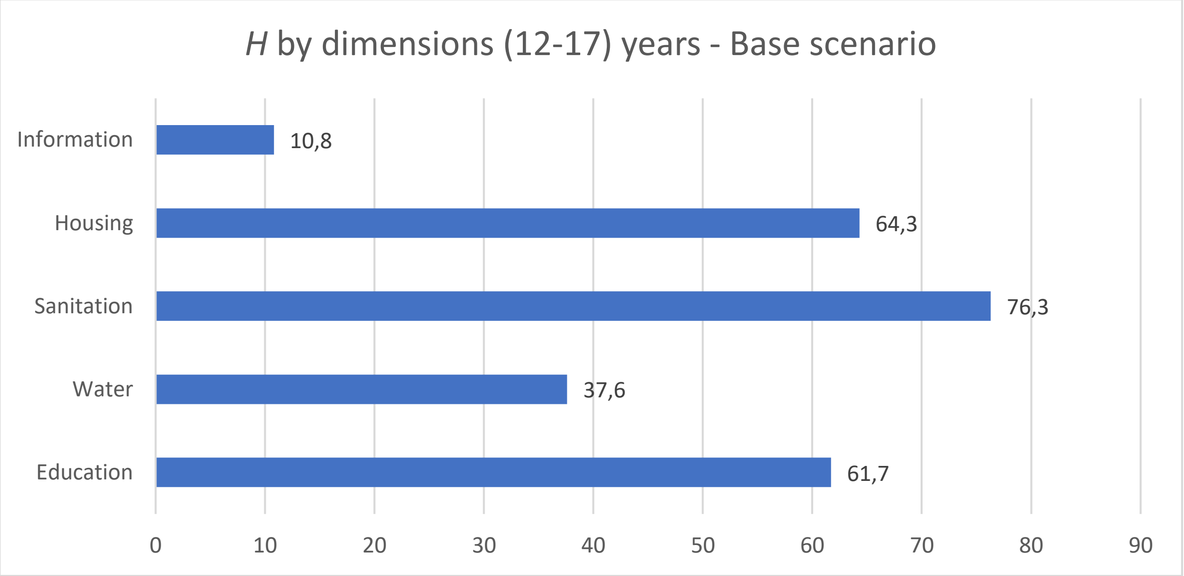




Source: Author's calculations using Nigeria MICS 5 2016-17

Figure 18: Deprivation headcount ratio (H) by dimensions across Baseline scenario and Scenario 3 (12-17 years).





Source: Author's calculations using Nigeria MICS 5 2016-17

Evaluation of findings on robustness checks

The findings of the robustness checks are twofold. First is the robustness of rankings by multidimensional headcount ratio based on four different profiles – region, wealth index, education level of household head, and education level of mother – when parametric changes are made. The second is the new insights gained when the parametric changes significantly deviate from specific findings in the original Nigeria MODA study. These differing outcomes, which do not invalidate the overall robustness of the original study, provide additional insights into multidimensional child deprivation in Nigeria, as well as areas where further research can be useful.

The 100% robustness of the multidimensional headcount rankings by wealth quintile, education level of household head, and education level of mother, show that in all the alternative scenarios, the pairwise rankings are the same (Table 6). This fact implies that, just as in the original MODA, children in the poorer wealth quintiles are more likely to be multidimensionally deprived than children in the richer quintiles. Likewise, the lower the educational levels of household heads and mothers, the more likely children are to be deprived. This pattern is also observed in each age group (Table 6).

Table 6: Multidimensional headcount ratio (H) of Nigerian children (0-17 years) by Wealth quintiles, Education level of household head and Education level of mother (%)

Wealth quintile	**Baseline**	**Scenario 1**	**Scenario 2**	**Scenario 3**
Richest quintile (Q1)	20.6	47.6	24.7	29.3
Richer quintile (Q2)	42.8	73.8	47.3	60.6
Middle quintile (Q3)	57.7	84.4	61.3	70.6
Poorer quintile (Q4)	67.8	89.9	70.7	79.2
Poorest quintile (Q5)	80.2	95.5	81.8	85.5
Education level of household head	**Baseline**	**Scenario 1**	**Scenario 2**	**Scenario 3**
Secondary education or higher	32.6	63.4	36.8	43.6
Primary education	52	78.6	57.6	66.3
No education	74.3	92.1	76.8	84.4
Education level of mother	**Baseline**	**Scenario 1**	**Scenario 2**	**Scenario 3**
Secondary education or higher	25.4	56.1	29.8	34.8
Primary education	46.8	77.1	51.6	59
No education	71.3	90.6	73.7	82.1

Source: Author's calculations using Nigeria MICS 5 2016-17

The ranking of states (regions), on the other hand, while showing high robustness across all ages and all age groups, also reveals very significant changes in some individual states. In Scenario 1, deprivation in only two dimensions is the requirement for multidimensional deprivation.

To see how changes at the levels of indicator and dimensions could have contributed to rankings, and gain some insights on what policy implication(s) may be derived, the study looks at the states that have the most significant changes in their rankings. This analysis involves a closer look at the two states that have moved the most ranks both up and down the rankings across the three alternative scenarios. As Table 7 shows, the "highest movers" both up and down the ranking are seen in Scenario 3 (refer Figures 12 to 15), which represents a more rigorous parametric change than both Scenarios 1 and 2.

Table 7: Rankings and multidimensional headcount ratios of "highest mover" regions

Region	Baseline ranking	Baseline *H* (%)	Alternate ranking *	Alternate *H* (%)	Move magnitude	Move direction	Age group (years)
Ekiti	3	9.22	15	35.4	12	↓	0-5
Akwa Ibom	16	48.7	5	40.1	11	↑	0-4
Anambra	5	17.2	15	46.9	10	↓	12-17
Abia	11	41.7	4	37.5	7	↑	0-4

*Source: Author's calculations using Nigeria MICS 5 2016-17 * Refers to Scenario 3*

It is noteworthy that Ekiti's downward shift in rankings cuts across all the other two age groups as well in a significant (more than three ranks) way (4^{th} to 12^{th} and 9^{th} to 15^{th} in 0-4 years and 12-17 years, respectively). Expectedly, the overall (0-17 years) change in rank is also highly significant, from 4^{th} to 15^{th}. The region Akwa Ibom does not have significant (>3) moves in rank in the other age groups (13^{th} to 12^{th} for age group 5-11 years and 12^{th} to 10^{th} in 12-17 years) even though the changes are in the same direction (upward). The overall (0-17 years) rank change is, however, significant (15^{th} to 11^{th}). Similarly, Anambra's move in ranks in age groups 0-4 years and 5-11 years are not significant (3^{rd} to 6^{th} and 6^{th} to 9^{th}, respectively), but are in the same direction (downward), and culminate in an overall (0-17 years) rank change of 7^{th} to 8^{th}. The region of Abia also has no other significant rank changes, going from 4^{th} to 3^{rd} in the age group 5-11 years and in the counter direction (4^{th} to 5^{th}) in the age group 12-17 years, the overall rank change is not significant at 6^{th} to 4^{th}.

While the study acknowledges the contribution of deprivation headcounts in other age groups to the overall rankings, for simplicity, the analyses are limited to the age groups where the rankings change the most for each of the regions. For dimensions common to both the baseline and alternative scenario[36], the study looks for dimensions with the most considerable magnitude of rank changes when the change is in the same direction as the overall rank move of the region in question[37]. For new dimensions, if the *H* ranking by the dimension is within the first third of ranks (1st to 12th), the dimension is considered significant in moving the region up the rank (in cases where rank change is upward). Conversely, if the ranking falls within the last third (28th to 37th), the dimension is considered significant in moving the region on the rank (where rank change is downward)[38].

Table 8 summarises the findings for each region. The most significant change in rank for Ekiti (age group 5-11 years) is in the dimension housing where the indicator cooking fuel is substituted for electricity. This suggests that the rise in deprivation rate in Housing from 42.2% to 76.3% in Ekiti (5-11 years) is a relatively higher decline compared to other regions. As already noted, the indicator electricity increases the multidimensional headcount ratio in the dimension housing across all age groups in Scenario 3 compared to the baseline scenario, making it an important indicator. This finding suggests that deprivation in the indicator electricity in Ekiti might be worse than the average national. Also, considering that electricity is a household level indicator, it is logical to conclude that this applies to all age-groups in Ekiti. A sectoral analysis at indicator level is, however, required to confirm this.

The housing dimension also plays a similar role in Anambra, which slides 11 ranks, suggesting the availability of electricity may be more challenging in Anambra than in other states. In Akwa Ibom, the reverse is suggested as the deprivation headcount ratio in housing falls in the alternative scenario from 52.6% to 45.2%, 17% points against the national rise in headcount ratio for the dimension from 71.2% to 76.3% in the same age group (Figure 16). This development strongly implies comparatively lower deprivation rates in the indicator electricity, suggesting Akwa Ibom may be ahead in this indicator compared to other regions. In Abia, more children appear to be deprived in health when the indicator skilled birth attendant is replaced with illnesses in the last two weeks, suggesting Abia may have a relatively higher under-5 morbidity health challenges. However, the fall in ranking in the dimension health appears not considerable enough to prevent the overall rise in rank for the region. The absence of a drastic change in the ranking by the dimension of housing, as well as high ranking in all three new dimensions, is a possible explanation for this observation.

[36] Dimension information is excluded because no changes are made to it and it therefore has no effect on the rankings.
[37] Rank changes of more than three ranks is considered significant, irrespective of direction.
[38] The choice of first or last third is arbitrary.

Table 8: Rank changes in existing dimensions and ranking in new dimensions for selected states

Ekiti (Age group 5-11 years)							
	Education	Water	Sanitation	Housing	HIV	Physical Development	Child Economic Labour
Baseline ranking	2nd	3rd	17th	6th	N/A	N/A	N/A
Alternate ranking	9th	8th	21st	21st	16th	8th	26th
Rank change	7	5	4	15	N/A	N/A	N/A
Akwa Ibom (Age group 0-4 years)							
	Nutrition	Health	Water	Sanitation	Housing	HIV	Physical Development
Baseline ranking	16th	25th	17th	6th	12th	N/A	N/A
Alternate ranking	20th	20th	15th	3rd	4th	3rd	16th
Rank change	4	5	2	3	8	N/A	N/A
Anambra (Age group 12-17 years)							
	Education	Water	Sanitation	Housing	HIV	Physical Development	Child Economic Labour
Baseline ranking	6th	7th	2nd	9th	N/A	N/A	N/A
Alternate ranking	2nd	16th	8th	20th	31st	2nd	10th
Rank change	4	9	6	11	N/A	N/A	N/A
Abia (Age group 0-4 years)							
	Nutrition	Health	Water	Sanitation	Housing	HIV	Physical Development
Baseline ranking	28th	19th	10th	5th	4th	N/A	N/A
Alternate ranking	31st	33rd	7th	6th	3rd	4th	9th
Rank change	3	14	3	1	1	N/A	N/A

Source: Author's calculations using Nigeria MISC 5 2016-17. N/A = Not applicable

For Ekiti, the other dimensions contributing to its slide are education, water, sanitation, and child economic labour (Table 8). For Akwa Ibom, changes in the dimension health, in the alternative scenario, as well as the ranking in the HIV dimension as the third-lowest deprived region, contribute to the overall upward change in rank of the region. Anambra also has water and sanitation dimensions as contributors to its slide in ranking at the alternative scenario (Table 8).

Conclusions and recommendations

This study finds that Nigeria MODA is robust to the parametric changes that were applied, namely lowering the multidimensional poverty cut-off *k* from three to two dimensions (Scenario 1), altering the indicators used to build the dimensions (Scenario 2), and adding new dimensions (Scenario 3). All these sets of parametric changes raised the national multidimensional headcount ratio *H* higher than the baseline one (53.9%), with Scenario 1 recording the highest *H* (78.7%), followed by Scenario 3 (65.8%), and then Scenario 2 (58.2%). This pattern is also consistent with the findings when *H* is disaggregated by the four profiles (region, wealth index, education of household head, and education level of mother) both for all children (0-17 years) and for each age group. Also noteworthy is the fact that the rankings consistently show that the regions with the most multidimensional deprivation in Nigeria are in the northern part, demonstrating that the injection of more aid into that part of the country is evidence-based, and justified.

As already acknowledged, these parametric changes, although based on rules and protocols, are fraught with arbitrariness. However, the high values of the Kendall Tau and Spearman correlation rank coefficients across all the scenarios provide sufficient grounds to conclude that the baseline study (i.e. Nigeria MODA) is highly robust. The lowest rank coefficients for Kendall Tau and Spearman are obtained in Scenario 3 for ranking by region in the age group 0-4 years (0.793 and 0.936 respectively), and the highest are in Scenario 2 for the same age group, with a perfect score of 1.000 for both coefficients. These are all statistically significant, and testify that the rank robustness is not due to chance.

For the other profiles, a score of 1.000 is obtained in all scenarios, all age groups, and for both coefficients. While the Spearman scores are statistically significant in all the profiles, the Kendall is not in the profiles of education level of household head, and education level of mother. While the latter suggests that the robustness of the rankings from these last two profiles might be a chance occurrence, the small sample size for these profiles (N=3) may also have accounted for the non-significant p-value (0.296).

Analysis of changes in multidimensional headcount ratios by dimensions in Scenario 2 shows a rise in *H* in the Housing dimension across all the age groups, suggesting that electricity is an important contributor to multidimensional deprivation in Nigeria. In the dimension health (0-4 years), *H* falls significantly, suggesting that generally, fewer under-5 Nigerian children suffer from the newly included indicator illnesses in the last two weeks than the substituted indicator skilled birth attendant. However, analysis of the most significant changes in the rankings of some regions in Scenario 3 brings to the fore how states may be performing in specific dimensions relative to others. For example, region Akwa Ibom has a much smaller *H* in housing than most regions, and also has a lower *H* in Scenario 3 than the baseline study for this dimension, contrary to the occurrence in most regions, and at the national level, where the reverse is the case. Since the indicator responsible for these changes is electricity, this suggests Akwa Ibom is generally better off than most other regions in the electricity dimension. In regions where the reverse is the case, such as Ekiti, the implication is that the region is faring worse in terms of electricity compared to other regions.

Limitations

The following limitations constrain this study:

1. Data availability
   a. Lack of child-level data for some other dimensions that could shed light on child multidimensional deprivation in Nigeria, including child violence, child protection/sexual and reproductive health, clothing, and leisure, which are all relevant to Nigerian children.
   b. Available data also lacks indicators across all age groups, in that the coverage of indicators does not fully cover the entire childhood period. This limits our understanding on whether the deprivations relate to a specific age period of affect children more generally.
   c. The study is based on cross-sectional data. Panel data would have provided more accurate evidence, including on whether deprivation is chronic or change across the life course for children.
2. The study could also have benefited from further robustness checks of multidimensional headcount deprivation analysis by indicator as well as of the overlapping deprivation analysis done on the baseline Nigeria MODA.

Nevertheless, the study adds much novelty to MODA analysis, being the first of its kind to check the robustness of the methodology. It provides a good platform for future MODA-related analyses to perform robustness and sensitivity checks, including the adoption of other techniques. The study also demonstrates how MODA studies can be further improved to generate more robust results.

Recommendations

This study aligns with the SDG rationale of leaving no one behind. By making parametric changes, other dimensions were added, which reveal additional insights into child deprivation in Nigeria. State-level deprivations also show how some regions may be faring in terms of dimensions and indicator-level deprivations, and this can serve as flags for State governments in Nigeria to focus on relevant sectors to meet up with their state-specific targets for the SDGs.

This study confirms the accuracy of the recommendations of the baseline study (UNICEF, 2021, forthcoming). In addition, this study makes the following recommendations:

1. **HIV/AIDS advocacy programs**: Almost two out of every five Nigerian children (0-17 years) are deprived in HIV, that is they lack comprehensive knowledge of the desease (parental knowledge for ages 0-14 years and personal knowledge for ages 15-17 years). The National Action Committee against AIDS (NACA) may take the lead in stepping up advocacy for HIV/AIDS using appropriate media outlets. At the regional level, the State Action Committees against AIDS (SACAs) may adopt strategies that reach their communities to augment behavioural change communication efforts regarding HIV/AIDS.
2. **Child economic labour**: This study finds that 40.1% of children aged 5-11, and 47.9% of children aged 12-17 are deprived in child economic labour, which is in the range of the 43% prevalence of child labour reported by the International Labour Organization (Business & Human Rights Resource Centre, 2019). Child labour is a vulnerability that requires a multisectoral approach to take action. Efforts need to tackle the root causes, one of which is poverty. Action points that can be taken are:
    a. The federal government may prioritise efforts to implement Child Labour laws in Nigeria (Nwazuoke & Igwe, 2016).
    b. States in Nigeria who are yet to adopt the National Child Labour Act should do so, as to provide a legal framework to tackle this vulnerability.
    c. Social assistance schemes may provide a scale-up platform to target poorest households who rely on child labour for subsistence.
    d. Interventions in education may be linked to provisions of child labour, for instance enforcing compulsory education attendance for children who drop out of school due to child labour constraints.
3. **Physical development**: About two out of every five Nigerian children are stunted. This study recommends enforcing the health and nutritional interventions mentioned in the Nigeria MODA. Also, in the short-term, food insecurity needs to be addressed through the provision of food items to the most vulnerable households. In the longer term, the government of Nigeria needs to tackle the barriers to food security, including the lack of competitive environment for agribusiness, lack of access to market, financial inputs, and credit (Downie, 2017).
4. **Electricity**: Rural electrification projects are ongoing in Nigeria as part of efforts to provide off-grid, stand-alone electricity to mainly rural deprived areas (Umana, 2018). These areas are hard to reach by extending the national grid due to their topography. The Nigeria Rural Electrification project, funded through the World Bank and the African Development Bank, and implemented by the Rural Electrification Agency, is to provide

alternative power to one million households. The Nigeria government needs to provide further support to scale-up the implementation of the project by reducing domestic financing constraints (Mshana, 2019).

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Annexes

A. Multidimensional headcount ratios for all scenarios, age groups and by all profiles

***Table A1** : Deprivation headcount ratio (H) at the national level, by regions (states), wealth index and education level (%) - baseline scenario*

	0-17 years	0-4 years	5-11 years	12-17 years
National	54.4	61.4	50	52.6
Abia	21.6	41.7	9.42	31.8
Adamawa	61.4	67.4	57	47.6
Akwa Ibom	33.1	48.7	22.4	64.3
Anambra	21.8	35.3	14.2	36.7
Bauchi	70.3	73.3	67.1	19.4
Bayelsa	30.9	46.6	18.5	62.7
Benue	49.9	56.8	46.2	11.9
Borno	61.4	65.1	56.8	20.2
Cross River	42.5	57.2	36.9	30.4
Delta	26.2	43.6	16	70.4
Ebonyi	57.1	63.4	49.5	14.6
Edo	19	36.6	10.9	79.3
Ekiti	20.4	36.4	9.22	50.8
Enugu	31	45.6	20.7	57.2
FCT Abuja	30.9	39	23.8	17.2
Gombe	72.8	76	71.8	63.8
Imo	20.4	39.7	8.61	75.9
Jigawa	72.6	72.3	69.2	39.7
Kaduna	50.3	54.4	47	26.8
Kano	60.1	67.3	56.1	13.4
Katsina	64.7	72.1	58.6	53.5
Kebbi	74.9	72.5	76.2	56.6
Kogi	38	47.2	30.9	18.5
Kwara	31.2	41.4	26.7	26.2
Lagos	17.3	32.7	5.11	20.6
Nasarawa	52.9	62	45.5	30.3
Niger	57.8	62.7	55	62.2
Ogun	25.5	41.6	18.5	18.1
Ondo	33.9	50.4	27.1	79.5
Osun	23.8	41.4	14.7	74.8
Oyo	35.5	51.1	26.4	74
Plateau	59.6	62.5	55.1	72.9
Rivers	20.9	32.1	14.3	31.8
Sokoto	80.4	81.4	80	80.9
Taraba	72.3	74.6	69.1	67.9
Yobe	71.1	68.8	71.1	57.6
Zamfara	74	76.4	72.8	40.7
Richest quintile	20.6	32.5	13.5	71.8
Richer quintile	42.8	53.4	35.7	17.2
Middle quintile	57.7	64.9	52.2	26.4
Poorer quintile	67.8	72.1	64.4	62
Poorest quintile	80.2	81.3	79	16
HH head: Secondary education or higher	32.6	46.2	23.3	27.7
HH head: Primary education	52	63.5	46.1	48.1
HH head: No education	74.3	75.9	73.2	74.1
Mother: Secondary education or higher	25.4	40.6	14.9	16.8
Mother: Primary education	46.8	61.5	39.1	43.1
Mother: No education	71.3	75	70.2	69

Source: Author's calculations using Nigeria MISC 5 2016-17

***Table A2** : Deprivation headcount ratio (H) at the national level, by regions (states), wealth index and education level (%) - Scenario 1*

	0-17 years	0-4 years	5-11 years	12-17 years
National	78.7	85.2	75.6	75.6
Abia	52	74.2	40.8	63.7
Adamawa	87.7	91.3	85.3	76.1
Akwa Ibom	62.8	75.3	56.5	84
Anambra	50.8	66.6	42.3	68
Bauchi	87.9	90.7	84.7	47.1
Bayelsa	67.3	78.1	61.6	82.5
Benue	79.5	85.1	77.7	43.9
Borno	86.7	91.9	84.4	53
Cross River	72.5	81	70.2	63.5
Delta	55.6	73.3	46.2	89.5
Ebonyi	82.3	90.4	77	43.1
Edo	48.1	66.2	37.4	94.5
Ekiti	55.4	70.7	46	75.8
Enugu	63.4	75.3	54.5	78.3
FCT Abuja	59.7	69	52.6	42.3
Gombe	89.9	93	87.7	85.5
Imo	51.4	73.1	39.5	88.4
Jigawa	94.1	95.5	92.9	73.5
Kaduna	75.9	79.4	73.3	55.3
Kano	83	88.6	81.2	46
Katsina	86.2	90.2	83.1	80.9
Kebbi	90.1	91.6	90	78.9
Kogi	72.1	80	66	49.1
Kwara	61.2	74.2	55.8	53.9
Lagos	53.9	65.1	48.4	49.4
Nasarawa	81	87.3	76	65.8
Niger	80.3	84.6	78	80.1
Ogun	58.6	74.3	53.6	48.2
Ondo	63	79.1	57.4	93.8
Osun	56.4	73	50.9	90.4
Oyo	70.6	81.6	65	90.6
Plateau	79	82.9	74.8	88.3
Rivers	52.4	61.9	48.2	59.5
Sokoto	93.9	94.5	93.4	94.9
Taraba	89.5	93	86.4	89.2
Yobe	91.5	93.4	90.6	83.4
Zamfara	90.4	93.8	88.9	69.2
Richest quintile	47.6	62.4	39.4	89.7
Richer quintile	73.8	82.8	69.6	44.8
Middle quintile	84.4	88.5	81.7	54.4
Poorer quintile	89.9	93.2	87.8	87.5
Poorest quintile	95.5	96.8	94.9	42.3
HH head: Secondary education or higher	63.4	75.4	56.6	56.8
HH head: Primary education	78.6	86.5	75.3	75
HH head: No education	92.1	94.5	91.2	90.6
Mother: Secondary education or higher	56.1	70.8	47.5	44.5
Mother: Primary education	77.1	87.4	72.6	73.2
Mother: No education	90.6	94	90	88

Source: Author's calculations using Nigeria MISC 5 2016-17

Table A3 : Deprivation headcount ratio (H) at the national level, by regions (states), wealth index and education level (%) - Scenario 2

	0-17 years	0-4 years	5-11 years	12-17 years
National	58.2	61.4	53.4	60.8
Abia	27.2	41.7	10.2	18.1
Adamawa	63.4	67.4	60	63
Akwa Ibom	38.3	48.7	25.5	33.2
Anambra	26.7	35.3	13.4	31.1
Bauchi	71.7	73.3	68.7	74.7
Bayelsa	35.2	46.8	20.9	36.2
Benue	53	56.8	48.7	53.2
Borno	64.7	65.1	60.2	72.2
Cross River	46.7	57.2	38.5	38.8
Delta	32.6	43.6	20.5	28.1
Ebonyi	59.8	63.4	50.9	70
Edo	24.7	36.6	12.4	14.6
Ekiti	26.2	36.4	10	29.5
Enugu	36.3	45.6	21.2	43.5
FCT Abuja	32.5	39.1	23.2	34.7
Gombe	73.9	76	71.8	73.2
Imo	24.7	39.7	9.23	15.6
Jigawa	72.2	72.3	68.7	79.4
Kaduna	53.3	54.4	50.3	56.9
Kano	61.9	67.3	57.1	61
Katsina	65.6	72.1	58.3	66.3
Kebbi	74.7	72.5	76.2	76.3
Kogi	39.7	47.5	30.3	42.4
Kwara	34.2	41.4	26.1	32
Lagos	22.6	32.7	6.67	21.3
Nasarawa	54.5	62.1	46.2	53.6
Niger	59.2	62.8	55.5	59
Ogun	29.5	41.6	16.3	20.3
Ondo	41.1	50.4	29.6	37.6
Osun	29.7	41.4	14.5	27.6
Oyo	41.8	51.1	30.4	40.1
Plateau	61.4	62.7	56.6	66.7
Rivers	23	32.1	14.4	14.3
Sokoto	80.9	81.4	80.1	81.3
Taraba	72.7	74.8	70.1	73.2
Yobe	69.9	68.8	69.4	72.8
Zamfara	74.2	76.4	72.6	73.2
Richest quintile	24.7	32.5	15.9	24.3
Richer quintile	47.3	53.4	38.9	50.4
Middle quintile	61.3	65	55.7	64.9
Poorer quintile	70.7	72.1	67.9	73.6
Poorest quintile	81.8	81.3	80.8	85
HH head: Secondary education or higher	36.8	46.2	26.3	34.5
HH head: Primary education	57.6	63.5	50.7	58.9
HH head: No education	76.8	75.9	75.9	80.1
Mother: Secondary education or higher	29.8	40.6	17.2	21.6
Mother: Primary education	51.6	61.5	42	51.6
Mother: No education	73.7	75	72	74.4

Source: Author's calculations using Nigeria MISC 5 2016-17

Table A4 : *Deprivation headcount ratio (H) at the national level, by regions (states), wealth index and education level (%) - Scenario 3*

	0-17 years	0-4 years	5-11 years	12-17 years
National	65.8	65.8	61.2	67.4
Abia	26.5	37.5	9.88	26.6
Adamawa	71.3	74.7	68.1	69.2
Akwa Ibom	38.4	40.1	30	42.4
Anambra	37.6	40.3	23.2	46.9
Bauchi	77.1	75.8	73	80.4
Bayelsa	37.9	44.3	25.4	44.6
Benue	53.3	52.2	49.8	52.9
Borno	66.1	67.6	62	70.1
Cross River	45.9	52	36.5	45.7
Delta	38.4	42.5	30.5	34.2
Ebonyi	64.8	64.3	55.8	75.9
Edo	23.4	36.5	8.3	13.4
Ekiti	44.9	45.5	35.4	47.8
Enugu	41.5	49.5	21.2	56.6
FCT Abuja	41	41.8	35.7	44.1
Gombe	84.4	80.8	84	84.3
Imo	34.7	42.8	17.1	22.6
Jigawa	81	78.2	78.8	82.6
Kaduna	59.5	57.2	56.4	64.4
Kano	69.8	71.4	65.2	65.5
Katsina	76.3	77.5	69.2	74.6
Kebbi	80.2	77.1	79.4	81.4
Kogi	47.6	45	41.5	47.4
Kwara	40.7	49.8	27.1	40.8
Lagos	23.8	34.5	5.96	24
Nasarawa	65.8	69.4	58.5	65.4
Niger	69.1	67.1	67.1	68.8
Ogun	35.4	46.3	21	33.8
Ondo	48.7	56.2	35	45.1
Osun	35.4	47.6	18.6	26.9
Oyo	54.1	60.3	45	51.2
Plateau	68.8	66.7	64.1	74.1
Rivers	19.7	29	12.1	7.88
Sokoto	91.2	89.1	92.4	90.3
Taraba	80.6	76.5	80.6	83.5
Yobe	80.8	79.9	77.5	75
Zamfara	78.4	78.5	75.5	75.7
Richest quintile	29.3	35.8	19.1	28.7
Richer quintile	60.6	60.1	55.3	63.7
Middle quintile	70.6	71.2	65.8	70.5
Poorer quintile	79.2	76.7	76.8	81.4
Poorest quintile	85.8	83.6	84.1	87.2
HH head: Secondary education or higher	43.6	49.2	33.5	41.2
HH head: Primary education	66.3	68.1	59.9	65.8
HH head: No education	84.4	81.5	83	85.7
Mother: Secondary education or higher	34.8	42.9	22	27.8
Mother: Primary education	59	64.8	49.1	57.1
Mother: No education	82.1	80.6	80.5	80.9

Source: Author's calculations using Nigeria MISC 5 2016-17

B. Deprivation headcount rates by dimensions in baseline scenario and Scenario 3

***Table B1** : Deprivation rates (H) by dimensions at both the national and regional (state) levels - baseline scenario (%)*

	0-4 years						5-11 years					12-17 years				
	Nutrition	Health	Water	Sanitation	Housing	Information	Education	Water	Sanitation	Housing	Information	Education	Water	Sanitation	Housing	Information
National	33	80	40.5	79.2	71.2	12.8	45.4	40.6	78.8	69.9	12.6	61.7	37.6	76.3	64.3	10.8
Abia	34.6	76.5	19.3	65.5	37.7	2.84	9.94	22.1	63.9	27.7	2.81	34.7	16.3	62.1	25.7	1.54
Adamawa	35	78.7	47.7	88.1	73.8	10.6	49.9	48.5	88.9	75.4	10.5	67.2	45.1	88.2	72.5	8.97
Akwa Ibom	29.3	81.5	28.2	68.3	52.6	5.81	15.6	28.9	65.8	53.9	5.42	37.9	27.6	61.6	41.7	4.74
Anambra	24.9	66.3	20.6	64.1	42.6	2.63	7.61	17.2	59.5	43.7	4.13	32.9	15.6	56.9	37.2	2.86
Bauchi	33.8	89.4	44.8	78	85.3	20.8	69	44	75.7	82.8	19	83.3	44.1	74.6	83.2	15.1
Bayelsa	23.5	77	15.1	86.8	58.2	6.54	13.6	15.1	85.1	54.4	7.71	35.5	16.3	86	49.3	11.3
Benue	26.7	63.1	40.6	87	72	6.54	38.2	38.5	84.6	67	7.56	61.2	33.7	79.3	59.2	5.72
Borno	34.6	82.4	64.4	70	70.9	2.99	52.4	66.8	70.6	70.8	2.32	67.8	61.7	72.5	71.6	3.04
Cross River	24.8	71	49.8	80.8	57.4	8.9	13.1	48.7	80.5	53.4	10.4	34.2	46.7	75.1	44.5	9.7
Delta	28.7	71.3	19.7	72.5	52.1	5.88	9.21	16	67.3	46.6	5.49	37.7	14	63.7	31.7	4.65
Ebonyi	30.4	68.9	37	95	66.8	16.8	30.4	40.8	94.5	62.6	19.9	62.8	41.8	94.7	64.7	18
Edo	30.6	63.3	16.3	70.3	34.6	3.32	10.6	13.8	71	30.7	2.9	30.7	11.4	65.4	25.3	2.88
Ekiti	25.2	61.2	10.5	79.4	53.4	2.56	6.53	12.7	76.2	42.4	1.13	29.8	13.3	81.4	38.6	1.99
Enugu	24.9	69.3	36.9	79.3	35.6	3.84	16.1	42.2	72.4	32.3	4.98	43	41.6	74.2	31.3	5.33
FCT Abuja	27.9	71.3	20.6	71	42.7	5.65	21.6	24	72.3	42.6	9.43	52.3	22.8	70.9	37.6	8.08
Gombe	37.3	84.5	61.8	70.3	87.2	23.6	69.8	65.3	70.5	85.9	23.8	80.4	60.9	68.8	83.9	18.7
Imo	32.2	76.7	11.6	64.9	46	2.37	6.62	13.6	56.8	41.5	1.83	27.1	18.9	56.3	32.2	3.57
Jigawa	37.9	91.4	25.4	90.1	89.7	23.9	65.8	24.6	90	91.2	24.8	84	25.1	91.5	89.8	25.2
Kaduna	31.9	71.8	40.2	81.5	62.1	5.95	40.7	41.2	79.9	66	8.34	65.1	36.4	75.2	61.8	7.5
Kano	37.8	89	44.9	73.4	79.2	17.5	55.6	44.3	72.5	77.9	17.4	66.8	41.3	68.1	72.4	13.6
Katsina	38.9	91.7	47	77.7	82.9	22.7	54.7	43.8	75.2	83	19.4	69.3	44.1	73.8	81.9	17.3
Kebbi	36.2	89.7	46.4	82.4	91.1	27	72.6	46.4	85.4	92.1	27.4	81.4	41.7	80.3	89.1	24.3
Kogi	25.6	66.9	29.7	88.1	54.6	5.34	21.5	31.7	86.8	51.8	6.02	52.2	27.8	85	50.3	5.6
Kwara	26.7	64.7	17.4	84.7	51.1	9.1	24.6	23.2	83.6	44.6	10.1	42.8	16.7	80.9	35.3	11.1
Lagos	31.6	55.5	3.12	60.8	55.5	0.772	5.01	3.03	64	54.6	0.93	26.9	2.59	60.3	46.5	0.627
Nasarawa	28.3	79.3	47.9	86.2	62.8	9.93	39.7	45.5	86.9	57	8.77	63.4	43.4	85.7	55.9	9.96
Niger	32	83	46.7	77.1	69.7	10.2	56.8	49.3	76.3	66.4	10	71.2	45.2	72.1	62.4	7.38
Ogun	31	65.2	9.35	79.2	56.9	3.74	16.6	13.8	73.3	51.7	2.59	37.3	9.89	66.8	37.8	1.41
Ondo	26.5	75.3	26.2	85.9	51.3	6.2	14.5	27.9	85.3	51	5.59	32.6	21.5	75.5	41	5.22
Osun	31.7	71.8	14.6	84.1	46.3	2.43	20.2	11.5	80.4	41.9	2.1	41.1	8.36	77.1	34.1	2
Oyo	25.5	67.3	23.5	87.7	65.6	5.13	26.6	19.9	86.1	57.7	3.78	39.6	17.3	82.3	49	5.08
Plateau	23.5	77.3	52.2	79.3	68.7	12.4	34.7	53.8	80.9	70.4	13.7	65	55.5	83.9	65.2	14.5
Rivers	22.3	74.9	16.1	62.7	37.2	1.48	10.1	17.7	72.5	43.1	1.76	34.7	16.2	61.9	34.8	1.19
Sokoto	38.5	88.1	70.8	88.3	87.8	22.5	75.1	68.5	88.2	88.5	21.3	87.5	66	86.6	86.8	17.9
Taraba	29.6	86.2	63.5	87.2	83.4	18.6	50.3	65	88.7	78	20.9	72	64.5	87.9	77.8	18.5
Yobe	43.2	90.2	41.9	87.6	89.4	17.4	69.9	39.4	86.6	88.8	18.3	79.5	38.3	87.1	83.8	16.7
Zamfara	35.5	90	51.7	90.9	83.7	19.3	66.4	52.6	90	82.9	17	74.9	50.7	89.5	79.2	14.6

Source: Author's calculations using Nigeria MISC 5 2016-17

Table B2 : Deprivation rates (H) by dimensions at both the national and regional (state) levels - Scenario 3 (%)

	0-4 years								5-11 years								12-17 years							
	Nutrition	Health	Water	Sanitation	Housing	Information	HIV	Physical Development	Education	Water	Sanitation	Housing	Information	HIV	Physical Development	Child Economic Labour	Education	Water	Sanitation	Housing	Information	HIV	Physical Development	Child Economic Labour
National	10.8	43.4	36.4	69.5	76.3	12	37	35.1	39.3	38.9	72.3	78.4	11.5	39.1	39.3	40.1	42.2	38.3	74	76.9	10.8	43	40.4	47.9
Abia	13.2	57.8	9.38	44.1	44.7	1.53	14	14.7	1.03	10.1	49.4	41.6	2.44	11.2	16.8	21.4	11.2	5.56	60.3	40.6	0	10.2	15.2	50.5
Adamawa	9.7	53.7	51.6	83.6	81.1	11.2	18.7	25.1	42.6	54.3	88.3	86.8	9.25	23.5	28.8	35	41.2	44	88.4	83.4	6.37	29.5	25.3	47
Akwa Ibom	8.54	46.7	19.6	40.6	45.6	2.72	13.3	21.8	4.45	27.8	54.2	53.9	2.48	8.32	20.1	34.4	13.6	24.7	41.5	48.6	2.58	21.1	20.6	42.6
Anambra	8.46	54.7	15.2	55.4	55.7	2.47	33.4	12.3	1.24	8.75	46.1	61.3	4.44	40.4	8.22	31.4	4.29	20.1	54.9	73.8	5.24	50.1	8.17	42.5
Bauchi	7	52	35.1	74.5	88.8	18	35.3	54.6	61.3	37.1	74.3	90.4	17.7	38.7	57.5	36.3	65.2	35.6	76	93.5	14.7	39.5	57.8	45.1
Bayelsa	3.65	43.5	7.5	70.4	75.1	1.71	23.5	13	6.18	8.15	74.6	76.1	4.58	19	15.8	34.4	8.84	12.7	81.2	74.2	5.38	30.2	19.3	48.6
Benue	6.5	29.5	38.5	80.2	87.6	3.01	20.7	19.6	16.8	39.1	78.7	84.1	1.95	24.9	18.4	45	12.7	36.5	73.4	76	2.84	31.3	20.2	62.8
Borno	17.8	59.8	55.2	56.7	74	3.87	18.3	27.7	39.9	56.7	58.4	71.7	3.24	21.9	31.1	32.7	39	50.6	67.1	66.6	3.45	29.2	41.7	43.7
Cross River	6.37	46.7	41	67.2	78.1	8.28	18.2	15.9	0.767	31.3	68.8	83.7	10.2	15.2	11	45.8	6.12	33	69.5	76.6	7.3	23.6	14.6	45.3
Delta	4.7	53.9	21.7	49.4	54.2	7.9	5.63	15.4	3.46	22.3	53.3	58.6	8.55	9.44	14.4	37.8	12.7	20.9	52.6	50.3	8.35	10.1	13.3	55.2
Ebonyi	12	38.9	15.9	93.7	84.6	8.35	32	23.1	11.1	19.3	95.4	81.4	6.57	31	21.5	39.1	12.3	17.7	94.9	87.9	4.97	44.7	21.8	47.5
Edo	7.92	51.8	8.2	55	39.5	1.23	14.4	13.8	0.321	4.63	51.1	39.4	0.882	19.2	19.6	16.9	10.9	7.57	66	18	0	15.8	20.5	15
Ekiti	6.73	44.7	7.17	57.3	66	0.541	24.9	22.7	1.9	11.6	65.4	76.3	0.76	27	16	42.5	3.26	4.1	82.9	68.2	0	40	14.6	56.1
Enugu	1.62	55.5	34.4	54.3	46	2.12	18.2	10.5	0.951	38.5	62.3	48.4	2.27	15.6	12.9	20.2	17.5	36.7	63.7	54.3	13.4	23.1	8.39	26.7
FCT Abuja	4.41	53.6	18.2	50.8	54.9	6.36	24.3	19.6	13.3	24.1	56.5	65.1	8.23	19	26	33.1	21.8	14.6	74.9	62.2	4.95	17.3	23.3	34.6
Gombe	13.7	51.8	56.4	71.3	91	20.9	58.1	41.8	67.1	67.2	71.4	85.8	21.1	64.9	45.4	55.8	65.7	61.4	74.2	88.1	20.5	69.8	46.1	63.4
Imo	5.43	64	7.21	61.2	49.1	0	35	12.9	0	11.8	55.7	59.3	0	30	16.5	35.9	4.55	13.6	54.1	55.5	0	26.5	25.1	62.9
Jigawa	11.7	34.7	18.6	86.8	91.8	23.9	42.3	56.7	57.5	16.3	88.6	90.4	21.4	43.5	56.9	45.1	57.8	14.9	91	87.6	14.8	46	50.3	46.2
Kaduna	12.1	34.6	40.3	66.8	66.1	7.94	20.9	35.4	32.7	46.2	70.3	71.4	8	24.9	46.2	32	44.4	42.2	67.4	73	8.87	31.2	53.5	42.4
Kano	10.2	35.7	39.5	70.6	79.2	14.8	49.2	46.8	44	39.7	70.1	77.5	12.1	49.4	48.9	48.8	39.5	40.2	70.2	74.8	13.8	50.1	47.8	51.8
Katsina	14.7	42.7	39.4	79	86	23	33.2	47.2	45	42.1	78.4	87.5	21.2	29.7	48.1	48	54.9	44.8	80.4	89.2	21.5	32.6	48.4	45.6
Kebbi	13.2	40.8	47.6	76.4	90.6	26.8	62.7	46.6	62	39.8	77.4	92.6	27	63.2	49.8	50.7	60.2	43.9	73.2	88.7	24.2	69	47.5	57.5
Kogi	7.88	34.4	20.1	78.8	68.6	3.81	34.4	24.7	7.58	15	79.4	72.8	4.33	33	28.1	49.5	12	10.3	80.7	71.7	4.83	28.7	29.4	49.3
Kwara	9.72	41.2	12.3	67	57.6	11.1	24.3	27.3	12	16.1	68.5	56	7.24	23	28.9	20.9	13.7	18.3	69.9	55.5	13.5	30.5	31.6	26.1
Lagos	11	40.3	1.91	18	57.1	1.3	12.7	5.46	0.699	1.82	19.2	60.2	1.35	7.6	6.41	5.8	13.7	1.48	34.4	66.3	0	16.8	4.44	12.2
Nasarawa	5.54	50.2	46.2	80.9	83.1	7.24	26.3	31.2	23.4	47.7	82.1	80	7.49	29.4	39.8	35.8	32.8	49.1	77.7	79.7	8.35	35.4	33.1	42.6
Niger	8.98	36	46.8	62.4	73.9	6.3	59.8	29.9	49.5	49.6	65.7	69.9	5.15	62.5	36.7	52.8	45.2	45.2	59.1	71.4	3.93	61.6	37.7	63.9
Ogun	8.33	44	6.75	44	63.3	2.36	32.3	18.2	4.7	6.49	42.3	58.8	1.27	32.4	19.1	30.8	5.88	5.84	41.7	48.7	0	43	26.7	47
Ondo	7.09	54.6	22	58.2	68.4	4.04	34.8	21.7	2.55	23.8	60.3	73.4	5.93	30.5	17.9	33	6.15	19.1	71.8	69.6	4.89	41.7	35	27.5
Osun	9.15	67.9	11	41.9	50.6	3.89	35.3	14.6	9.77	16	44.2	45.1	3.5	40.9	17.4	39.3	18.7	6.04	46.6	32.2	3.96	30.8	11	63.8
Oyo	7.65	51.1	20.2	60.8	65	3.95	52.7	22.8	20.6	25.1	67.4	67.6	2.4	52	27.1	23.9	33.6	23.6	64.7	59.5	5.12	47.5	20	52.6
Plateau	6.32	46.9	50.4	71.9	75.6	11.9	42.2	30.8	20.6	59.3	75	81.6	10.7	43.2	35.8	36.6	23	63.8	82.9	80.3	10.1	42.7	28.3	42.1
Rivers	4.66	58.5	12.1	39.6	36.8	0.403	17.8	5.87	0.7	9.9	43.5	41	0	8.94	8.98	23.9	6.04	10.9	39.2	20.6	0	14.7	9.44	32.2
Sokoto	17.3	30.6	69	93	87.7	18.1	77.8	51.6	69.4	69	95.2	87.8	16.1	77.5	55.4	40.9	68.8	68.4	95.1	87	18.3	79.2	57.8	47.7
Taraba	8.05	33.7	63.4	81	91.6	14.8	44.1	29.6	42.8	67.7	79.5	89.9	12.9	48.8	29.2	39.9	27.6	62.2	84.8	81.4	7.11	58.4	41.2	58.2
Yobe	17.4	28.7	37.4	87	88.6	16.1	71.7	46.7	58	32.5	86.7	89.6	17.6	74	50.3	43.3	52.7	27.4	87.5	88	12.4	79.6	39.5	56
Zamfara	10.7	39.6	44.9	88.4	87.9	18.4	29.8	45.2	59	44.6	87.5	86.6	12.3	31	42.4	46.7	58	41.9	87.8	82.3	10.7	32.8	44.1	47.5

Source: Author's calculations using Nigeria MISC 5 2016-17