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# Individual-level predictors of practices of nutrition-specific and nutrition-sensitive interventions for infants and young children in West and Central Africa: a cross-sectional study

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## ABSTRACT

**Objectives** To explore the role of individual-level and household-level characteristics for practice of nutrition-specific and nutrition-sensitive interventions.

**Design** Secondary data analysis (cross-sectional).

**Setting** West and Central Africa.

**Participants** Data are from the Demographic and Health Surveys in the time period between 1986 and 2016. The final sample included between 116 325 and 272 238 observations depending on the outcome.

**Primary and secondary outcome measures** Nutrition-specific and nutrition-sensitive interventions were identified based on the UNICEF Conceptual Framework for child undernutrition. These were early breastfeeding initiation, minimum dietary diversity, full age-appropriate immunisation, iodised salt usage, vitamin A supplementation, iron supplementation, deworming in children aged 1 to 5, clean cooking fuel, safe drinking water and improved sanitation. Explanatory variables include household, mother and child characteristics. Linear probability models were fitted for each outcome, both unadjusted as well as fully adjusted including primary sampling unit fixed effects.

**Results** Prevalence of early breastfeeding initiation was 54.31% (95% CI: 53.22% to 55.41%), minimum dietary diversity 13.89% (95% CI: 13.19% to 14.59%), full age-appropriate immunisation 13.04% (95% CI: 12.49% to 13.59%), iodised salt usage 49.66% (95% CI: 46.79% to 52.53%), vitamin A supplementation 52.87% (95% CI: 51.41% to 54.33%), iron supplementation 10.73% (95% CI: 10.07% to 11.39%), deworming 31.33% (95% CI: 30.06% to 32.60%), clean cooking fuel usage 3.02% (95% CI: 2.66% to 3.38%), safe drinking water 57.85% (95% CI: 56.10% to 59.59%) and improved sanitation 42.49% (95% CI: 40.77% to 44.21%). There was a positive education and wealth gradient for the practices of all interventions except deworming. Higher birth order was positively associated with the practice of early breastfeeding initiation, minimum dietary diversity, vitamin A supplementation and negatively associated with full immunisation and improved sanitation.

**Conclusions** Household, maternal, and child-level characteristics explain practices of nutrition-specific and nutrition-sensitive interventions beyond intervention delivery at the regional level.

## Strengths and limitations of this study

- This study investigates individual-level and household-level predictors of practices of nutrition-specific and nutrition-sensitive interventions for infants and young children in the entire West and Central African region.
- The study cannot distinguish between different roots of low intervention practice such as limited access to or failure to uptake an intervention, it solely observes whether it is being practiced.
- Some of the outcome variables (in particular the availability of iron and iodine supplementation as well as deworming, and to a lesser degree minimum dietary diversity) have a substantial number of missing values.

## INTRODUCTION

Early breastfeeding initiation, minimum dietary diversity, full age-appropriate immunisation, iodised salt usage, vitamin A supplementation, iron supplementation, deworming, usage of clean cooking fuels, safe drinking water and improved sanitation are considered to be nutrition-specific and nutrition-sensitive high-impact interventions to reduce the burden of (childhood) undernutrition and malnutrition as part of the UNICEF framework.[1 2] Yet little is known about predictors for their practices at the individual level (in this study, we define household, maternal and child-level characteristics as 'individual' characteristics of a child, as they affect each child uniquely in their combination). Existing studies focus mainly on identifying local or regional-level characteristics of their practice[3–14]: a comparatively larger body of evidence is available for the Nigerian setting (eg, Begum *et al*[3] for iron–folic acid supplementation, Odusanya *et al*[4] and Adeloye *et al*[6] on vaccination coverage

and Ogbo *et al*[8] on breast feeding). Haile *et al*[9] and Belew *et al*[13] investigate vitamin A supplementation (VAS) and dietary diversity and meal frequency, respectively, in Ethiopia (or its subregions). Ayoya *et al*[7] contribute evidence on vitamin A supplementation coverage in Mali, Bendech *et al*[10] on the same indicator in Guinea, Chirawurah *et al*[12] on iodised salt usage in rural north Ghana and Mutua *et al*[14] on immunisation coverage in Nairobi, Kenya. Whenever data are being pooled, it is not done so consequently for the entire Sub-Saharan African (SSA) region or its subregions West, Central, East and Southern Africa—for example, Janmohamed *et al*[5] pool data from 13 SSA countries to investigate VAS and its determinants. These studies oftentimes focus on a few particular risk factors of poor outcomes, such as most prominently antenatal and postnatal care attendance, low maternal education, income/wealth and intervention-specific knowledge (for a systematic review on this question *cf* Bhutta *et al* 2008 and 2013[15 16]). For the West and Central African regions most of the available studies rely on publicly available data such as the Demographic and Health Surveys (DHS); however, only looking at separate countries (as illustrated above), while some studies rely on own data collection with smaller numbers of observations[7 10 14] and no national or regional representativeness. To the best of our knowledge this is the first study considering several high-impact intervention outcomes and their individual-level and household-level predictors on a supranational level for the entire West and Central African region.

The focus on local or regional-level characteristics is likely due to the perception that the abovementioned interventions are delivered to populations and not to individuals. However, as it is the case with all public health interventions, providing populations with information or access to goods and services does not necessarily imply that all individuals of the population understand or trust the information that is given to them and then take action accordingly. Similarly, it does not necessarily imply that they use the goods and services that are offered to them, or there could prevail logistical, financial, religious or political barriers that keep them from using these goods and services. While the local and regional characteristics of a population are important for intervention targeting, the individual-level characteristics of the member of the population might contain additional valuable information if and to what extent the intervention that is delivered to the population reaches each individual. Filling this knowledge gap is precisely the aim of this study.

## METHODS

### Data sources

Data for this study come from the Demographic and Health Surveys (DHS). These surveys are administered by ICF International and are nationally representative cross-sectional surveys in low-income and middle-income countries that have been conducted at varying intervals from 1985 and are still ongoing. The DHS used a multi-staged stratified sampling design. Each country was divided into regions and within these subnational regions, populations were stratified by urban and rural area of residence. Within these stratified areas, a random selection of enumeration areas taken from the most recent population census was drawn. These primary sampling units (PSUs) were selected based on probability proportional to the population size. In the second stage of sampling, all households within the cluster were listed and, on average, 25 households within a cluster were randomly selected for an interview by equal probability systematic sampling. Detailed sampling plans are available from survey final reports. Within each sampled household, the household members were listed and women eligible for a more detailed interview were identified. Typically, this was women who were between the age of 15 and 49 years. We analysed data from all DHS from the West and Central African region that are available at this date. The unit of observation was children under the age of 5 years. Depending on the outcome, the final sample included between 116 325 and 272 238 children. Sample generation is shown in figure 1.

### Patient and public involvement

No patients were involved in this study.

### Outcomes

Based on the UNICEF Conceptual Framework for child undernutrition, we identified nutrition-specific and nutrition-sensitive interventions to be included in the analyses. Nutrition-specific interventions for child health and nutritional outcomes are early breastfeeding initiation, dietary diversity, iodine fortification, iron and vitamin A supplementation, clean cooking fuel, safe drinking water and improved sanitation. Early breastfeeding initiation is defined as start of breast feeding within 1 hour of birth and is measured for the last-born child. This variable has been chosen for the analysis instead of self-reported breastfeeding duration as it has been shown to be a good indicator for the latter while being less error prone.[17] Minimum dietary diversity has been derived by aggregating foods fed to the child within a 24 hours recall period into seven essential nutritional groups (‘grains, roots and tuber’, ‘legumes and nuts’, ‘dairy’, ‘animal protein excluding eggs’, ‘eggs’, ‘other fruits’ and ‘foods rich in vitamin A’) and setting the cut-off for minimum dietary diversity at having received four food groups or more. Unlike other interventions in this study, information on dietary diversity is only available for children below 2 years of age. Salt has been coded as properly iodised whenever a household salt rapid test has detected iodine levels of 15 ppm or higher. The indicator variable for vitamin A supplementation in children bases on maternal recall data or alternatively child’s health card entry, while iron supplementation bases entirely on information provided by mothers and assumes the value 1 if the mother reports that her child receives iron pills, sprinkles or syrup.

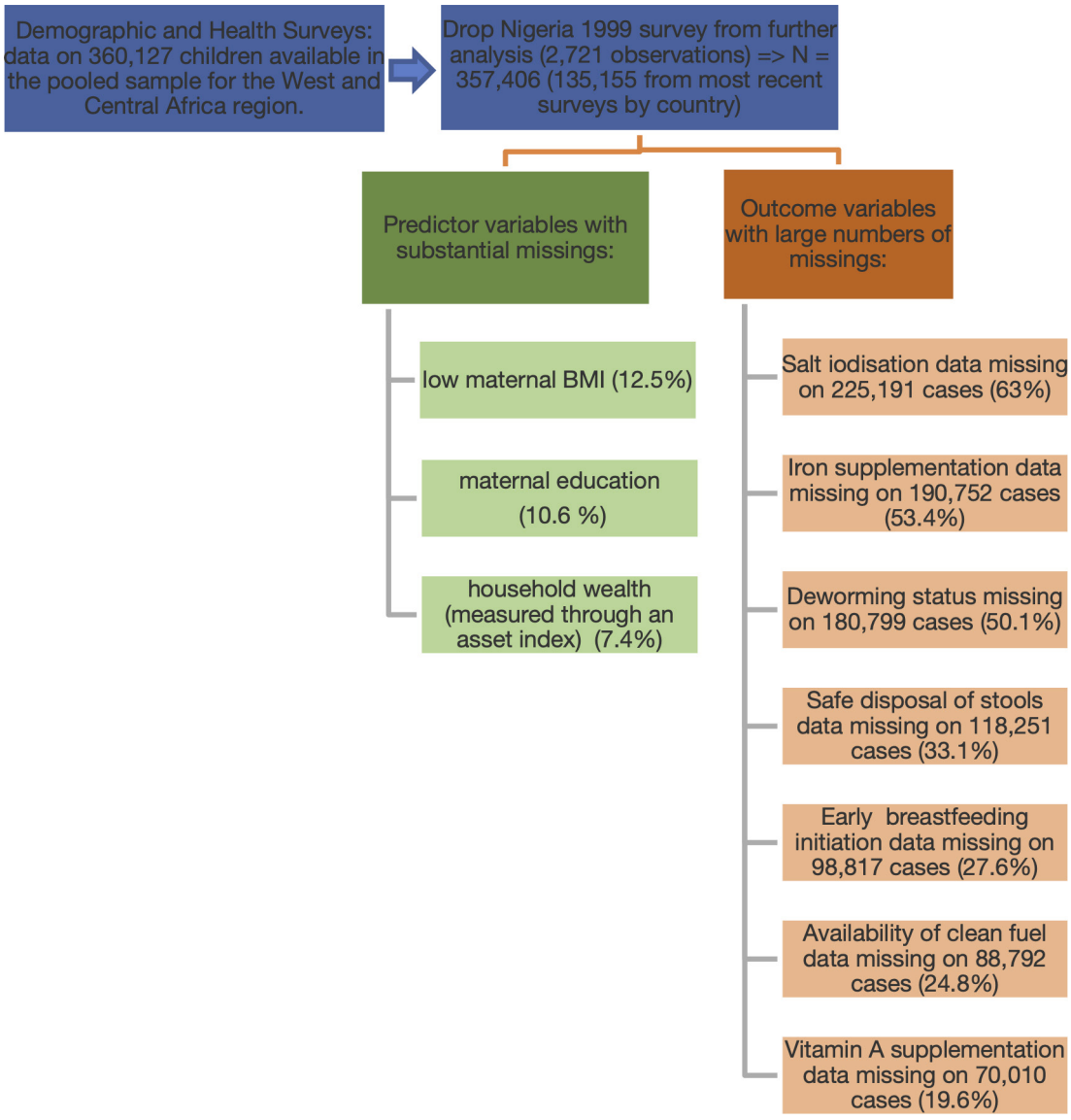


**Figure 1** Sample generation. BMI, body mass index.

Indoor air pollution is captured through the usage of clean cooking fuel. All houses cooking outside as well as those using electricity, liquefied petroleum gas, natural gas, or biogas are classified as clean, whereas those using kerosene or any type of solid fuel are considered unsafe with regards to indoor air quality.

Safe drinking water sources are piped water into dwelling, yard or plot/public tap or standpipe/tubewell or borehole/protected dug well/protected spring/rainwater collection[18] and sanitation facilities are considered 'improved' when they hygienically separate human excreta from human contact, such as facilities with sewer connections, septic system connections, pour-flush latrines, ventilated improved pit latrines and pit latrines with a slab or covered pit.

Nutrition-sensitive interventions for child anthropometry outcomes are deworming and age-appropriate immunisation. Age-appropriate immunisation has been determined based on a set of eight vaccines available from the DHS. For children older than 12 months, we define all children who received Bacillus Calmette-Guérin vaccine (BCG, administered against tuberculosis), measles and three doses of diphtheria, pertussis and tetanus (DPT) and polio each as fully immunised (eight vaccines). Children below 1 year of age are defined as fully immunised if they follow the recommended immunisation calendar (BCG in month 1–3, DPT and polio before month 4 (excluding the polio vaccine dose given shortly after birth as customary in some regions) and measles after 9 months).

## Exposure

Explanatory variables include sex of the child, age of the child in months, number of children in the household, an indicator whether the child had fever in the past 2 weeks, an indicator whether the child had diarrhoea in the past 2 weeks, indicators for birth order of the child (reference category: first born), wealth quintile measured by an asset

index based on a principal component analysis (reference category: poorest quintile), indicator for female household head, indicator for urban residence, indicator for low maternal body mass index (BMI) defined by mother's BMI being below 18.5 $kg/m^2$, age of the mother in years, age of the mother at first birth, indicators for maternal education (reference category: less than primary education) and religion of the household (reference category: Muslim).

### Statistical analysis

For each outcome the following linear probability models were estimated: (1) The outcome with each explanatory variable separately, only adjusted for country and year fixed effects. In case of categorical variables this means indicators for each category excluding the reference category. (2) The outcome with all explanatory variables and in addition PSU fixed effects. PSUs are survey specific and therefore implicitly also control for country and year fixed effects as well as urban location. PSU fixed effects control for characteristics of the local environment at the time of the survey that all households have in common, such as local food markets, health systems but also environmental conditions. Regression and descriptive analyses have been weighted with DHS survey weights and rescaled to reflect individual countries' population sizes in pooled samples.

The linear probability models are preferable over logistic regression models because logistic regression models with large number of fixed effects suffer from incidental parameter problems leading to inconsistent estimates. Standard errors are clustered at the PSU level.

## RESULTS

Table 1 shows prevalence of each intervention for the entire West and Central African region. Table 2 shows intervention prevalence for each country. Practice of early breastfeeding initiation was 54.31% (95% CI: 53.22% to 55.41%), ranging from 29.0% in Chad to 81.7% in Mali. Practice of minimum dietary diversity was 13.89% (95% CI: 13.19% to 14.59%). Burkina Faso had the lowest practice with 3.7% and Sao Tome and Principe the highest with 50.7%. Cameroon had the second highest rate with 28.7%. Coverage of full age-appropriate immunisation was 13.04% (95% CI: 12.49% to 13.59%), ranging from 8.2%in Chad to 43.0% in Gambia. Information on iodised salt usage was only available for a few countries, it was lowest in Niger with 20.6% and highest in Cameroon with 85.7%. The population-weighted average was 49.66% (95% CI: 46.79% to 52.53%). Vitamin A supplementation was lowest in Nigeria with 40.4% and highest in Togo with 81.2%, the population-weighted average was 52.87% (95% CI: 51.41% to 54.33%). Coverage of iron supplementation was 10.73% (95% CI: 10.07% to 11.39%), Senegal had the lowest coverage with 1.7% and Sierra Leone the highest with 35.2%. Deworming prevalence ranges from 11.9% (Burkina Faso) to 67.6% (Gabon) and the population-weighted average was 31.33% (95% CI: 30.06% to 32.60%). Clean cooking fuel usage is close to 0 in most countries, Gabon being an exception with 83.4% coverage. Cameroon, Cote d'Ivoire, Ghana and Senegal had coverage rates between 10% and 20%. The regional average was 3.02% (95% CI: 2.66% to 3.38%). Availability of safe drinking water sources was 57.85% (95% CI: 56.10% to 59.59%), ranging from 28.7% in the Central African Republic to 93.3% in Sao Tome and Principe. Availability of improved sanitation was 42.49% (95% CI: 40.77% to 44.21%). In Sao Tome and Principe coverage was 0, among the others the range was 10.8% in Chad to 64.4% in Ghana.

Table 3 shows the associations found in the unadjusted linear probability models. Each coefficient (or in case of categorical variables: each group of coefficients) is the result of one single regression, which for the purpose of better visualisation is shown in one single column for the respective outcome. Some associations are consistent across all outcomes, for instance education is associated with higher practices of all interventions. Similarly, children of older mothers and mothers who were older at first birth have a higher probability of intervention practice.

**Table 1** Prevalence of nutrition interventions in West and Central Africa (based on most recent available survey for each country)

| | Mean | SE | 95% CI | N |
|---|---|---|---|---|
| Early breastfeeding initiation | 54.31% | 0.56% | 53.22% to 55.41% | 66 440 |
| Minimum dietary diversity | 13.89% | 0.36% | 13.19% to 14.59% | 67 113 |
| Full vaccination | 13.04% | 0.28% | 12.49% to 13.59% | 97 452 |
| Iodised salt usage | 49.66% | 1.46% | 46.79% to 52.53% | 15 480 |
| Vitamin A supplement | 52.87% | 0.74% | 51.41% to 54.33% | 94 927 |
| Iron supplement | 10.73% | 0.34% | 10.07% to 11.39% | 90 682 |
| Deworming | 31.33% | 0.65% | 30.06% to 32.60% | 93 877 |
| Clean cooking fuel | 3.02% | 0.18% | 2.66% to 3.38% | 95 051 |
| Improved water source | 57.85% | 0.89% | 56.10% to 59.59% | 97 452 |
| Improved sanitation | 42.49% | 0.87% | 40.77% to 44.21% | 97 452 |

**Table 2** Prevalence of nutrition interventions by country (based on most recent available survey per country)

| | Year of most recent survey | Early breast feeding | Dietary diversity | Full vaccination | Iodised salt usage | Vitamin A supplement | Iron supplement | Deworming | Clean cooking fuel | Improved water | Improved sanitation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Benin | 2012 | 68.5 | 25.4 | 12.5 | n/a | 53.6 | 30.4 | 48.3 | 3.3 | 75.5 | 28.6 |
| Burkina Faso | 2010 | 54.5 | 3.7 | 32.2 | n/a | 63.9 | 7.3 | 11.9 | 1.9 | 75.0 | 24.2 |
| Cameroon | 2011 | 49.0 | 28.7 | 23.5 | 85.7 | 65.2 | 8.7 | 47.1 | 10.6 | 62.7 | 50.8 |
| Central African Republic | 1995 | 38.8 | 1.4 | 22.2 | n/a | n/a | n/a | n/a | n/a | 28.7 | 13.6 |
| Chad | 2015 | 29.0 | 8.0 | 8.2 | n/a | 41.7 | 14.7 | 24.6 | 2.3 | 52.6 | 10.8 |
| Cote d'Ivoire | 2012 | 41.7 | 7.5 | 21.8 | n/a | 62.8 | 13.6 | 32.9 | 10.6 | 73.7 | 42.2 |
| Gabon | 2012 | 49.6 | 22.2 | 14.5 | n/a | 55.3 | 18.8 | 67.6 | 83.4 | 87.8 | 58.9 |
| Ghana | 2014 | 69.5 | 18.7 | 32.9 | 28.1 | 69.2 | 21.2 | 33.5 | 18.4 | 63.6 | 64.4 |
| Guinea | 2012 | 33.4 | 4.8 | 12.3 | n/a | 41.6 | 8.9 | 23.4 | 0.2 | 72.5 | 36.9 |
| Liberia | 2013 | 75.3 | 7.7 | 20.8 | n/a | 59.3 | 26.6 | 51.7 | 0.0 | 68.0 | 40.9 |
| Mali | 2013 | 81.7 | 17.4 | 10.5 | n/a | 60.8 | 20.0 | 26.0 | 0.3 | 62.5 | 38.4 |
| Niger | 2012 | 63.3 | 6.4 | 20.5 | 20.6 | 55.8 | 10.8 | 25.9 | 0.7 | 64.8 | 16.8 |
| Nigeria | 2013 | 47.5 | 14.4 | 9.3 | n/a | 40.4 | 5.4 | 18.4 | 1.6 | 55.5 | 51.0 |
| Senegal | 2015 | 46.1 | 11.3 | 28.8 | n/a | 74.6 | 1.7 | 60.6 | 20.5 | 70.2 | 58.7 |
| Sao Tome and Principe | 2009 | 63.5 | 50.7 | 21.4 | 66.0 | 77.1 | 15.0 | 50.7 | 0.2 | 93.3 | 0.0 |
| Sierra Leone | 2013 | 67.6 | 12.0 | 21.1 | n/a | 81.1 | 35.2 | 52.6 | 0.1 | 52.8 | 46.0 |
| Togo | 2014 | 73.7 | 15.3 | 25.3 | n/a | 81.2 | 24.9 | 45.0 | 4.1 | 58.1 | 32.2 |
| Gambia | 2013 | 74.2 | 10.6 | 43.0 | 0.0 | 79.5 | 16.3 | 33.1 | 0.3 | 87.6 | 54.6 |

**Table 3** Predictors of practice of nutrition interventions—unadjusted models (coefficients represent marginal effects, weighted)

| | Early breast feeding | Dietary diversity | Full vaccination | Iodine supplement | Vitamin A supplement | Iron supplement | Deworming | Clean cooking fuel | Improved sanitation | Improved water |
|---|---|---|---|---|---|---|---|---|---|---|
| **Child characteristics** | | | | | | | | | | |
| Child is male | −0.010** (0.004) | −0.003 (0.003) | 0.001 (0.002) | −0.005 (0.004) | 0.001 (0.004) | −0.002 (0.003) | 0.004 (0.004) | −0.000 (0.003) | −0.002 (0.002) | −0.002 (0.002) |
| Child's age in months | 0.000*** (0.000) | 0.001*** (0.000) | −0.005*** (0.000) | −0.000 (0.000) | 0.003*** (0.000) | 0.000*** (0.000) | 0.005*** (0.000) | 0.000 (0.000) | 0.000** (0.000) | 0.000** (0.000) |
| Fever within past 2 weeks | −0.056*** (0.006) | 0.010*** (0.004) | 0.013*** (0.003) | −0.008* (0.005) | 0.029*** (0.005) | 0.035*** (0.005) | 0.063*** (0.006) | −0.017*** (0.004) | −0.023*** (0.003) | −0.023*** (0.003) |
| Diarrhoea within past 2 weeks | −0.064*** (0.007) | 0.009** (0.004) | 0.015*** (0.003) | −0.003 (0.005) | 0.007 (0.006) | 0.016*** (0.005) | 0.020*** (0.007) | −0.026*** (0.004) | −0.025*** (0.004) | −0.025*** (0.004) |
| Child is second born | 0.020*** (0.005) | 0.005 (0.003) | 0.013*** (0.003) | −0.005 (0.005) | 0.018***(0.004) | 0.014*** (0.003) | 0.019*** (0.005) | 0.022*** (0.003) | 0.021*** (0.003) | 0.021*** (0.003) |
| Child is third born | 0.012** (0.006) | 0.006 (0.004) | −0.001 (0.003) | 0.000 (0.004) | 0.016*** (0.005) | 0.013*** (0.003) | 0.014** (0.005) | 0.010*** (0.004) | 0.011*** (0.003) | 0.011*** (0.003) |
| Child is fourth born or above | 0.012** (0.005) | −0.016*** (0.004) | −0.023*** (0.002) | 0.005 (0.004) | −0.025*** (0.004) | −0.025*** (0.003) | −0.030*** (0.005) | −0.040*** (0.003) | −0.042*** (0.003) | −0.042*** |
| **Maternal characteristics** | | | | | | | | | | |
| Low maternal BMI | −0.041*** (0.009) | −0.014** (0.007) | −0.017*** (0.003) | −0.015** (0.007) | −0.058*** (0.007) | −0.012* (0.007) | −0.059*** (0.008) | −0.032*** (0.004) | −0.051*** (0.005) | −0.051*** (0.005) |
| Mother's age | 0.002*** (0.000) | 0.001*** (0.000) | −0.002*** (0.000) | 0.001*** (0.000) | 0.004*** (0.000) | 0.001*** (0.000) | 0.005*** (0.000) | 0.001*** (0.000) | 0.001*** (0.000) | 0.001*** (0.000) |
| Mother's age at first birth | 0.003*** (0.001) | 0.005*** (0.000) | 0.005*** (0.000) | 0.001 (0.001) | 0.013*** (0.001) | 0.006*** (0.000) | 0.011*** (0.001) | 0.010*** (0.001) | 0.011*** (0.001) | 0.011*** (0.001) |
| Mother has primary/ incomplete secondary education | 0.040*** (0.007) | 0.037*** (0.005) | 0.044*** (0.003) | 0.002 (0.007) | 0.104*** (0.006) | 0.058*** (0.005) | 0.092*** (0.007) | 0.046*** (0.005) | 0.075*** (0.005) | 0.075*** (0.005) |
| Mother has secondary or higher education | 0.059*** (0.011) | 0.131*** (0.009) | 0.112*** (0.006) | 0.040*** (0.010) | 0.254*** (0.012) | 0.108*** (0.008) | 0.222*** (0.008) | 0.188*** (0.016) | 0.276*** (0.014) | 0.276*** (0.014) |
| **Household characteristics** | | | | | | | | | | |
| Second wealth quintile | −0.029*** (0.008) | −0.037*** (0.004) | −0.030*** (0.003) | −0.025*** (0.007) | −0.093*** (0.006) | −0.050*** (0.004) | −0.088*** (0.006) | −0.063*** (0.004) | −0.116*** (0.005) | −0.116*** (0.005) |
| Third wealth quintile | 0.004 (0.007) | −0.023*** (0.004) | −0.003 (0.003) | −0.006 (0.007) | −0.028*** (0.006) | −0.008 (0.006) | −0.022*** (0.006) | −0.054*** (0.005) | −0.032*** (0.005) | −0.032*** (0.005) |
| Fourth wealth quintile | 0.035*** (0.007) | 0.026*** (0.005) | 0.033*** (0.003) | 0.029*** (0.007) | 0.073*** (0.007) | 0.037*** (0.006) | 0.068*** (0.007) | 0.018*** (0.005) | 0.114*** (0.006) | 0.114*** (0.006) |
| Fifth wealth quintile | 0.057*** (0.008) | 0.099*** (0.006) | 0.063*** (0.004) | 0.066*** (0.007) | 0.187*** (0.008) | 0.084*** (0.006) | 0.165*** (0.007) | 0.191*** (0.010) | 0.351*** (0.009) | 0.351*** (0.009) |
| Female household head | 0.013 (0.010) | 0.009 (0.008) | −0.004 (0.003) | −0.013*** (0.000) | 0.035*** (0.008) | 0.029*** (0.007) | 0.042*** (0.009) | 0.012** (0.006) | 0.022*** (0.007) | 0.022*** (0.007) |
| Urban location | 0.042*** (0.007) | 0.069*** (0.005) | 0.050*** (0.003) | 0.049*** (0.007) | 0.135*** (0.007) | 0.067*** (0.006) | 0.134*** (0.007) | 0.128*** (0.008) | 0.263*** (0.007) | 0.263*** (0.007) |
| Number of children in the household | 0.001 (0.002) | −0.008*** (0.001) | −0.005*** (0.001) | 0.013*** (0.002) | −0.018*** (0.002) | −0.012*** (0.001) | −0.022*** (0.002) | −0.013*** (0.001) | −0.007*** (0.001) | −0.007*** (0.001) |
| Christian (reference Muslim) | 0.054*** (0.008) | 0.051*** (0.004) | 0.066*** (0.003) | −0.030*** (0.008) | 0.177*** (0.008) | 0.080*** (0.004) | 0.173*** (0.006) | 0.070*** (0.011) | 0.044*** (0.008) | 0.044*** (0.008) |
| Traditional religion | 0.005 (0.014) | −0.036*** (0.006) | −0.036*** (0.005) | −0.016 (0.015) | −0.057*** (0.011) | −0.051*** (0.011) | −0.067*** (0.024) | −0.049*** (0.004) | −0.138*** (0.009) | −0.138*** (0.009) |
| Religion unknown or other | 0.024 (0.015) | −0.005 (0.006) | −0.009* (0.005) | −0.013 (0.019) | −0.126*** (0.013) | −0.020 (0.013) | −0.044* (0.023) | −0.035*** (0.006) | 0.013 (0.011) | 0.013 (0.011) |
| Number of observations | 237 660 | 201 105 | 320 706 | 122 581 | 258 470 | 163 146 | 165 377 | 240 622 | 320 706 | 320 706 |

Note: SEs are shown in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% level.
BMI, body mass index.

Children of mothers with low BMI have lower probability of intervention practice. Other associations differ across outcomes, for instance, fever and diarrhoea are negatively associated with early breastfeeding initiation, clean cooking fuel, safe drinking water and improved sanitation but positive with other outcomes. With respect to wealth quintiles, the second and third quintiles have a lower probability of intervention practice and the richest two quintiles have a higher probability, all compared with the poorest quintile (and unadjusted for other factors or local area characteristics). For all interventions except iodised salt usage Christians are more likely and traditional religion households are less likely than Muslims to receive the intervention.

In table 4, results of a mutually adjusted model are shown. All covariates are included simultaneously for each outcome and in addition are adjusted for PSU fixed effects. The PSU fixed effects absorb all characteristics of the local environment, which are uniform for all households. The remaining variation can be interpreted as within PSU variation. Compared with the unadjusted models, maternal characteristics except education are (mostly) no longer statistically significant. Education however remains statistically significant with a strong positive gradient between education level and intervention practice. Contrary to the unadjusted models, a positive gradient can now also be found for wealth quintile and intervention availability. After mutually adjusting for covariates and controlling for PSU fixed effects, the second and third quintiles are no longer worse off in terms of intervention availability than the poorest quintile. Also, Christians are no longer universally better off than Muslims, which suggests that the unadjusted differences were confounded by socioeconomic characteristics which are now controlled for.

## DISCUSSION

There are several individual-level or household-level characteristics that predict practice of nutrition-specific or nutrition-sensitive interventions above and beyond what local or regional characteristics can explain. Our findings on nutritional supplementation, early breast feeding, minimum dietary diversity and immunisation are generally in line with the existing literature on these outcomes in SSA (as the literature basis on these outcomes is limited, we expanded our search to the entire African region rather than only West and Central Africa), as far as they are available and report the same or similar predictors. However, there exists some evidence which is different from our findings: Aremu *et al*[19] find a negative association between vitamin A supplementation uptake and maternal education in Nigeria while Aemro *et al*[20] find higher birth orders to be adversely linked with minimum dietary diversity in Ethiopia. For the West and Central African region we find the opposite associations.

Moreover, we find the rates for full immunisation to be substantially lower than oftentimes reported within general policy communication and scientific work (eg, Maina *et al* report an immunisation coverage of 77% in Kenya,[21] Fadnes *et al* 75% in Uganda[22]). This finding is mainly driven by the BCG and measles vaccines, for which vaccination rates can be as low as 5%–6% in individual countries in the most recent survey (eg, Congo, Democratic Republic and Chad) and 18.5% or 20% on average in the region, respectively.

The study is not without limitations. Most importantly, none of the presented associations can be interpreted as causal. Causality would require the additional assumption of no unobserved confounding. Furthermore, some outcomes have rather large numbers of missing observations and are thus no longer representative for the underlying population. Representativeness would require the additional assumption that observations are missing at random.

## CONCLUSIONS

This study has established that individual-level and household-level characteristics have an information value, which goes beyond local area characteristics, for predicting practices of nutrition-specific or nutrition-sensitive interventions. In combination with local and regional characteristics, this individual-level information can be used for improving our understanding which children currently benefit from these interventions and to improve future targeting. The findings show that households with lowest wealth and education within a PSU have the lowest probability to practice the interventions. Our study cannot explain why some individuals practice particular nutrition-specific or nutrition-sensitive interventions while others do not. We cannot distinguish between limited access to these interventions and limited uptake of provided interventions, all we observe is the final practice. We further do not study the impact of these interventions on the ultimate health and nutrition outcomes.

A good understanding of current practices will help policymakers to further increase practice by either extending coverage of access to nutrition-specific or nutrition-sensitive interventions or improving uptake in settings where coverage already is high. Programme managers should develop advocacy strategies to increase the awareness of policymakers on the low practice of nutrition-specific and nutrition-sensitive interventions. Unless strategies to improve coverage and uptake of interventions are endorsed and prioritised by policymakers, progress on undernutrition indicators will likely be slow. Future research may contribute to this effort with identifying socioanthropological barriers to the practices and access to interventions. It is interesting to note that there is no country which is doing best on all outcomes and there is also no country that is performing worst on all outcomes, therefore country-specific approaches with different priorities seem to be in order.

**Table 4** Predictors of practice of nutrition interventions—fully adjusted models with PSU fixed effects (coefficients represent marginal effects, weighted)

| | Early breast feeding | Dietary diversity | Full vaccination | Iodine supplement | Vitamin A supplement | Iron supplement | Deworming | Clean cooking fuel | Improved sanitation | Improved water |
|---|---|---|---|---|---|---|---|---|---|---|
| **Child-level characteristics** | | | | | | | | | | |
| Child is male | −0.008* (0.005) | −0.005 (0.003) | −0.000 (0.002) | −0.001 (0.003) | 0.000 (0.004) | −0.001 (0.003) | −0.000 (0.004) | 0.001 (0.001) | −0.001 (0.002) | 0.001 (0.002) |
| Child's age in months | 0.000 (0.000) | 0.002*** (0.000) | −0.004*** (0.000) | −0.000 (0.000) | 0.003*** (0.000) | 0.000*** (0.000) | 0.005*** (0.000) | 0.000 (0.000) | −0.000 (0.000) | 0.000 (0.000) |
| Fever within past 2 weeks | −0.030*** (0.006) | 0.009** (0.005) | 0.007*** (0.003) | −0.003 (0.004) | 0.046*** (0.005) | 0.037*** (0.004) | 0.057*** (0.006) | −0.001 (0.002) | −0.005* (0.003) | −0.003 (0.004) |
| Diarrhoea within past 2 weeks | −0.033*** (0.007) | 0.018*** (0.005) | 0.001 (0.003) | 0.004 (0.005) | 0.044*** (0.006) | 0.022*** (0.005) | 0.061*** (0.007) | 0.002 (0.002) | 0.002 (0.003) | −0.004 (0.004) |
| Child is second born | 0.059*** (0.007) | 0.005 (0.004) | −0.003 (0.004) | −0.006 (0.006) | 0.014** (0.006) | 0.009** (0.004) | 0.010* (0.006) | 0.000 (0.002) | −0.004 (0.003) | 0.002 (0.004) |
| Child is third born | 0.060*** (0.009) | 0.013** (0.006) | −0.010** (0.004) | 0.002 (0.007) | 0.021*** (0.007) | 0.012** (0.005) | 0.013* (0.007) | 0.001 (0.003) | −0.007* (0.004) | −0.001 (0.005) |
| Child is fourth born or above | 0.069*** (0.010) | 0.018** (0.008) | −0.012*** (0.005) | 0.001 (0.009) | 0.027*** (0.008) | 0.010 (0.007) | 0.019** (0.009) | −0.000 (0.004) | −0.007 (0.005) | −0.015** (0.006) |
| **Maternal characteristics** | | | | | | | | | | |
| Low maternal BMI | −0.010 (0.009) | 0.014* (0.007) | −0.003 (0.003) | 0.004 (0.006) | 0.001 (0.007) | 0.008 (0.006) | −0.002 (0.007) | −0.004 (0.002) | 0.000 (0.004) | 0.002 (0.006) |
| Mother's age | −0.001 (0.001) | −0.001 (0.000) | −0.000 (0.000) | 0.001* (0.001) | 0.000 (0.001) | −0.001 (0.000) | 0.000 (0.001) | −0.001*** (0.000) | 0.000 (0.000) | 0.001** (0.000) |
| Mother's age at first birth | 0.001 (0.001) | 0.001 (0.001) | 0.001*** (0.000) | −0.001 (0.001) | 0.003*** (0.001) | 0.001 (0.001) | 0.002** (0.001) | 0.002*** (0.000) | 0.001 (0.001) | −0.001** (0.001) |
| Mother has primary/incompletet secondary education | 0.008 (0.009) | 0.024*** (0.007) | 0.017*** (0.004) | 0.009 (0.008) | 0.049*** (0.008) | 0.027*** (0.005) | 0.032*** (0.009) | 0.016*** (0.003) | 0.011** (0.005) | −0.002 (0.006) |
| Mother has secondary or higher education | 0.017 (0.013) | 0.066*** (0.012) | 0.048*** (0.007) | 0.025** (0.011) | 0.096*** (0.012) | 0.040*** (0.008) | 0.070*** (0.011) | 0.063*** (0.010) | 0.045*** (0.008) | −0.010 (0.009) |
| **Household characteristics** | | | | | | | | | | |
| Second wealth quintile | 0.025** (0.010) | 0.003 (0.007) | 0.003 (0.004) | 0.007 (0.008) | −0.003 (0.009) | 0.002 (0.005) | −0.004 (0.007) | 0.000 (0.001) | 0.067*** (0.005) | 0.053*** (0.007) |
| Third wealth quintile | 0.024** (0.010) | 0.005 (0.007) | 0.012** (0.005) | 0.011 (0.009) | 0.021** (0.009) | 0.017** (0.008) | 0.012 (0.009) | 0.004* (0.002) | 0.110*** (0.006) | 0.092*** (0.008) |
| Fourth wealth quintile | 0.043*** (0.011) | 0.030*** (0.009) | 0.020*** (0.005) | 0.012 (0.011) | 0.051*** (0.010) | 0.016** (0.008) | 0.022** (0.010) | 0.013*** (0.004) | 0.184*** (0.007) | 0.149*** (0.010) |
| Fifth wealth quintile | 0.063*** (0.013) | 0.063*** (0.011) | 0.029*** (0.006) | 0.023* (0.013) | 0.088*** (0.011) | 0.037*** (0.009) | 0.048*** (0.012) | 0.064*** (0.007) | 0.304*** (0.011) | 0.196*** (0.011) |
| Female household head | −0.003 (0.011) | −0.003 (0.010) | −0.010*** (0.004) | −0.008 (0.009) | −0.001 (0.008) | 0.011 (0.008) | 0.001 (0.009) | 0.002 (0.003) | 0.010* (0.006) | 0.027*** (0.006) |
| Number of children in the household | 0.006*** (0.002) | −0.009*** (0.001) | 0.000 (0.001) | 0.009*** (0.002) | −0.004* (0.002) | −0.004** (0.002) | −0.008*** (0.002) | −0.001 (0.001) | 0.003** (0.001) | 0.006*** (0.002) |
| Christian (reference Muslim) | 0.001 (0.009) | 0.013** (0.006) | 0.007 (0.005) | −0.001 (0.009) | 0.021** (0.011) | 0.020*** (0.007) | 0.026*** (0.008) | 0.014** (0.006) | −0.004 (0.005) | 0.001 (0.006) |
| Traditional religion | −0.007 (0.014) | 0.007 (0.007) | −0.018*** (0.006) | 0.007 (0.016) | −0.002 (0.014) | 0.000 (0.015) | −0.006 (0.016) | −0.001 (0.007) | −0.011 (0.008) | −0.010 (0.010) |
| Religion unknown or other | −0.017 (0.018) | −0.001 (0.011) | −0.029*** (0.009) | 0.012 (0.021) | 0.013 (0.016) | 0.013 (0.014) | −0.006 (0.021) | 0.009 (0.006) | −0.016 (0.012) | −0.024 (0.016) |
| Number of observations | 209822 | 169614 | 272238 | 116325 | 216664 | 125972 | 129082 | 201519 | 272238 | 272238 |

Note: SEs are shown in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% level.
BMI, body mass index.

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## REFERENCES

1 Improving_Child_Nutrition_-_the_achievable_imperative_for_global_progress.pdf [Internet]. Available: https://www.unicef.org/gambia/Improving_Child_Nutrition_-_the_achievable_imperative_for_global_progress.pdf [Accessed cited 1Apr 2018].
2 Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition? - *The Lancet* [Internet]. Available: http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(13)60843-0/abstract [Accessed cited 2 Apr 2018].
3 Begum K, Ouédraogo CT, Wessells KR, *et al*. Prevalence of and factors associated with antenatal care seeking and adherence to recommended iron-folic acid supplementation among pregnant women in Zinder, Niger. *Matern Child Nutr* 2018;14:e12466.
4 Odusanya OO, Alufohai EF, Meurice FP, *et al*. Determinants of vaccination coverage in rural Nigeria. *BMC Public Health* 2008;8:381.
5 Janmohamed A, Klemm RD, Doledec D. Determinants of successful vitamin A supplementation coverage among children aged 6–59 months in thirteen sub-Saharan African countries. *Public Health Nutr* 2017;20:2016–22.
6 Adeloye D, Jacobs W, Amuta AO, *et al*. Coverage and determinants of childhood immunization in Nigeria: a systematic review and meta-analysis. *Vaccine* 2017;35:2871–81.
7 Ayoya MA, Bendech MA, Baker SK, *et al*. Determinants of high vitamin A supplementation coverage among pre-school children in Mali: the National nutrition weeks experience. *Public Health Nutr* 2007;10:1241–6.
8 Ogbo FA, Page A, Agho KE, *et al*. Determinants of trends in breast-feeding indicators in Nigeria, 1999–2013. *Public Health Nutr* 2015;18:3287–99.
9 Haile D, Biadgilign S, Azage M. Differentials in vitamin A supplementation among preschool-aged children in Ethiopia: evidence from the 2011 Ethiopian demographic and health survey. *Public Health* 2015;129:748–54.
10 Bendech MA, Cusack G, Konaté F, *et al*. National vitamin A supplementation coverage survey among 6-59 months old children in guinea (West Africa). *J Trop Pediatr* 2007;53:190–6.
11 Schoeps A, Ouédraogo N, Kagoné M, *et al*. Socio-demographic determinants of timely adherence to BCG, Penta3, measles, and complete vaccination schedule in Burkina Faso. *Vaccine* 2013;32:96–102.
12 Chirawurah D, Apanga S, Addah J. Assessing iodized salt use in rural Northern Ghana: a mixed method approach. *Food Public Health* 2015;5:70–6.
13 Belew AK, Ali BM, Abebe Z, *et al*. Dietary diversity and meal frequency among infant and young children: a community based study. *Ital J Pediatr* 2017;43:73.
14 Mutua MK, Kimani-Murage E, Ngomi N, *et al*. Fully immunized child: coverage, timing and sequencing of routine immunization in an urban poor settlement in Nairobi, Kenya. *Trop Med Health* 2016;44:13.
15 Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? - *Semantic Scholar* [Internet]. Available: https://www.semanticscholar.org/paper/Evidence-based-interventions-for-improvement-of-and-Bhutta-Das/a1543b170a198b12ab45bd0972c9b039ec48dea6 [Accessed cited 2Apr 2018].
16 Bhutta ZA, Ahmed T, Black RE, *et al*. What works? Interventions for maternal and child undernutrition and survival. *Lancet* 2008;371:417–40.
17 Corsi DJ, Mejía-Guevara I, Subramanian SV. Improving household-level nutrition-specific and nutrition–sensitive conditions key to reducing child undernutrition in India. *Soc Sci Med* 2016;157:189–92.
18 WHO Guidelines for Drinking Water Quality [Internet]. Available: http://apps.who.int/iris/bitstream/handle/10665/254637/9789241549950-eng.pdf?sequence=1 [Accessed cited 2Apr 2018].
19 Aremu O, Lawoko S, Dalal K. Childhood vitamin A capsule supplementation coverage in Nigeria: a multilevel analysis of geographic and socioeconomic inequities. *ScientificWorldJournal* 2010;10:1901–14.
20 Aemro M, Mesele M, Birhanu Z, *et al*. Dietary diversity and meal frequency practices among infant and young children aged 6–23 months in Ethiopia: a secondary analysis of Ethiopian demographic and health survey 2011. *J Nutr Metab* 2013;2013:1–8.
21 Maina LC, Karanja S, Kombich J. Immunization coverage and its determinants among children aged 12 - 23 months in a peri-urban area of Kenya. *Pan Afr Med J* 2013;14:3.
22 Fadnes LT, Nankabirwa V, Sommerfelt H, *et al*. Is vaccination coverage a good indicator of age-appropriate vaccination? A prospective study from Uganda. *Vaccine* 2011;29:3564–70.