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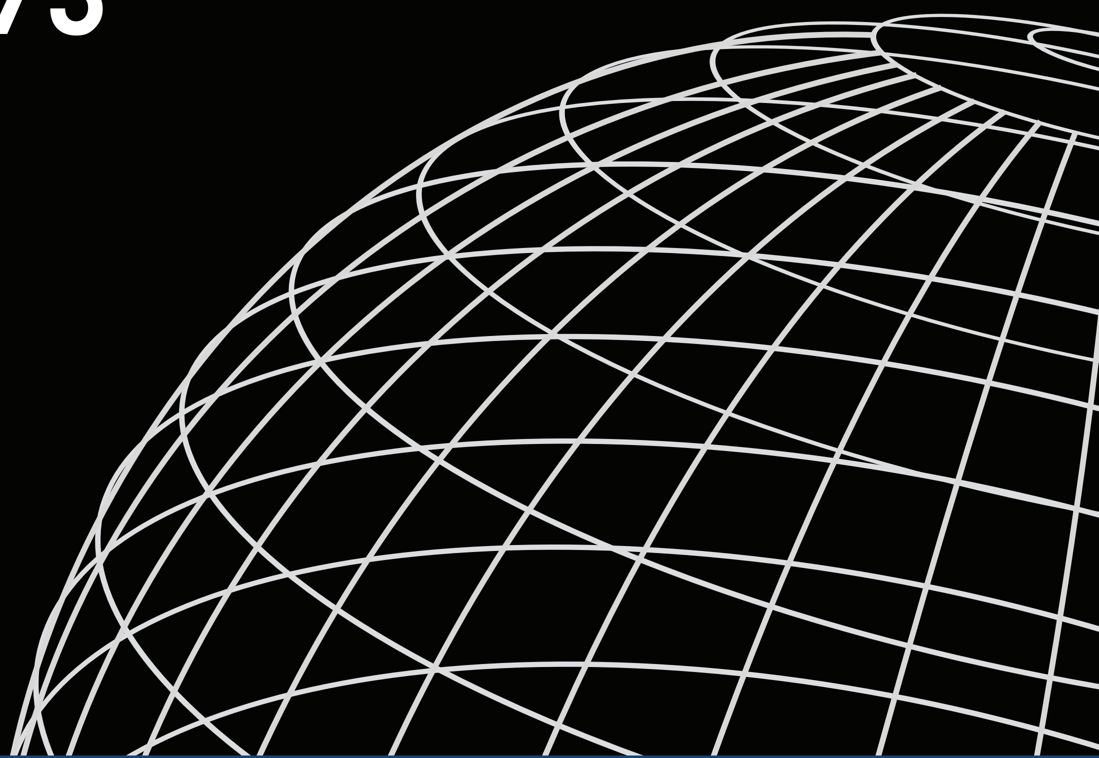
VARIATIONS IN HEALTH OUTCOMES WITH ALTERNATIVE MEASURES OF URBANICITY, USING DEMOGRAPHIC AND HEALTH SURVEYS 2013-18

DHS ANALYTICAL STUDIES 73



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Variations in Health Outcomes with Alternative Measures of Urbanicity, Using Demographic and Health Surveys 2013-18

Shireen Assaf[1]
Christina Juan[1]

ICF
Rockville, Maryland, USA

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[1] ICF, The DHS Program

Corresponding author: Shireen Assaf, International Health and Development, ICF, 530 Gaither Road, Suite 500, Rockville, MD 20850, USA; phone: +1 301-407-6500; fax: +1 301-407-6501; email: Shireen.assaf@icf.com

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PREFACE

The Demographic and Health Surveys (DHS) Program is one of the principal sources of international data on fertility, family planning, maternal and child health, nutrition, mortality, environmental health, HIV/AIDS, malaria, and provision of health services.

One of the objectives of The DHS Program is to analyze DHS data and provide findings that will be useful to policymakers and program managers in low- and middle-income countries. DHS Analytical Studies serve this objective by providing in-depth research on a wide range of topics, typically including several countries and applying multivariate statistical tools and models. These reports are also intended to illustrate research methods and applications of DHS data that may build the capacity of other researchers.

The topics in this series are selected by The DHS Program in consultation with the U.S. Agency for International Development.

It is hoped that the DHS Analytical Studies will be useful to researchers, policymakers, and survey specialists, particularly those engaged in work in low- and middle-income countries.

Sunita Kishor
Director, The DHS Program

ABSTRACT

The literature has firmly established the link between urban/rural place of residence and health indicators, and the association of poor health outcomes and health services in rural areas. However, few studies have looked at gradients of urban areas or urbanicity, which have been described as the *impact* of living in those areas at a given time. In this report, we used several measures of urbanicity to study four health indicators: using modern contraceptives (mCPR); having four or more antenatal care (ANC4) visits for the most recent birth among women; completing three doses of an immunization that protects children against diphtheria, pertussis, and tetanus (DPT3); and providing the minimum acceptable diet (MAD) for children. The urbanicity measures include the urban/rural dichotomous measure, SMOD, which uses satellite data and population density to identify rural, peri-urban (suburbs), and urban centers; nightlights, which measures the level of luminosity; and a variable constructed from DHS data which splits urban areas into urban poor and urban non-poor clusters. Data from 30 countries with a recent DHS were used for the analysis. Of these, an in-depth analysis was also performed on six DHS surveys: Bangladesh 2014, Democratic Republic of the Congo (DRC) 2013-14, India 2015-16, Kenya 2014, Nigeria 2016, and Senegal 2016. The in-depth analysis examined the urbanicity variables and used unadjusted and adjusted regression to examine associations between the urbanicity variables and the health indicators. The analysis of the 30 surveys used adjusted regressions to examine the association between SMOD and the urban poor cluster variable with the health outcomes. The findings show few significant associations, particularly those with DPT3 and MAD. The urban poor cluster variables exhibited the most significant associations, particularly with mCPR. However, results were country specific, with some countries exhibiting large significant differences that favored the urban non-poor or urban centers. For example, in Haiti and Burundi, there were more than 80% lower odds of MAD for children who live in urban poor clusters compared to the urban non-poor. Some limitations of the analysis include small sample sizes for certain categories of the urbanicity variables and for the DPT3 and MAD outcomes. In addition, the analysis included health services indicators, which may exhibit few differences within an urban environment compared to health outcomes indicators.

Key words: urbanicity, SMOD, nightlights, urban poor, urban poverty, family planning, maternal and child health

1 BACKGROUND OF THE REPORT

Urbanization is a term that is widely used to define a change in density, size, and heterogeneity of cities (Cyril, Oldroyd, and Renzaho 2013; Vlahov and Galea 2002). The process of urbanization has rapidly increased at global and regional levels. Among the approximately 7.6 billion people in the world, 6.4 billion live in less developed regions (DESA 2018), or low- and middle-income countries (LMICs). According to 2018 estimates, more than half of the world's population (55%) live in urban areas (DESA 2018). As the world's population continues to grow, two-thirds (66%) of the population are forecasted to live in urban areas by 2050 (World Health Organization and UN-Habitat 2016). Furthermore, most of rapid urban growth will continue to occur in LMICs, and at a faster pace in those regions compared to others, with an estimated 8.5 billion out of 9.8 billion living in LMICs by 2050 (Cyril, Oldroyd, and Renzaho 2013; DESA 2018).

The widely used term *urbanization* is a *process* through which cities change in terms of their size, heterogeneity, and density. This concept differs from the lesser-known concept of urbanicity, which refers to the *impact* of living in urban areas at a given time (Cyril, Oldroyd, and Renzaho 2013; Vlahov and Galea 2002). Urbanicity is static compared with the notion that describes a city's evolving characteristics that occur over time. Previous research has assessed urbanicity by the number of addresses per square kilometer (Verheij, Maas, and Groenewegen 2008). Urbanicity contrasts existing cities and surrounding areas, and highlights differences between a city and surrounding towns or peri-urban areas. The concepts of urbanicity and urbanization are complementary. Urbanicity can also be viewed through the lens of three domains: the social environment, the physical environment, and access to health and social services, in which the prevalence of conditions such as respiratory disease is more characteristic of urban areas compared to the nonurban areas (Vlahov and Galea 2002).

A number of different scales have been used to measure urbanization and urbanicity. Studies have typically relied on the measurement of urbanization through a dichotomous rural-urban residence variable. Statistical analyses that include this two-category variable are limited, however, in terms of their ability to capture the heterogeneity that likely takes place to varying degrees in urban environments (Jones-Smith and Popkin 2010). Such classifications are also inherently country-specific and dependent on an unstandardized mix of characteristics such as a functioning economy, population density, and administrative regions (Dahly and Adair 2007; Vlahov and Galea 2002). Countries like Singapore classify all areas as urban (Dahly and Adair 2007).

Although countless studies assess urbanization or the impact of urbanization through the rural-urban residence dichotomy, there is a dearth of research that measures urbanization's complex and more nuanced features beyond these two categories. An urbanicity index, for example, measures the degree to which an environment is urban at one point in time and examines how urban living affects health outcomes. Through a systematic review that examined measurement properties of scales that evaluate urbanicity, Cyril et al. (2013) discussed studies from Africa, Asia, and Europe that included from 7 to 12 items in the scales. Previous research assessed urbanicity with items related to remote sensing, the collection of neighborhood characteristics, or single-dimension proxy measures such as population density. Allender et al. (2008), for example, developed a 7-item scale based on components such as the existence of phone services, access to public transportation, the presence of health facilities such as a maternal health clinic, and the presence of gas stations. In contrast to single-dimension proxy measures, Dahly and Adair (2007) developed an urbanicity scale based on an *a priori* conceptual framework (Cyril, Oldroyd, and Renzaho 2013) and available data across survey years (Dahly and Adair 2007). Other measures of urbanicity include access to infrastructure and services such as education, electricity, and water. In contrast to defining residence areas by administrative definitions, another urbanicity measure (SMOD) uses data from the Global Human Settlement Layer, which uses population density, built cover, and settlement size to define cities, towns, suburbs (or peri-urban areas), and rural areas (European Commission 2020).

Previous studies have shown the linkages between urbanization and urbanicity with health outcomes. As cities become more populous and booming with growth in the economy, education, and infrastructure, so too are the changes in health trends that have both beneficial and deleterious effects. Urbanization is associated with an increase in access to and utilization of health services (Cyril, Oldroyd, and Renzaho 2013). With more people living in more densely populated areas, there is greater opportunity for innovation, care, and caregiving as well as the growth of businesses. Better access to health care has a greater impact on reducing child mortality (Harttgen and Misselhorn 2006), and lowering rates of untreated hypertension (Vorster 2002), while rural environments are usually more deprived of the facilities that address these and other health issues. Research has supported the claim that, on average, urban residents have better health outcomes compared to residents in rural areas (Van de Poel, O'Donnell, and Van Doorslaer 2007). For example, a 33-country study that examined anthropometric indicators of child growth (such as the prevalence of stunting, wasting, and underweight) found that urban children had better nutrition than children in rural areas (Von Braun 1993). Further, more urbanized countries tend to have a lower prevalence of underweight preschoolers compared to countries with less urbanization, although malnutrition in large cities is similar to rural areas in some countries (Von Braun 1993). Von Braun (1993) reflected on the poor living conditions, low-income households, and difficulty in meeting demand for services in rapidly growing cities.

Another study that compared overall childhood mortality between urban and rural children in 12 countries, including Senegal, Egypt, Mexico, and Thailand, found that children in rural areas have 1.6 times greater odds of dying before the age five compared to children in the urban areas (Cleland, Bicego, and Fegan 1992). Urbanization is linked with poor health outcomes, which makes the effects of this process less clear. Women and men in urban areas have been shown to have higher mean body mass index (BMI) compared to other groups (Vorster 2002), and a higher probability of reporting poor health from social isolation, overcrowding, pollution, and other unhygienic living conditions found at higher levels of urbanization (Van de Poel, O'Donnell, and Van Doorslaer 2012). In urban environments, city officials are responsible for managing global health issues and demographic transitions, such as water contamination, health pandemics, pollution, communicable and noncommunicable diseases, and slum upgrading (World Health Organization and UN-Habitat 2016). Globally, government and city officials are directing and managing the effects of COVID-19 (Corburn et al. 2020), in which cities have largely been the epicenter of the current public health crisis (Branas et al. 2020). During demographic transitions, the urban environment may affect health, and can modify effects of unpredicted stressors on cities (Vlahov and Galea 2002).

To measure urbanization and urbanicity and their relationship with health, studies have traditionally relied on the dichotomous urban and rural area variable (Damasceno et al. 2009; Peen et al. 2010). Thus, use of a surrogate measure such as the urban/rural dichotomy is limited in terms of assessing stability and consistency across time and countries (Cyril, Oldroyd, and Renzaho 2013). Beyond this generic measure, previous studies have looked at urbanization in a more nuanced way—as living standards that vary more within urban settings, for example, with greater income inequality compared to rural areas, as well as health programs that may overlook urban poor residents while targeting their rural counterparts (Van de Poel, O'Donnell, and Van Doorslaer 2007).

Menon et al. (2000) used DHS data from 11 countries to test the hypothesis that intra-urban differentials across socioeconomic status quintiles in child stunting are greater than intra-rural differentials, and that stunting prevalence among the urban and rural poor is equally high (Menon, Ruel, and Morris 2000). Malnutrition in urban areas was greatest among the poorest urban populations. A systematic review of 11 studies investigated the association between urbanization and undernutrition and overweight nutrition outcomes in children (Eckert and Kohler 2014). Eckert and Kohler found that urbanization was associated with a lower risk of undernutrition and a higher risk of overweight outcomes in children. In addition, risk factors for chronic diseases were more common in urban areas. A 47-country study that used DHS data examined the magnitude of rural-urban disparities and differences in the degree of socioeconomic inequality in child nutritional status and under-5 mortality, and found that urban poor in a number of countries have higher stunting and under-5 mortality rates than the rural poor (Van de Poel, O'Donnell, and Van Doorslaer 2007). In Ghana, researchers analyzed life history calendar data, and found that urban women had lower odds of giving birth than rural women, with particular effects of urbanization on the first birth (White et al. 2008). White et al. (2008) interpret this decline in fertility as reflective of opportunities such as employment and education, delay in marriage and other norms of living in an urban environment, and access to health care services. It also depends on the association between urbanization and health outcomes in terms of harmful or beneficial effects. In contrast to the study by Cleland et al. (1992), which relied on the urban-rural residence variable and found that urban children had a lower risk of dying before their fifth birthday compared to their rural counterparts, another study found that under-5 mortality increased with more urban population growth, which worsened as levels of urban disadvantage grew (Antai and Moradi 2010).

Previous studies of urbanicity have explored the relationship between cities and health. One study analyzed DHS data from 30 countries to understand urbanicity based on population density and associations with malnutrition, obesity and anemia in women of childbearing age, and stunting in preschool-age children (Jones, Acharya, and Galway 2016). These indicators, which examined the impact of cities on health and were constructed using geolocated DHS data to create cluster-level mean population densities, found that malnourishment among women and children (including the prevalence of overweight and obesity outcomes) was higher among those in urban and peri-urban areas, compared with women of childbearing age and preschool-age children in rural areas. Peri-urban areas were also associated with an increased odds of child stunting compared to urban areas, which suggested problems in health infrastructure, food, and other amenities in peri-urban areas (Jones, Acharya, and Galway 2016). There was a similar or higher prevalence of stunting among children in the peri-urban areas as compared to their rural and semi-rural counterparts (Jones, Acharya, and Galway 2016). Another study investigated urbanicity scales and their associations with noncommunicable diseases (NCDs), nutrition, physical activity, and exposure to pollution through a systematic review of urbanicity scales (Cyril, Oldroyd, and Renzaho 2013). One study in this review conducted a systematic review and found that high urbanicity—in which five of the nine studies used population density and the others used composite measures—was associated with a sedentary lifestyle, high BMI, and diabetes mellitus regardless of sex (Allender et al. 2008).

Another study conducted in Austria found strong statistical evidence for an association between urbanicity and musculoskeletal diseases such as osteoporosis and arthritis. The prevalence of these diseases decreased with increasing levels of urbanicity (Vavken and Dorotka 2011). The authors suggest that although greater levels of urbanicity in LMICs is associated with poorer living conditions, more specialized health care in more industrialized countries such as Austria may attenuate risk factors associated with living in urban environments. To assess the degree of change in urban features across communities, urbanicity was assessed on a continuum for its association with adult BMI in China (Jones-Smith and Popkin 2010). Women who lived in communities that transitioned from a low initial urban score to higher levels of urbanicity had higher odds of overweight and obesity outcomes (Jones-Smith and Popkin 2010). In addition to understanding the net effect of urbanization on health behaviors and outcomes such as physical activity and hypertension by using longitudinal data in China, another study that examined self-assessed health found that urbanization increased the probability of reporting symptoms of illness or disease (Van de Poel, O'Donnell, and Van Doorslaer 2012).

With increasing urbanization comes a growth in slums (Crocker-Buque et al. 2017; Pörtner and Su 2018; Unger and Riley 2007). According to the United Nations Human Settlements Program (UN-HABITAT), 863 million people—or one-third—of the urban population in developing countries live in slums (Habitat 2013; Pörtner and Su 2018). More than three-fourths (78%) of the least developed countries' urban population live in slums (Unger and Riley 2007). A slum household is defined by UN-HABITAT as a group of people who live under the same roof in an urban area, lacking at least one or more of the following:

1. Durable housing of a permanent nature that protects against extreme climate conditions
2. Sufficient living space, which means not more than three people sharing the same room
3. Easy access to safe water in sufficient amounts at an affordable price
4. Access to adequate sanitation in the form of a private or public toilet shared by a reasonable number of people
5. Security of tenure that prevents forced evictions (United Nations Human Settlements Programme 2006-2007)

This is a global problem that continues to worsen. Within LMICs, there are certain regions such as sub-Saharan Africa (SSA) where most of its urban population live in slums (Mberu et al. 2016). Approximately 56% of Kenya's urban population lived in slums in 2014, and Kibera, one of the largest slums in the world, is located in Nairobi (Mberu et al. 2016). Countries in Southeast Asia such as Bangladesh and India also have high proportions of their urban populations living in slums, such as 55% in Bangladesh in 2014 (Mberu et al. 2016). In Bangladesh and Kenya, malnutrition and childhood illness mortality and morbidity indicators were worse in slums compared to urban and rural communities (Mberu et al. 2016). Another study found that children under age 5 who live in slums in Senegal lack basic water, sanitation, and hygiene (WASH) services, and that this creates greater risks of waterborne and gastrointestinal conditions such as diarrhea (Thiam et al. 2017).

While some studies have shown a more straightforward relationship between living in slums and health outcomes, others have illustrated a more complex relationship between the two. Understanding contextual and compositional effects that are linked to living in slums and their associations with child health outcomes is important to consider. Slums had been found to have better maternal health services than rural communities (Mberu et al. 2016). After adjusting for wealth and other health variables, children in urban areas in India were the tallest on average, while children living in slums were taller than their rural counterparts (Pörtner and Su 2018). A 45-country DHS analysis between 2000-2009 examined associations between urban slum residency—constructed through characteristics such as water, sanitation, and housing conditions—and infant mortality (Kyu et al. 2013). The authors found that living in a slum neighborhood is associated with higher infant mortality, although this was attenuated among children born to women who had received antenatal care (ANC) from trained providers. This key finding by Kyu et al. (2013) differs from a 73-country DHS study that found slum children to have lower mortality and stunting risks than their rural counterparts, although their health risks were worse compared to urban children (Fink, Günther, and Hill 2014). Similar to other studies that examined slums and child health outcomes, observed differences across a large portion of these countries can be explained by differences in wealth, health access, and maternal education (Fink, Günther, and Hill 2014).

We seek to understand if it is worse in terms of health behaviors and outcomes for resource-constrained people to live in rural areas or urban areas. We examine this central question through a number of variables that assess urbanicity in gradients.

Our study seeks to answer the following research questions:

1. Do peri-urban areas have worse health outcomes than urban areas, and is this disparity similar to or different from that between rural and urban areas?
2. Do people in urban poor areas experience worse health outcomes compared to their urban non-poor counterparts, and if so, is this disparity similar to or different from rural and urban non-poor contexts?

2 DATA AND METHODS

2.1 Data

Data from countries that had a DHS survey from 2014 to the present were included in the analysis. Countries with a population of fewer than 10 million and no GPS data collected during the DHS survey were excluded, which left 30 surveys for the analysis. Six countries were selected for in-depth analysis: Bangladesh, DRC, India, Kenya, Nigeria, and Senegal (Agence Nationale de la Statistique et de la Démographie - ANSD/Sénégal and ICF 2017; International Institute for Population Sciences - IIPS/India and ICF 2017; Kenya National Bureau of Statistics et al. 2015; Ministère du Plan et Suivi de la Mise en œuvre de la Révolution de la Modernité - MPSMRM/Congo, Ministère de la Santé Publique - MSP/Congo, and ICF International 2014; National Population Commission - NPC and ICF 2019; Research et al. 2016). The results for the six countries are discussed country by country, with further analysis of all 30 surveys summarized. Table 1 summarizes the sample sizes.

Table 1 Surveys included in the analysis

Country	DHS survey	Number of households interviewed	Number of women age 15-49 interviewed
Angola	2015-16	16,109	14,379
Bangladesh*	2014	17,300	17,863
Benin	2017-18	14,156	15,928
Burundi	2016-17	15,977	17,269
Cambodia	2014	15,825	17,578
Chad	2014-15	17,233	17,719
Congo Democratic Republic (DRC)*	2013-14	18,171	18,827
Egypt	2014	28,175	21,762
Ethiopia	2016	16,650	15,683
Ghana	2014	11,835	9,396
Guatemala	2014-15	21,383	25,914
Guinea	2018	7,912	10,874
Haiti	2016-17	13,405	14,371
India*	2015-16	601,509	699,686
Jordan	2017-18	18,802	14,689
Kenya*	2014	36,430	31,079
Malawi	2015-16	26,361	24,562
Mali	2018	9,510	10,519
Myanmar	2015-16	12,500	12,885
Nepal	2016	11,040	12,862
Nigeria*	2018	40,427	41,821
Pakistan	2017-18	11,869	12,364
Philippines	2017	27,496	25,074
Rwanda	2014-15	12,699	13,497
Senegal*	2016	4,437	8,865
South Africa	2016	11,083	8,514
Tanzania	2015-16	12,563	13,266
Uganda	2016	19,588	18,506
Zambia	2018	12,831	13,683
Zimbabwe	2015	10,534	9,955

Note: *countries selected for in-depth analysis.

2.2 Variables

2.2.1 Urbanicity variables

We include the place of residence variable available in the DHS datasets that has the urban and rural categories. This variable is based on the country's statistical office classification. This is usually based on the most recent census conducted in the country and may not always be up to date. For instance the Zambia 2018 DHS used the Census of Population and Housing of the Republic of Zambia conducted in 2010 (see the sample frame description in Appendix A of the 2018 Zambia DHS final report) (Zambia Statistics Agency - ZSA et al. 2020).

The analysis uses two variables from external data sources to describe the level of urbanicity at the cluster level: SMOD derived from the Global Human Settlement Model grid (GHS-SMOD) (Pesaresi and Freire 2016) and a nightlights composite produced by the National Oceanic and Atmospheric Administration (NOAA) (National Centers for Environmental Information 2015). The most recent dataset for these two variables is from 2015, which we used in this analysis because it is closest to the survey years for the countries in the analysis.

The SMOD variable represents the degree of urbanization and is constructed with data on the Global Human Settlement Layer (GHSL) built-up areas and population density. This information is used to produce three categories: urban centers (cities), urban clusters (peri-urban: towns or suburbs), and rural, for an area within a 2 km (urban) or 10 km (rural) buffer that surrounds the DHS survey cluster location. For a graphical description of this variable, please see https://ghsl.jrc.ec.europa.eu/data.php?sl=4/.

The nightlights variable measures the average level of luminosity in an area within the 2 km (urban) or 10 km (rural) buffer that surrounds the DHS survey cluster location during nighttime hours. This variable is often related to urbanicity, although it also measures economic activity. Nightlights is a continuous variable. The higher the value, the higher the level of urbanicity. After examining the distribution of this variable in the six countries for the in-depth analysis, we divided the distribution into three categories: 0-1 (the lowest level of urbanicity or rural areas), 2-10 (representing peri-urban areas), and more than 10 (representing urban areas). Standardizing the categories of nightlights across the countries was performed in order to easily make cross-country comparisons.

A third variable was constructed from variables available in the DHS data that represent the urban poor. Due to the DHS displacement procedures, we cannot with certainty identify the slum areas within an urban area. However, identifying the urban poor can be a close proxy. The UN HABITAT definition of a slum household is one that lacks one or more of the following: durable housing of permanent nature, sufficient living space for not more than three persons per room, access to safe water, access to adequate sanitation, and security of tenure that prevents forced evictions (United Nations Human Settlements Programme 2006-2007). The DHS data contain information on all these areas except for security of tenure. Using this definition as a guide, an urban poor household is identified as lacking two or more of the following: a household made of durable material for the floor, wall, and roof; access to improved water; access to improved sanitation; and fewer than three persons per sleeping room. An urban poor cluster is defined as a cluster with more than 50% of urban poor households. This definition was also used by Van de Poel et al. (2007). This variable was analyzed at the cluster level instead of remaining at the household level in order to define areas that may be considered slum-like areas (i.e., the urban poor). The urban poor cluster variable in this study has three categories: rural, urban poor, and urban non-poor.

The India survey included two slum variables in the dataset. One was the census-based definition of a slum, and the second was the observation of a slum area by the survey team. A slum variable was constructed that combines the observation and census definitions into the following categories: rural, urban slum, and urban non-slum.

One limitation of this analysis arises from the DHS displacement procedures, which displaces urban clusters up to 2 km. Since our main independent variables focused on urban area locations, this displacement could weaken the associations we observe in the analysis.

2.2.2 Outcome variables

Four outcomes were selected that cover family planning and maternal and child health outcomes. The definitions of these outcomes are presented below.

Modern contraceptive prevalence rate (mCPR): The proportion of women age 15-49, currently in a union, who are using a modern contraceptive method. Modern contraceptive methods include pills, intrauterine devices (IUDs), injections, implants, diaphragms, female and male condoms, female and male sterilization, foam or jelly, and the lactational amenorrhea method (LAM). The mCPR may also include other modern contraceptive methods that are country-specific or less commonly used, but were reported by the respondent and identified in the datasets as modern methods.

Four or more ANC visits (ANC4): The proportion of women age 15-49 who gave birth in the past 2 years, and who had at least four ANC visits for the most recent birth.

Completion of three doses of DPT vaccine (DPT3): The proportion of children age 12-23 months who received all three doses of the DPT vaccine. The DPT3 immunization is selected for the indicator because children who receive this vaccine generally have received all other recommended immunizations.

Minimum Acceptable Diet (MAD): This indicator is defined among the youngest children age 6-23 months living with the mother, and uses the definitions of minimum dietary diversity and minimum meal frequency as follows:

- Breastfed children—minimum dietary diversity and minimum meal frequency as defined below.
- Non-breastfed children—minimum dietary diversity but excluding the dairy products category, and minimum meal frequency and 2 or more milk feeds.

Minimum dietary diversity: The child is fed five out of eight food groups during the day or night before the survey. The food groups are: 1. breast milk; 2. grains, roots, and tubers; 3. legumes and nuts; 4. dairy products (milk, yogurt, and cheese); 5. flesh foods (meat, fish, poultry, and liver/organ meats); 6. eggs; 7. vitamin A rich fruits and vegetables; 8. other fruits and vegetables.

Minimum meal frequency:

- 2 or more solid or semisolid feeds for breastfeeding children age 6-8 months, or
- 3 or more solid or semisolid feeds for breastfeeding children age 9-23 months, or
- 4 or more solid or semisolid or milk feeds for nonbreastfeeding children age 6-23 months.

2.3 Methods

The analysis has two parts, which include the in-depth analysis of six countries and further analysis of 30 countries. The 30 countries in the further analysis include the six countries from the in-depth analysis. The in-depth analysis involved a further assessment of the urbanity variables and use of unadjusted and adjusted regression models. The results for this analysis are discussed country by country and include a summary of the findings. The further analysis involved fitting only the adjusted regression models and using the SMOD and urban poor cluster variable. These results are discussed by outcome and are described below.

Descriptive statistics of the urbanicity variables were produced for the six countries in the in-depth analysis. In addition, descriptive maps were constructed using ArcGIS software to show the distribution of the urbanicity variables across country regions. Crosstabulation of the urbanicity variables with the four outcomes of interest was performed to observe associations. Statistical tests determined whether there were significant disparities in the health outcomes by the urbanicity variables for each survey.

To determine the magnitude of the associations, logistic regressions were fit for each outcome and each urbanicity variable separately. Unadjusted and adjusted regressions were fit for the six countries selected for the in-depth analysis, while only adjusted regression was performed for the 30 surveys. The adjusted regressions included the following control variables for the mCPR and ANC4 outcomes: woman's age at birth for the most recent birth, number of living children, woman's education level, and region. For the DPT3 and MAD outcomes, the same controls were used along with the sex of the child and the child's age in months. The wealth index was not included in the models because it was found to be highly correlated with the urbanicity variables. Four unadjusted and adjusted models were fit for each outcome for the six countries in the in-depth analysis:

- Model 1: Place of residence (rural, urban)
- Model 2: SMOD (rural, peri-urban, urban centers)
- Model 3: Nightlights (0-1 2-10, >10)
- Model 4: Urban poverty cluster (rural, urban poor, urban non-poor)

For India, an additional model was fit for the country-specific slum variable available in the dataset:

- Model 5: India slums (rural, urban slum, urban non-slum)

For Models 1-3, the reference was the most urban category (urban, urban centers, and greater than 10 nightlights). For Model 4, the reference was urban non-poor and for Model 5, urban non-slum.

Models 2 and 4 were fit for the adjusted logistic regressions performed on all 30 surveys. The same controls were used, with the results summarized for each outcome separately. This further analysis on 30 surveys attempted to find a pattern for these urbanicity variables.

All analyses took into account the sampling design and sampling weights and were performed with Stata 16 software.

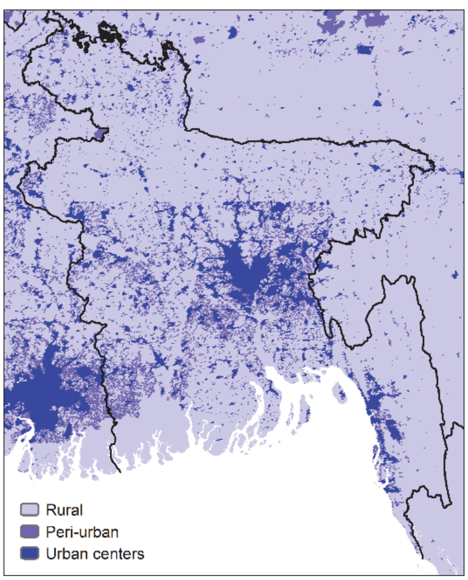
3 RESULTS

The results will first report the in-depth analysis performed on the recent DHS surveys from Bangladesh, DRC, India, Kenya, Nigeria, and Senegal. This is followed by the results from the further analysis of the 30 DHS surveys. Appendix Table 1 shows the exact estimates for the percent distribution of the urbanicity variables summarized in the figures for the six countries in the in-depth analysis. All regression results are summarized in the results section using figures. Appendix Tables 2-7 provide the exact estimates for the regression results for the in-depth analysis and Appendix Tables 8-11 show the regression results for the 30 countries analysis.

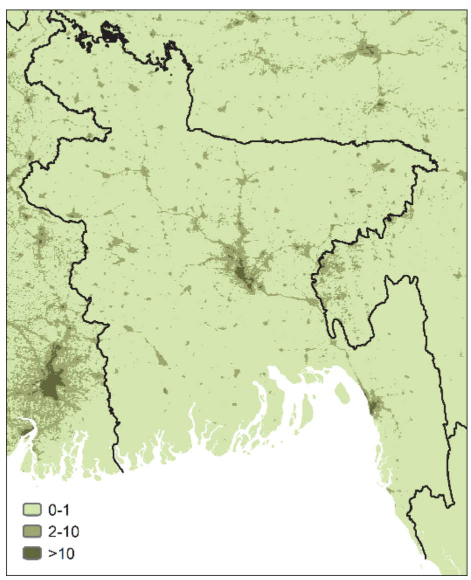
3.1 Bangladesh

Figure 1 shows the geographic distribution of the urbanicity variables in Bangladesh. The maps show a concentration of highly urban areas in the Dhaka region across the three variables. Figure 2 summarizes the percent distribution of women age 15-49 according to the urbanicity variables. We see general agreement in the rural category for all variables, which ranges from 65% for the SMOD rural category to approximately 70% for the rural category with the remaining variables. Approximately 30% of women resided in urban centers and 5% in peri-urban clusters. Almost a quarter of women lived in urban non-poor clusters, while 3% lived in urban poor clusters. Having a high level of nightlights is comparable to a highly urban area. However, only 9% of women were found to be in clusters with greater than 10 nightlights, which did not agree with the urban categories for the remaining variables.

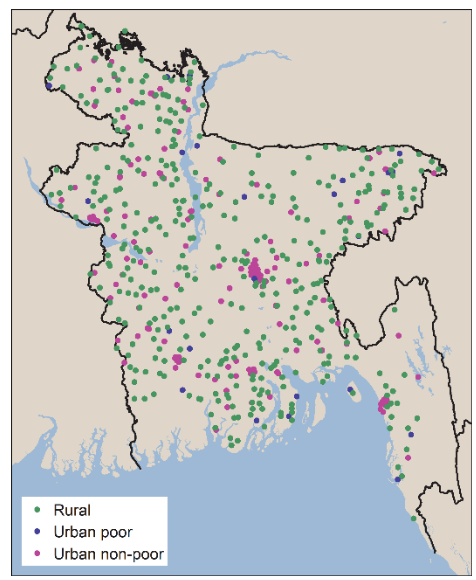
Figure 1 Maps showing the geographic distribution of (a) SMOD, (b) nightlights, and (c) urban poor cluster variables in Bangladesh 2014 DHS.



(a) SMOD

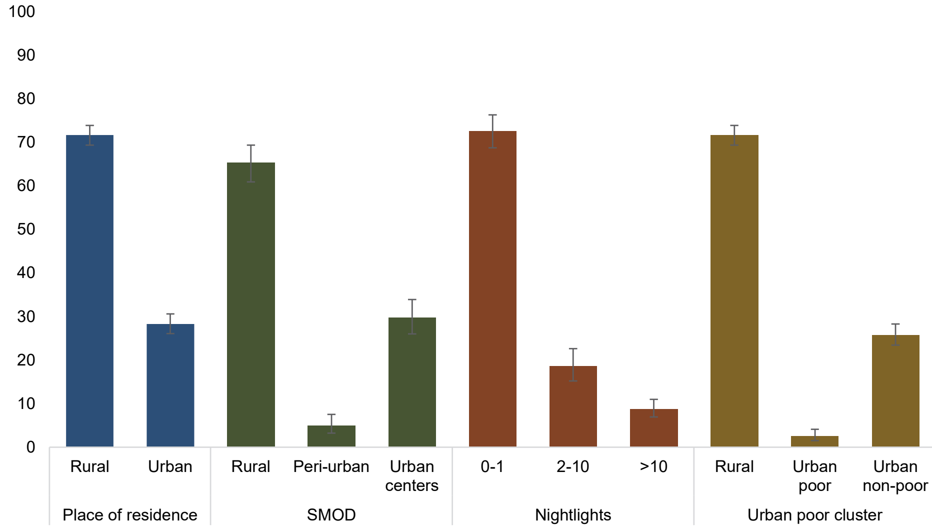


(b) Nightlights



(c) Urban poor cluster

Figure 2 **Percent distribution of the urbanicity variables in the Bangladesh 2014 DHS**



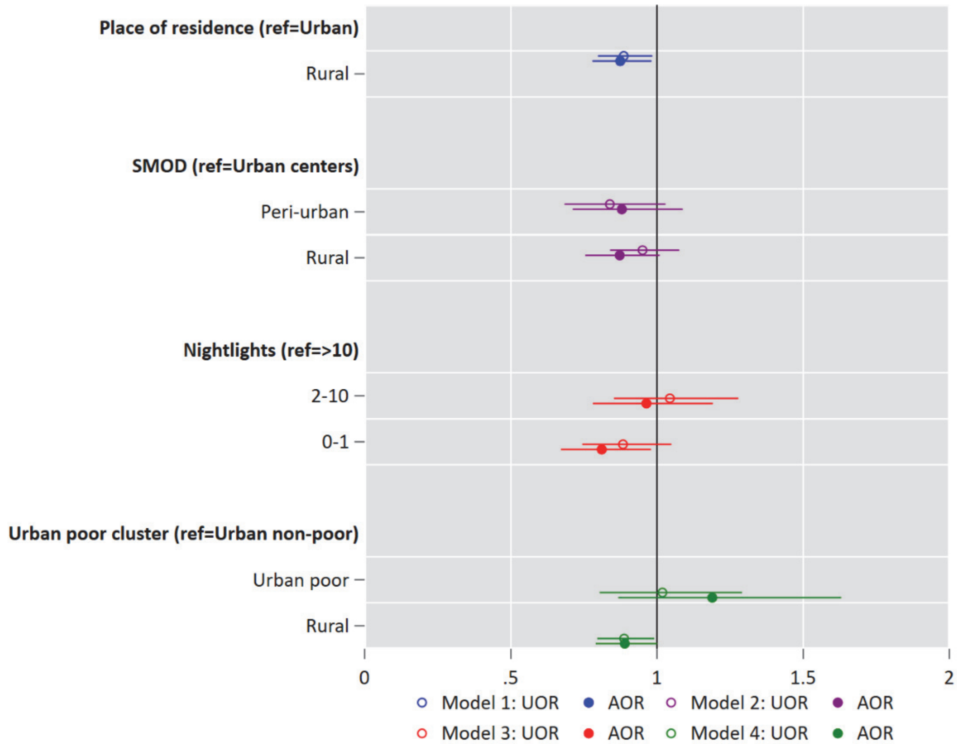
Just over half (54%) of women age 15-49 in Bangladesh are using a modern contraceptive method. Small differences were observed between the urbanicity variables and mCPR as shown in Table 2. This was also observed in the regression results in Figure 3. In Models 1 and 3, women who reside in rural areas had lower odds of mCPR compared to the reference. However, mCPR for women in rural areas according Models 2 and 4 were not significantly different from the reference. There were also no statistically significant differences between women who reside in peri-urban areas compared to those in urban centers (Model 2), between women with 2-10 level of nightlights compared to greater than 10 (Model 3), and between the urban poor and urban non-poor (Model 4). This was true for both the unadjusted and adjusted models.

Table 2 **Crosstabulations of urbanicity variables with health outcomes in Bangladesh 2014 DHS**

	Modern contraceptive use		At least four ANC visits		Three doses of DPT vaccine		Minimum acceptable diet	
Variable	**% [C.I.]**	**p-value**	**% [C.I.]**	**p-value**	**% [C.I.]**	**p-value**	**% [C.I.]**	**p-value**
Total	54.1 [52.8,55.3]		31.5 [28.9,34.1]		91.3 [88.7,93.3]		23.1 [21.0,25.4]	
Place of residence		*		***				**
Rural	53.2 [51.7,54.8]		26.0 [23.1,29.1]		90.4 [87.1,93.0]		21.0 [18.6,23.6]	
Urban	56.2 [54.1,58.3]		47.1 [42.1,52.0]		93.6 [90.5,95.7]		29.1 [25.0,33.7]	
SMOD				***		*		
Rural	53.9 [52.4,55.3]		26.4 [23.4,29.5]		89.6 [85.8,92.5]		22.6 [20.0,25.6]	
Peri-urban	50.7 [46.1,55.4]		33.6 [22.6,46.7]		95.1 [83.5,98.7]		23.3 [15.5,33.4]	
Urban centers	55.1 [52.5,57.7]		43.0 [37.4,48.7]		94.1 [91.2,96.1]		24.1 [20.3,28.3]	
Nightlights		*		***				
0-1	53.0 [51.6,54.5]		26.4 [23.7,29.3]		90.3 [86.9,92.8]		22.2 [19.7,24.9]	
2-10	57.2 [54.2,60.0]		44.4 [38.2,50.8]		94.0 [89.9,96.5]		23.5 [19.3,28.4]	
>10	56.1 [52.1,60.1]		51.2 [37.4,64.8]		94.9 [89.5,97.6]		31.2 [22.2,41.7]	
Urban poor cluster		*		***				***
Rural	53.2 [51.7,54.8]		26.0 [23.1,29.1]		90.4 [87.1,93.0]		21.0 [18.6,23.6]	
Urban poor	56.6 [51.0,62.0]		28.8 [19.1,41.1]		94.3 [82.1,98.4]		20.4 [13.4,29.9]	
Urban non-poor	56.2 [53.9,58.4]		49.2 [43.8,54.5]		93.5 [90.2,95.8]		30.1 [25.6,35.1]	

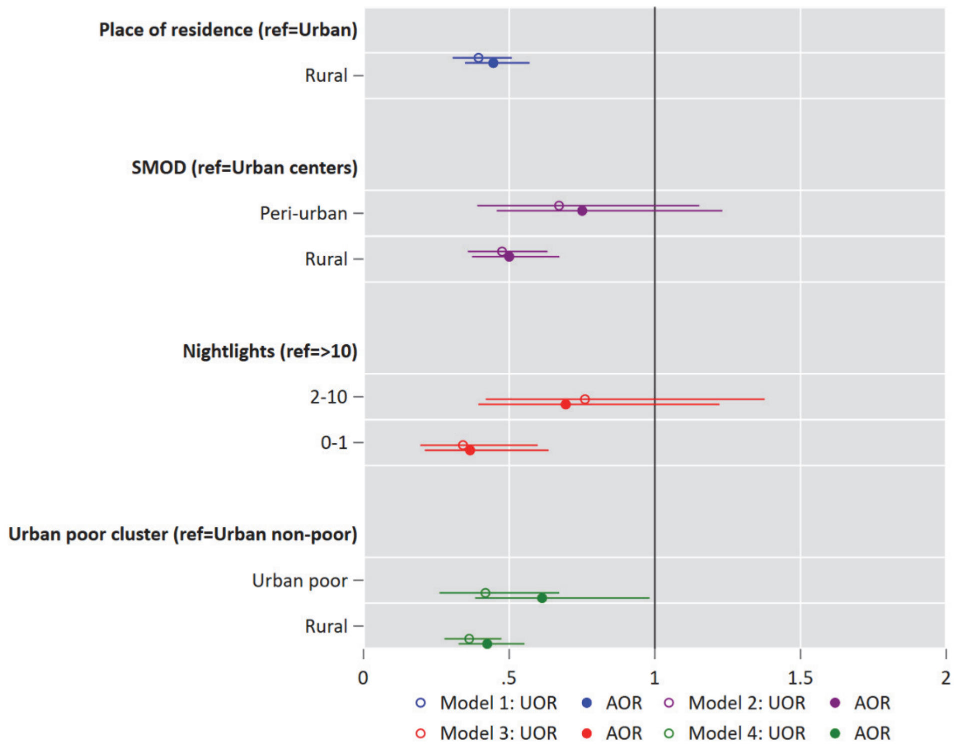
Note: *p<0.05,**p<0.01, ***p<0.001

Figure 3 Unadjusted and adjusted odds ratios of the urbanicity variables and mCPR in Bangladesh 2014 DHS



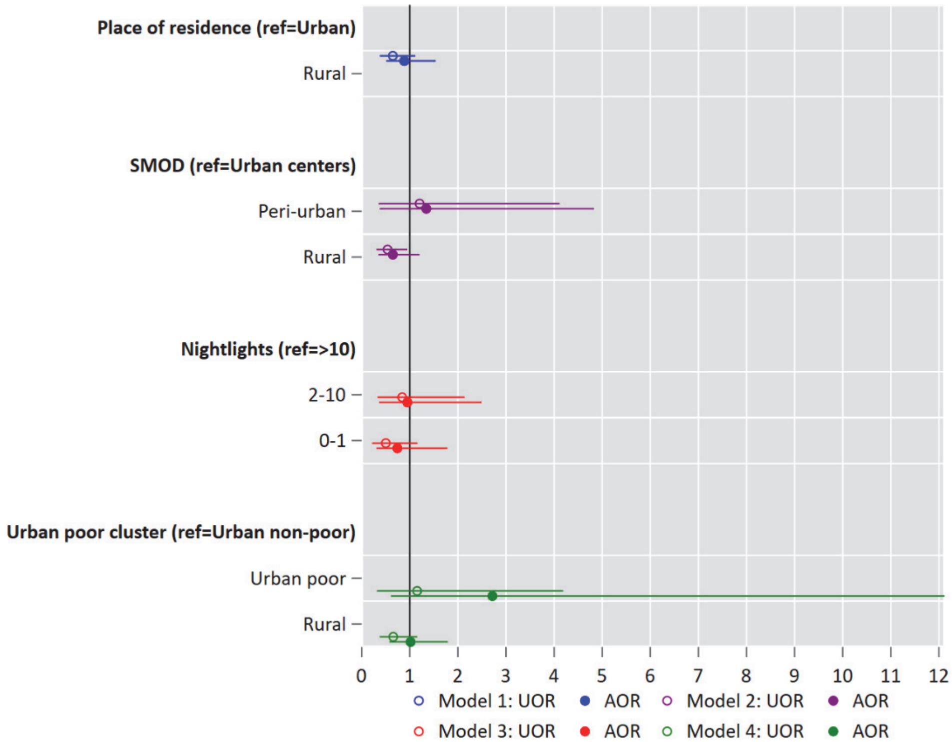
Approximately one-third (32%) of women in Bangladesh age 15-49 attended at least four ANC visits for their most recent birth. Table 2 shows that the percentage of women with ANC4 increases with increasing level of urbanicity. The gap between the lowest level of urbanicity and the highest is approximately 25 percentage points with a range between 25% and 50%. However, in the regression results shown in Figure 4, we find no statistically significant differences in the odds of ANC4 between peri-urban and urban centers for the SMOD variable (Model 2) and the 2-10 nightlights and greater than 10 nightlights (Model 3). Women living in urban poor clusters had approximately 40% lower odds of ANC4 compared to the urban non-poor women (adjusted Model 4).

Figure 4 Unadjusted and adjusted odds ratios of the urbanicity variables and ANC4 in Bangladesh 2014 DHS



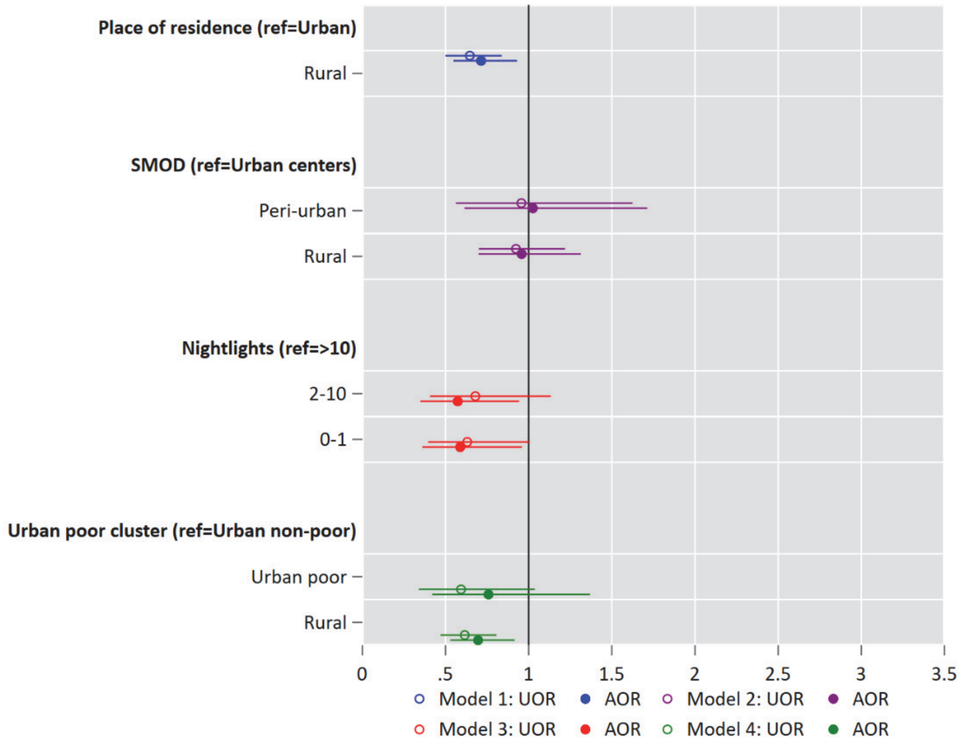
Over 90% of children age 12-23 months in Bangladesh had all three doses of the DPT immunization. As shown in Table 2, there were almost no differences by the urbanicity variables. This finding is also confirmed by the regression results shown in Figure 5. There were no significant differences between the categories and the reference category for all the urbanicity variables in the four models. This was true for both the unadjusted and the adjusted models. One exception is the rural category for the SMOD variable, where children living in rural clusters had significantly lower odds of DPT3 in the unadjusted model compared to women living in urban centers.

Figure 5 Unadjusted and adjusted odds ratios of the urbanicity variables and DPT3 in Bangladesh 2014 DHS



Fewer than a quarter (23%) of the youngest children age 6-23 months who live with their mother had a minimum acceptable diet. Table 2 shows that this only differed significantly by the place of residence and the urban poverty cluster variables. The highest percentage of MAD was found in children living in urban non-poor clusters (30%) and in clusters with greater than 10 nightlights (31%). Children living in rural, peri-urban areas, and urban poor clusters had similar levels of MAD (21-23%). The regression results in Figure 6 show several significant findings. In all models except Model 2 with the SMOD variable, rural children have lower odds of having MAD compared to the reference. In addition, children living in clusters with 2-10 nightlights had lower odds of MAD compared to children living in clusters with greater than 10 nightlights in the adjusted model. There were no significant differences in MAD between children living in peri-urban areas compared to urban centers, and children living in urban poor clusters compared to urban non-poor in both the adjusted and unadjusted models.

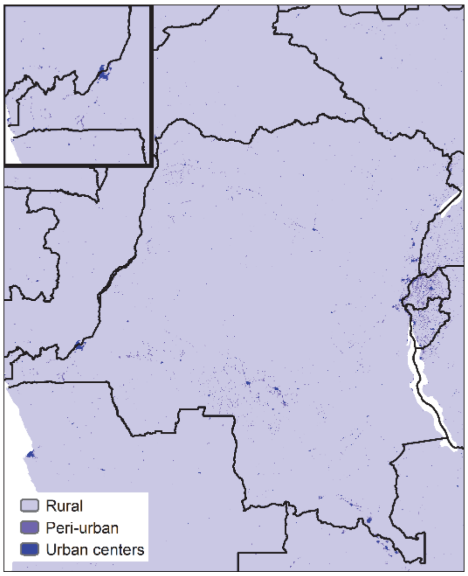
Figure 6 Unadjusted and adjusted odds ratios of the urbanicity variables and MAD in Bangladesh 2014 DHS



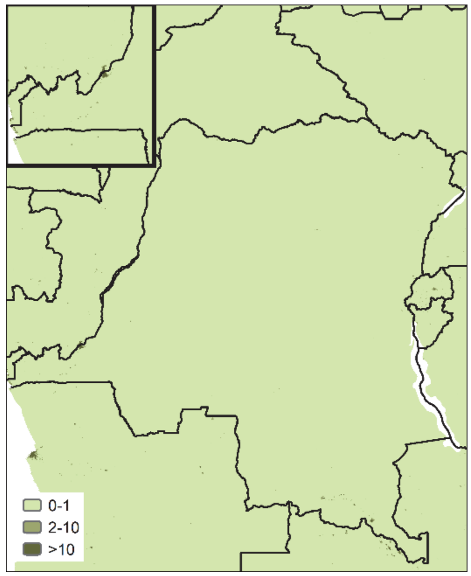
3.2 Democratic Republic of Congo

Figure 7 displays the geographic distribution of SMOD, nightlights, and urban poor cluster variables in the DRC based on 2013-14 DHS data. Across these indicators, urbanicity appears to cluster in Kinshasa in the southwestern corner of the country, in areas along the border with Zambia in the southeastern region, and in northeastern DRC. The SMOD and urban poor cluster variables appear to show more variation of urbanicity than the nightlights variable.

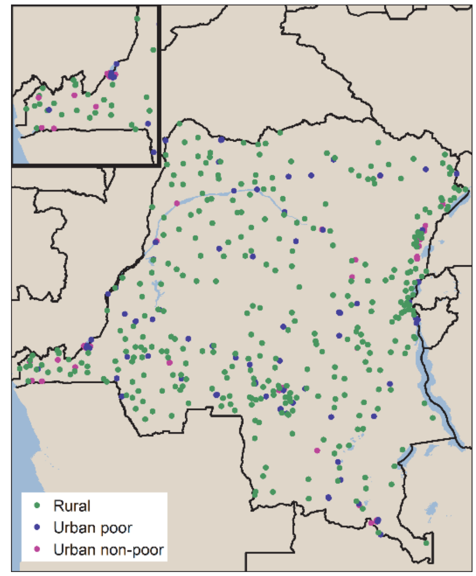
Figure 7 Maps showing the geographic distribution of (a) SMOD, (b) nightlights, and (c) urban poor cluster variables in the DRC 2013-14 DHS



(a) SMOD



(b) Nightlights

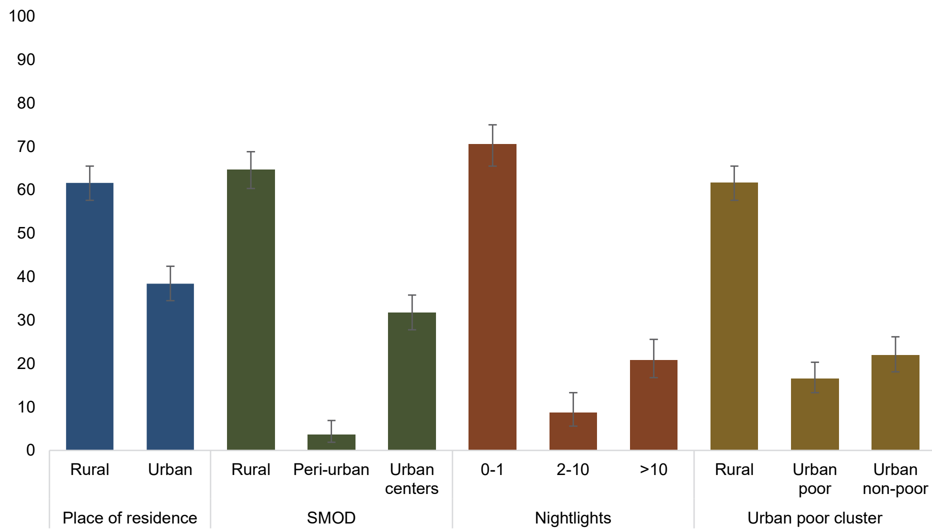


(c) Urban poor cluster

Note: The upper left box is an enlarged image of Kinshasa and surrounding clusters.

Figure 8 shows the percent distribution of women age 15-49 according to four indicators to assess gradients of urbanicity: place of residence, SMOD, nightlights, and the urban poor cluster variable. There appears to be general agreement in the rural category for all variables, ranging from 62%—for both place of residence and the urban poor cluster variable—to 71% in the lowest (0-1) nightlights category. According to the SMOD indicator, nearly one-third (32%) of women in the DRC resided in urban centers, compared to 4% living in peri-urban areas. Based on the urban poor cluster indicator, 17% of women lived in urban poor clusters, and more than one-fifth (22%) of women lived in urban non-poor clusters. The percentage of women living in the highest urban area categories across the urbanicity indicators displayed a wider range compared to their rural counterparts, from 21% in clusters with greater than 10 nightlights and urban non-poor clusters to 38% in the urban category of place of residence.

Figure 8 Percent distribution of the urbanicity variables in the DRC 2013-14 DHS



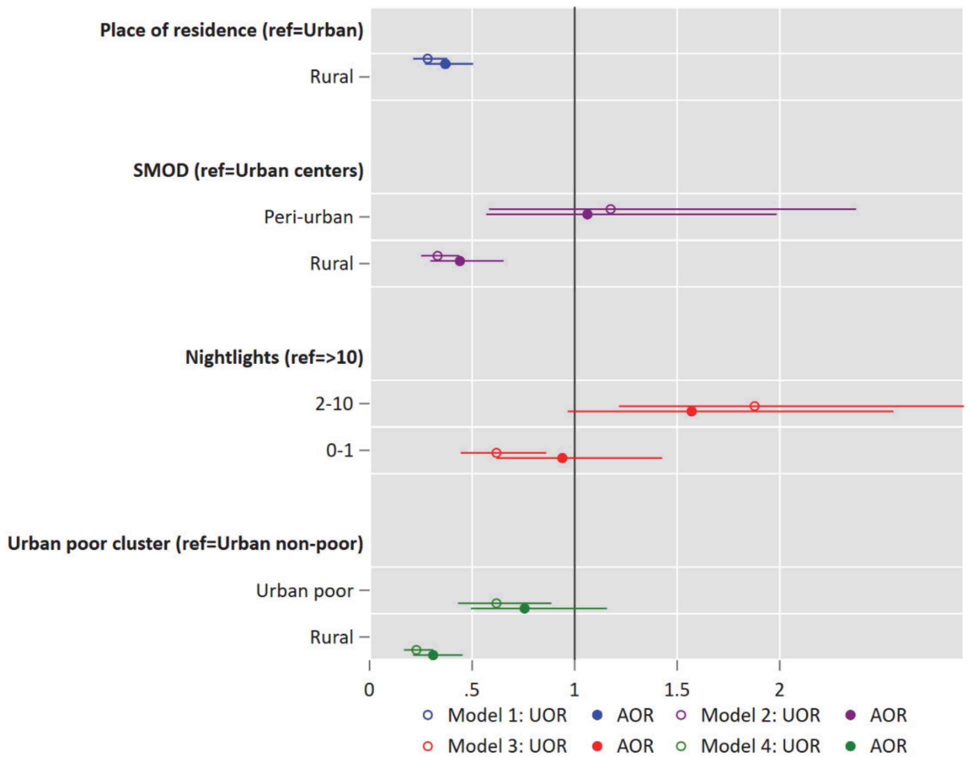
Only 8% of women age 15-49 in the DRC are using a modern contraceptive method. This differed significantly by all urbanicity variables with ranges from as low as 5% to the highest of 18% in urban non-poor clusters (Table 3). Women living in peri-urban clusters had a slightly higher percentage of mCPR (17%) compared to women living in the urban centers (15%). A larger difference was found between women living in clusters with 2-10 nightlights (17%) compared to women living in clusters with greater than 10 nightlights (10%). The regression results summarized in Figure 9 show that in Models 1, 2, and 4, women living in rural clusters have lower odds of mCPR compared to their respective reference categories (approximately 70% lower odds in these models). The remaining categories were not significant in the adjusted models. This indicates that there was no difference in mCPR between women living in the peri-urban and urban centers (Model 1), 2-10 nightlights and greater than 10 nightlights (Model 3), and urban poor and urban non-poor (Model 4).

Table 3 Crosstabulations of urbanicity variables with health outcomes in DRC 2013-14 DHS

	Modern contraceptive use		At least four ANC visits		Three doses of DPT vaccine		Minimum acceptable diet	
Variable	**% [C.I.]**	**p-value**	**% [C.I.]**	**p-value**	**% [C.I.]**	**p-value**	**% [C.I.]**	**p-value**
Total	7.8 [6.9,8.9]		46.6 [44.3,48.9]		60.7 [57.4,63.9]		8.4 [7.1,9.9]	
Place of residence		***		***		***		**
Rural	4.6 [3.7,5.8]		41.3 [38.3,44.3]		54.3 [49.9,58.6]		6.8 [5.3,8.5]	
Urban	14.6 [12.7,16.7]		58.4 [55.1,61.5]		74.2 [70.0,78.0]		12.1 [9.5,15.2]	
SMOD		***		***		***		**
Rural	5.5 [4.4,6.8]		41.0 [38.0,44.1]		56.2 [52.0,60.3]		6.8 [5.3,8.6]	
Peri-urban	17.1 [4.3,48.3]		41.4 [21.6,64.5]		70.6 [23.3,95.0]		15.2 [3.9,44.5]	
Urban centers	14.9 [13.3,16.7]		61.9 [58.3,65.5]		76.7 [71.8,80.9]		11.9 [8.9,15.8]	
Nightlights		***		***		**		*
0-1	6.4 [5.4,7.7]		42.9 [40.2,45.7]		57.4 [53.6,61.1]		7.4 [6.0,9.0]	
2-10	17.3 [12.5,23.3]		58.1 [47.1,68.3]		79.1 [69.0,86.5]		15.4 [8.6,26.0]	
>10	10.0 [8.0,12.4]		58.5 [54.6,62.2]		66.3 [56.5,74.8]		10.0 [7.0,14.1]	
Urban poor cluster		***		***		***		**
Rural	4.6 [3.7,5.8]		41.3 [38.3,44.3]		54.3 [49.9,58.6]		6.8 [5.3,8.5]	
Urban poor	11.6 [8.8,15.1]		49.3 [45.9,52.8]		62.3 [56.5,67.7]		11.2 [8.3,14.9]	
Urban non-poor	17.5 [14.9,20.4]		68.1 [63.6,72.2]		87.0 [82.9,90.3]		13.0 [8.8,18.7]	

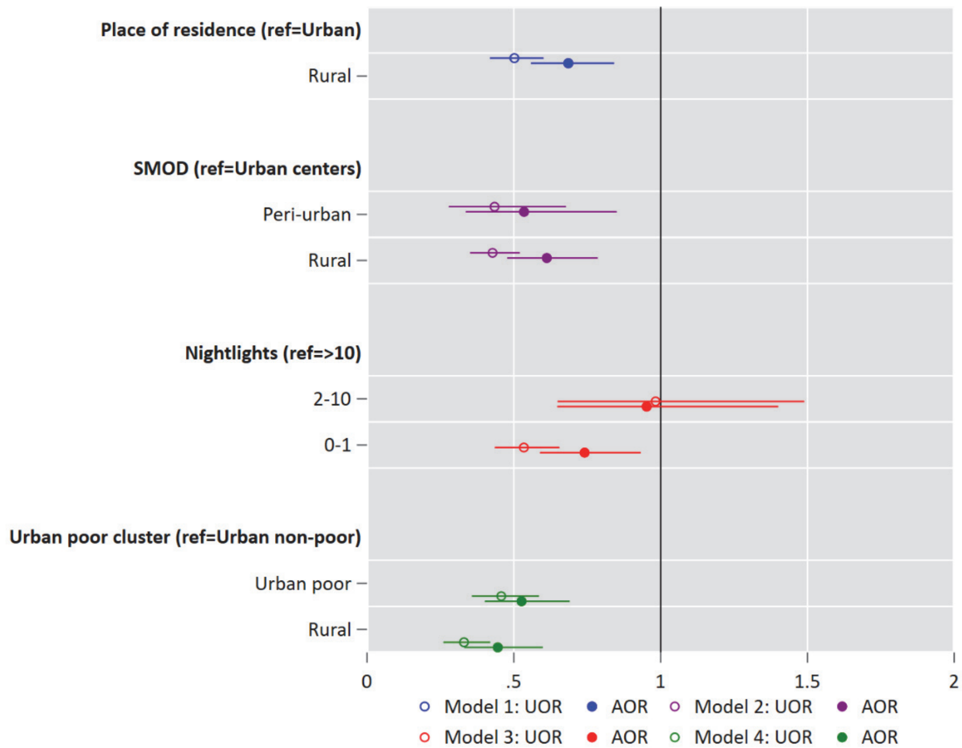
Note: *p<0.05,**p<0.01, ***p<0.001

Figure 9 **Unadjusted and adjusted odds ratios of the urbanicity variables and mCPR in the DRC 2013-14 DHS**



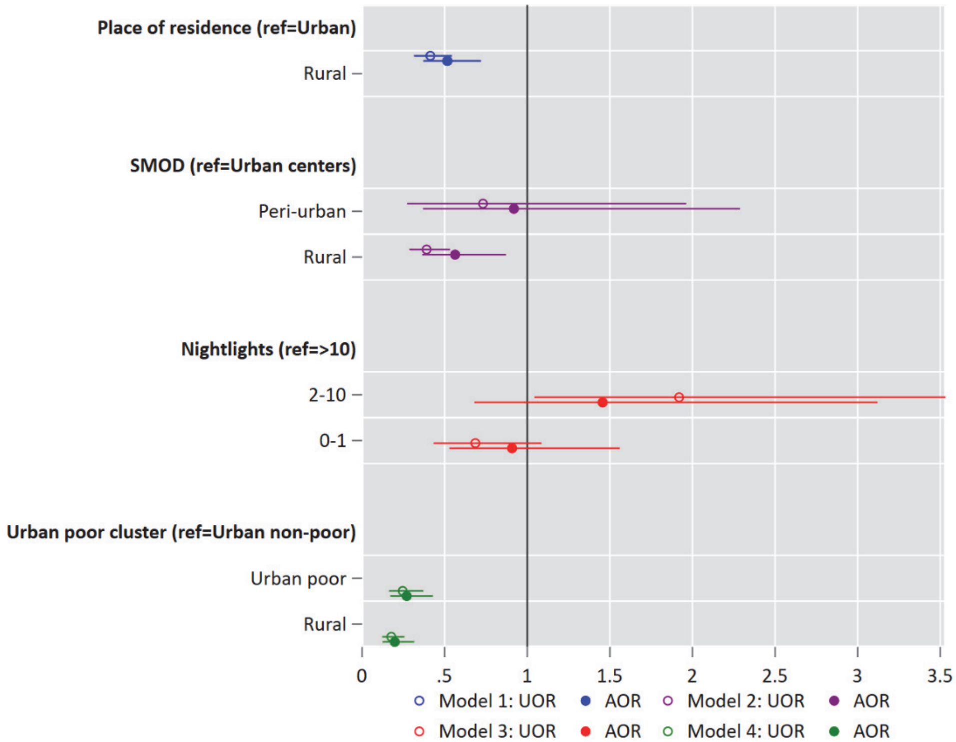
Approximately half (47%) of women age 15-49 in the DRC have attended at least four ANC visits for their most recent birth. This ranged from approximately 41% to 68% by the urbanicity variables as shown in Table 3. Women living in peri-urban clusters had the same level of ANC4 as women living in rural clusters (both approximately 41%). In Figure 10, we see lower odds of ANC4 in all categories compared to the reference for all models except for the 2-10 nightlights category in Model 3. In addition, the odds ratios of the categories for SMOD and the urban poor cluster were of similar magnitude, which indicated a similar level association with ANC4 compared to the reference. In Model 2, women living in peri-urban clusters and rural clusters had 50% and 40% lower odds of ANC4, respectively, when compared to urban centers. In Model 4, women living in urban poor and rural clusters had approximately 50% lower odds of ANC4 compared to women in the urban non-poor clusters.

Figure 10 **Unadjusted and adjusted odds ratios of the urbanicity variables and ANC4 in the DRC 2013-14 DHS**



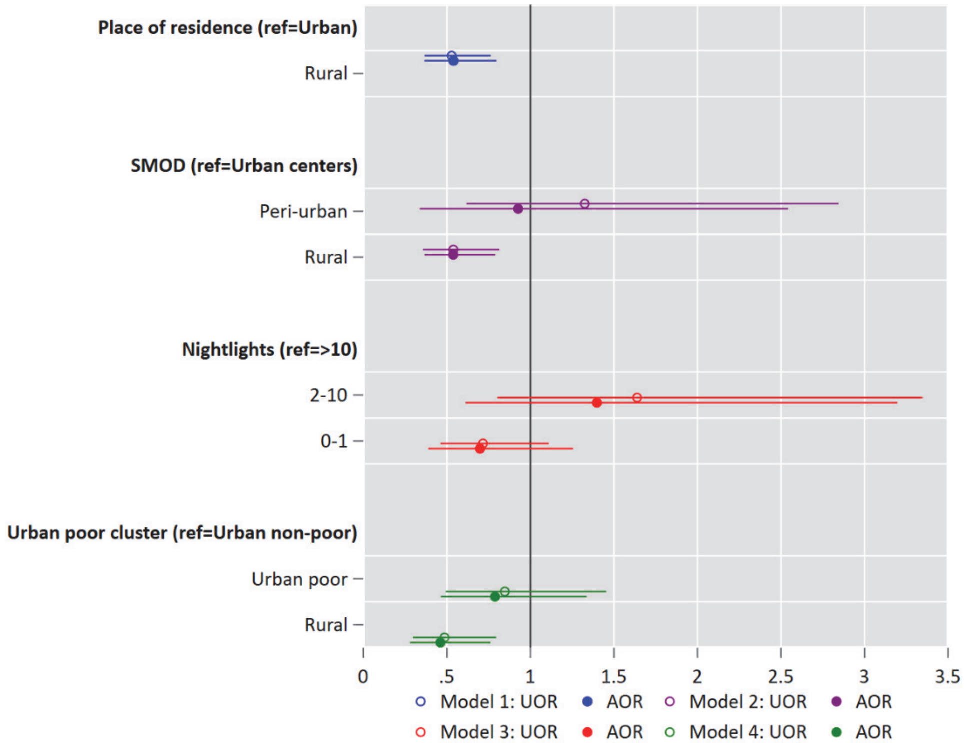
Almost two-thirds (61%) of children age 12-23 months had all three doses of DPT vaccine. This differed by all urbanicity variables and ranged from a low of 54% in rural areas to a high of 87% for children living in the urban non-poor clusters (Table 3). The regression results summarized in Figure 11 show that in Models 1, 2, and 4, children living in rural clusters have lower odds of receiving DPT3 compared to the reference categories. In Models 1 and 2, children living in rural areas had approximately 50% lower odds of DPT3 compared to urban and urban centers. However, in Model 4, rural children had 80% lower odds compared to children in the urban non-poor clusters. In Model 2, children in peri-urban clusters did not differ significantly from children in urban centers in DPT3 uptake. In Model 4, we see that children living in urban poor clusters had 70% lower odds and children living in rural clusters had 80% lower odds of DPT3 compared to children in the urban non-poor clusters. No significant results were found in Model 3.

Figure 11 Unadjusted and adjusted odds ratios of the urbanicity variables and DPT3 in the DRC 2013-14 DHS



Only 8% of children age 6-23 months in the DRC had a minimum acceptable diet. This differed significantly by all urbanicity variables with ranges from approximately 7% in rural areas to the highest percentage found for children living in urban non-poor clusters at 13% (Table 3). The regression results summarized in Figure 12 show that in Models 1, 2, and 4, children living in rural clusters had approximately 50% lower odds of MAD compared to the reference categories. The remaining categories across the urbanicity indicators were not significant in the unadjusted and adjusted models. This indicates that there was no difference in MAD between children living in peri-urban and urban centers (Model 1), 2-10 nightlights and greater than 10 nightlights (Model 3), and urban poor and urban non-poor (Model 4).

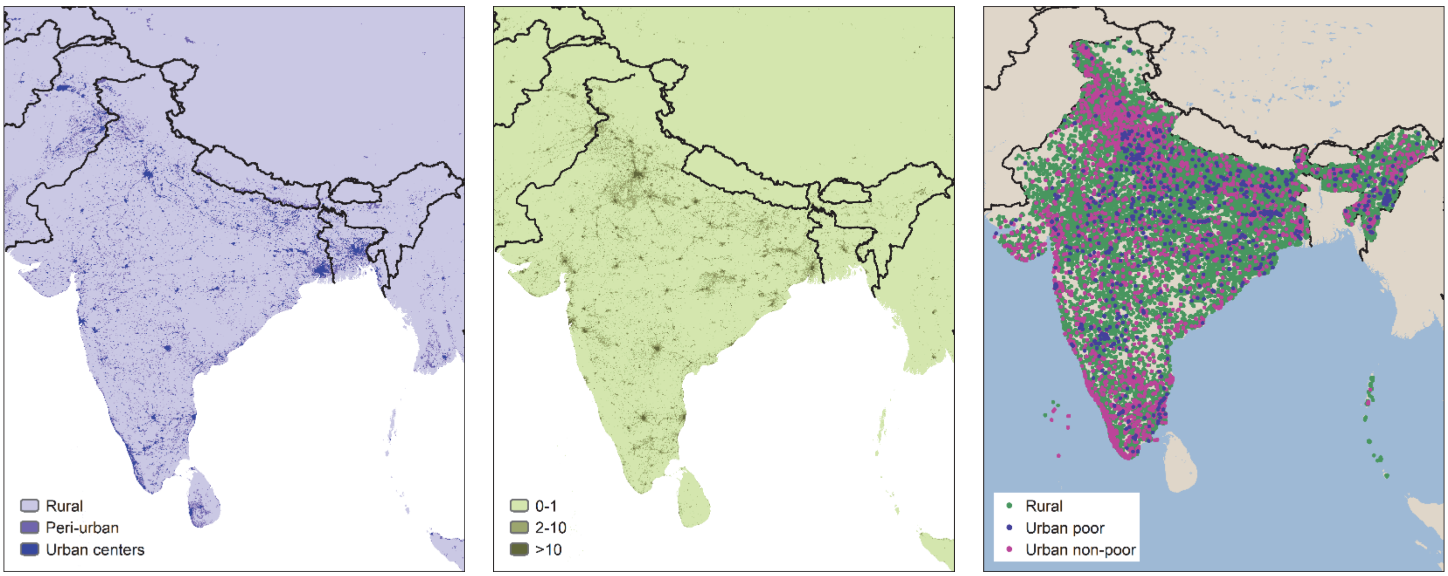
Figure 12 Unadjusted and adjusted odds ratios of the urbanicity variables and MAD in the DRC 2013-14 DHS



3.3 India

Figure 13 displays the geographic distribution of SMOD, nightlights, and urban poor cluster variables in India based on 2015-16 DHS data. Across these three indicators, urbanicity appears to center and then break apart from cities including New Delhi in the northwestern region, Kolkata along the border of Bangladesh, Mumbai, and Chennai. Urban centers and clusters with greater than 10 nightlights (in Figures 13a and 13b) share similar patterns in India in terms of urbanicity levels. Figure 13c illustrates a clustering of the urban poor in cities like New Delhi as well as along the southern coastline.

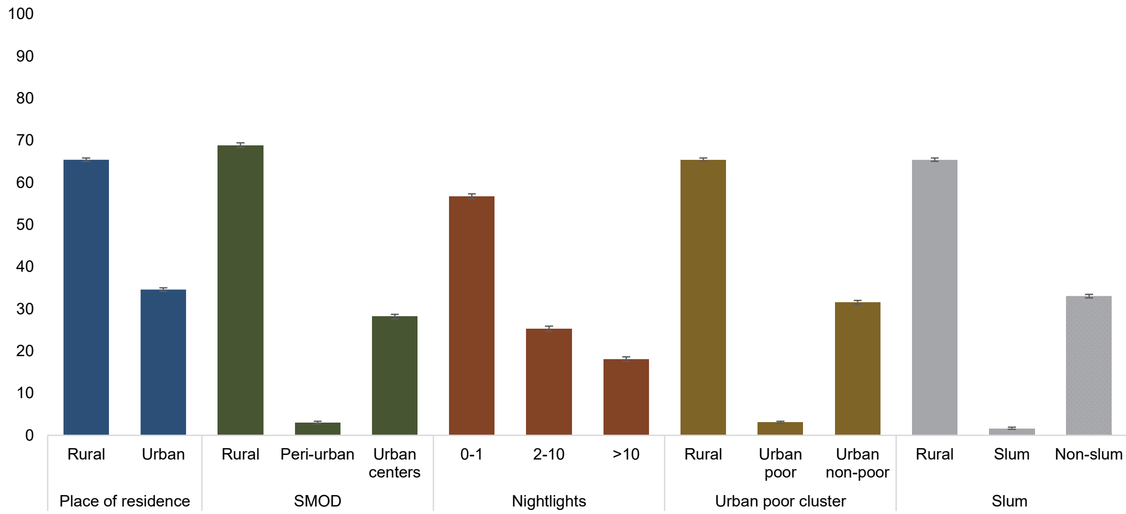
Figure 13 Maps showing the geographic distribution of (a) SMOD, (b) nightlights, and (c) urban poor cluster variables in India 2015-16 DHS



(a) SMOD (b) Nightlights (c) Urban poor cluster

Figure 14 shows the percent distribution of women in India age 15-49 according to place of residence, SMOD, nightlights, the urban poor cluster variable, and a country-specific slum indicator with gradients of urbanicity. The rural category for all variables is in general agreement, with ranges from 57% in the lowest (0-1) nightlights category to 69% according to SMOD. According to the SMOD indicator, 28% of women in India resided in urban centers, with 3% of women in the peri-urban areas. The urban poor cluster indicator displays similar patterns seen with SMOD, with 32% of women living in urban non-poor clusters, and 3% of women living in urban poor clusters. Similarly, the slum variable agrees with all categories found in SMOD and the urban poor cluster indicators; 33% of women live in non-slum areas and 2% live in slums.

Figure 14 Percent distribution of the urbanicity variables in India 2015-16 DHS



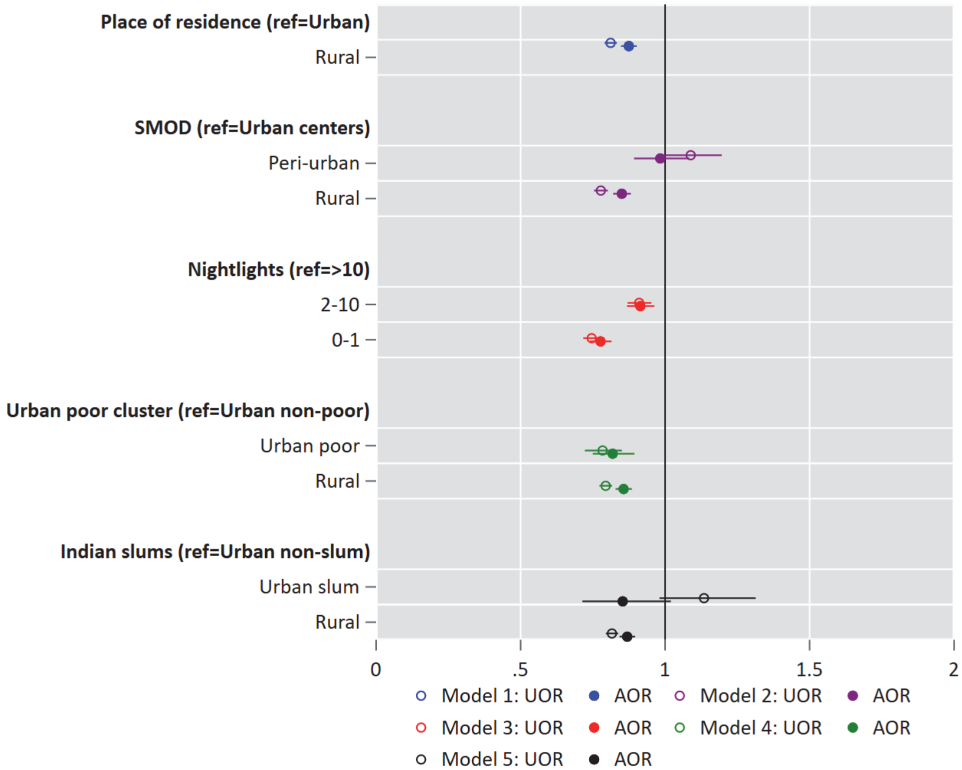
Almost half (48%) of women age 15-49 in India are using a modern contraceptive method. As shown in Table 4, mCPR differed significantly across all urbanicity variables. However, the differences were minimal with ranges from approximately 45% to 54% for all variables. Figure 15 shows the unadjusted and adjusted regression results for Models 1-4. For India, an additional fifth model was fit for the slum variable in the India dataset. For all models, the most rural category had lower odds of mCPR compared to the reference. Women living in peri-urban areas did not differ significantly from women in urban centers in mCPR use (Model 2). However, women living in clusters with 2-10 nightlights had 10% lower odds of mCPR compared to women living in clusters with greater than 10 nightlights (Model 3). Women living in urban poor clusters had 20% lower odds of mCPR compared to women living in urban non-poor clusters. This odds ratio was also similar to the odds ratio for rural women (approximately 0.8 as shown in Appendix Table 4). In Model 5, there is no statistical difference in mCPR between women living in urban slums compared to women living in urban non-slums.

Table 4 Crosstabulations of urbanicity variables with health outcomes in India 2015-16 DHS

	Modern contraceptive use		At least four ANC visits		Three doses of DPT vaccine		Minimum acceptable diet	
Variable	**% [C.I.]**	**p-value**	**% [C.I.]**	**p-value**	**% [C.I.]**	**p-value**	**% [C.I.]**	**p-value**
Total	47.8 [47.5,48.0]		50.4 [49.9,50.9]		78.4 [77.8,78.9]		9.8 [9.4,10.2]	
Place of residence		***		***		**		***
Rural	46.0 [45.7,46.3]		44.5 [43.9,45.0]		77.7 [77.1,78.3]		8.9 [8.6,9.3]	
Urban	51.2 [50.7,51.8]		66.1 [65.0,67.3]		80.2 [78.9,81.5]		12.0 [11.1,12.9]	
SMOD		***		***		***		***
Rural	45.8 [45.5,46.1]		44.5 [43.9,45.0]		77.4 [76.8,77.9]		8.9 [8.5,9.2]	
Peri-urban	54.2 [52.2,56.1]		69.8 [66.3,73.1]		85.0 [81.2,88.1]		18.3 [15.3,21.8]	
Urban centers	52.1 [51.4,52.7]		68.7 [67.2,70.1]		80.9 [79.4,82.4]		11.8 [10.7,12.9]	
Nightlights		***		***		***		**
0-1	45.3 [44.9,45.6]		44.2 [43.7,44.8]		76.7 [76.1,77.4]		9.2 [8.8,9.6]	
2-10	50.2 [49.7,50.8]		55.6 [54.5,56.8]		81.5 [80.5,82.5]		10.7 [9.9,11.4]	
>10	52.6 [51.7,53.5]		69.5 [67.5,71.4]		80.4 [78.1,82.4]		10.8 [9.4,12.4]	
Urban poor cluster		***		***		***		***
Rural	46.0 [45.7,46.3]		44.5 [43.9,45.0]		77.7 [77.1,78.3]		8.9 [8.6,9.3]	
Urban poor	45.7 [44.2,47.2]		48.2 [45.2,51.2]		72.7 [69.2,76.0]		11.6 [9.7,13.9]	
Urban non-poor	51.8 [51.2,52.4]		68.7 [67.5,70.0]		81.3 [79.9,82.6]		12.1 [11.1,13.1]	
Indian slums		***		***		**		***
Rural	46.0 [45.7,46.3]		44.5 [43.9,45.0]		77.7 [77.1,78.3]		8.9 [8.6,9.3]	
Urban slum	54.2 [50.7,57.8]		75.9 [70.5,80.5]		70.2 [59.8,78.8]		14.8 [10.0,21.4]	
Urban non-slum	51.1 [50.5,51.7]		65.6 [64.5,66.8]		80.7 [79.4,81.9]		11.9 [11.0,12.8]	

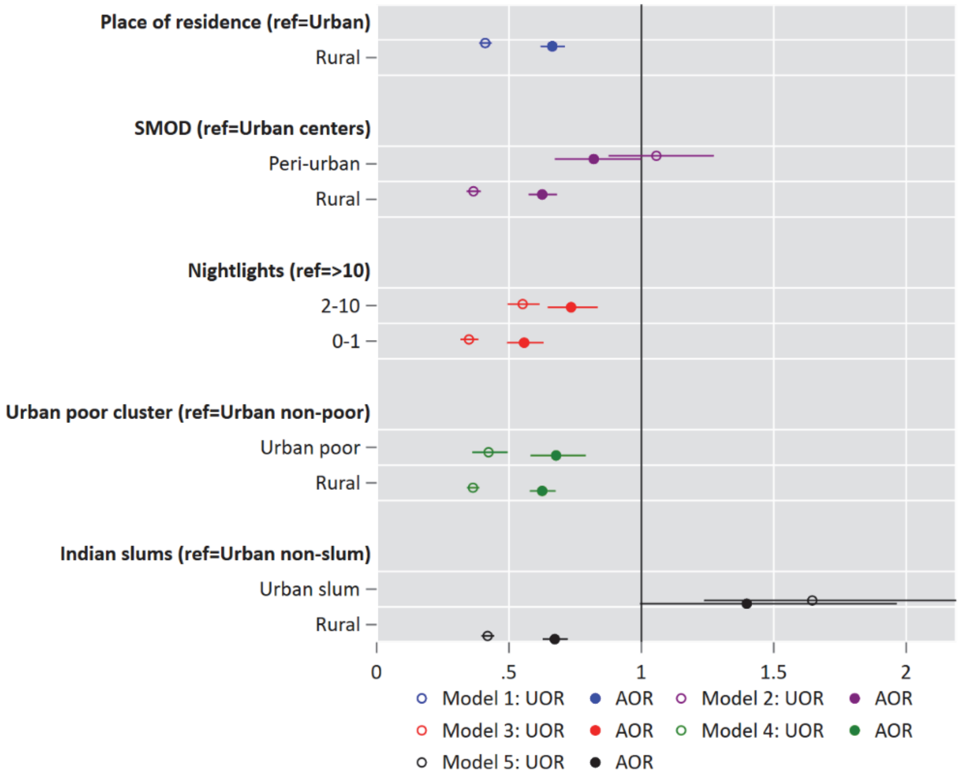
Note: *p<0.05,**p<0.01, ***p<0.001

Figure 15 Unadjusted and adjusted odds ratios of the urbanicity variables and mCPR in India 2015-16 DHS



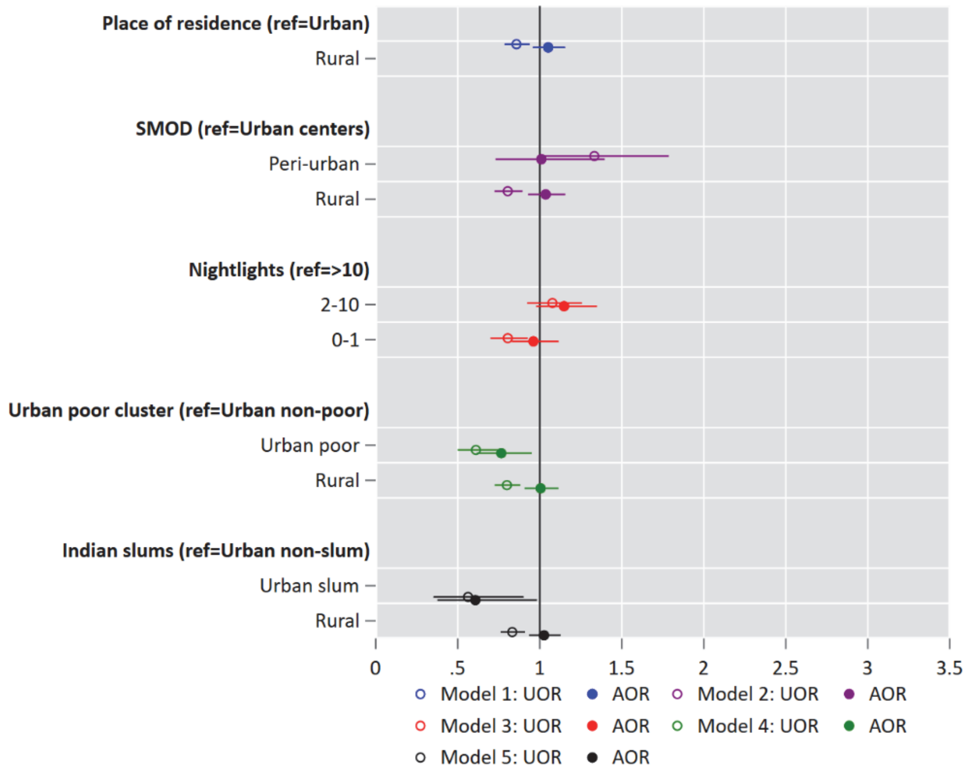
Half of women age 15-49 attended at least four ANC visits for their most recent birth. This differed significantly by all urbanicity variables with the lowest percentages found in rural areas (45%). The highest percentage was found for women residing in urban slums at 76%, followed by women living in clusters with greater than 10 nightlights (70%) and the urban non-poor (69%) (Table 4). In Figure 16, women in rural areas had lower odds of ANC4 compared to the reference in all models. In Model 2, there was no statistical difference in ANC4 between women in peri-urban compared to the urban centers. Women living in clusters with 2-10 nightlights had 27% lower odds of ANC4 compared to women living in clusters with greater than 10 nightlights (Model 3). In Model 4, women living in urban poor clusters had 32% lower odds of ANC4 compared to women in urban non-poor clusters. This odds ratio was similar to the odds for rural women with 37% lower odds of ANC4 compared to the urban non-poor. For Model 5, the unadjusted model indicated that women living in urban slums had 1.7 times higher odds of ANC4 compared to women in urban non-slums. However, after adjusting for controls, there was no significant difference found between women living in urban slums and urban non-slums (Appendix Table 4).

Figure 16 Unadjusted and adjusted odds ratios of the urbanicity variables and ANC4 in India 2015-16 DHS



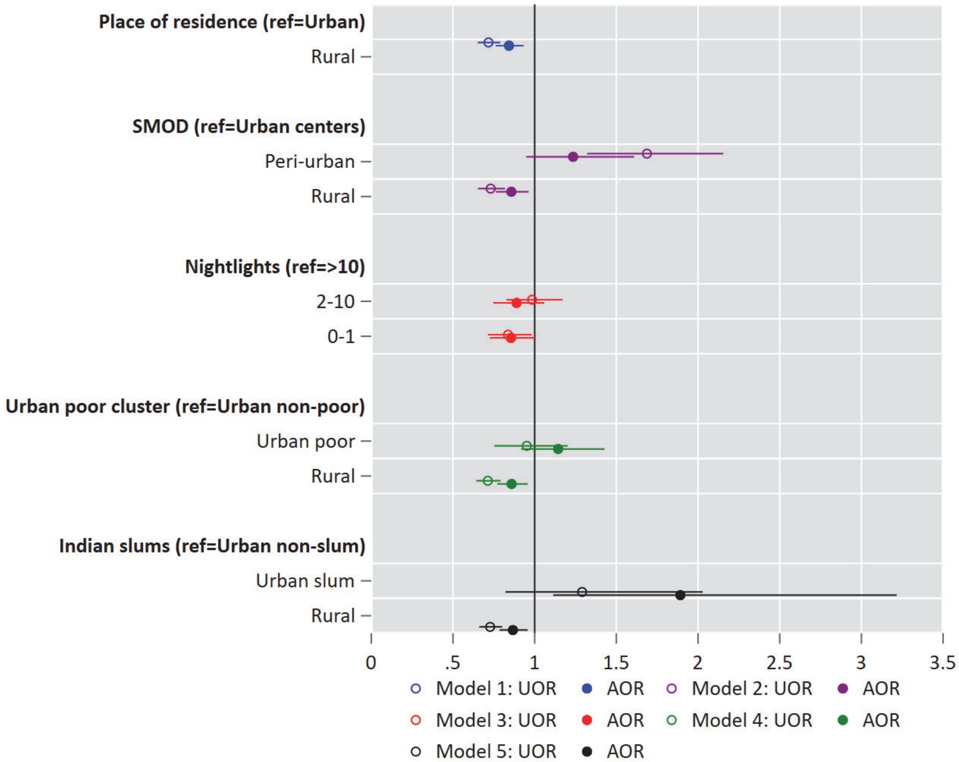
Over three-quarters (78%) of children age 12-23 months had all three doses of DPT vaccine. This differed significantly by all the urbanicity variables, although the differences were small ranging from 77% in rural areas to 85% in the peri-urban areas (Table 4). Figure 17, in contrast, shows few significant findings. In all five unadjusted models, the rural category had significantly lower odds of DPT3 compared to the reference. However, the significance was lost in the adjusted models. In Model 2, there was no statistical difference in DPT3 between children living in peri-urban clusters compared to children in urban centers. In Model 3, we see no significant difference in DPT3 for children living in clusters with 2-10 nightlights compared to those with greater than 10 nightlights in both unadjusted and adjusted models. Children living in urban poor clusters (Model 4) and children living in urban slums (Model 5) had significantly lower odds of DPT3 in both the unadjusted and adjusted models compared to the urban non-poor and urban non-slums, respectively.

Figure 17 Unadjusted and adjusted odds ratios of the urbanicity variables and DPT3 in India 2015-16 DHS



Only 10% of children age 6-23 months had a MAD in India. This differed significantly by all urbanicity variables, although the differences were small (Table 4). The percentages of MAD by urbanicity variables ranged from 9% in rural areas to 12% for most of the other categories, and reached 18% for peri-urban areas. The regression results summarized in Figure 18 show that children living in rural areas had significantly lower odds of MAD compared to the reference in all the models. In unadjusted Model 2, children living in peri-urban areas had 1.7 times significantly higher odds of MAD compared to urban centers. However, this significance was lost in the adjusted model. In adjusted Model 5, children living in urban slums had 1.9 significantly higher odds of MAD compared to children living in urban non-slums. However, the significance was marginal with a wide confidence interval (95% C.I. 1.1, 3.2).

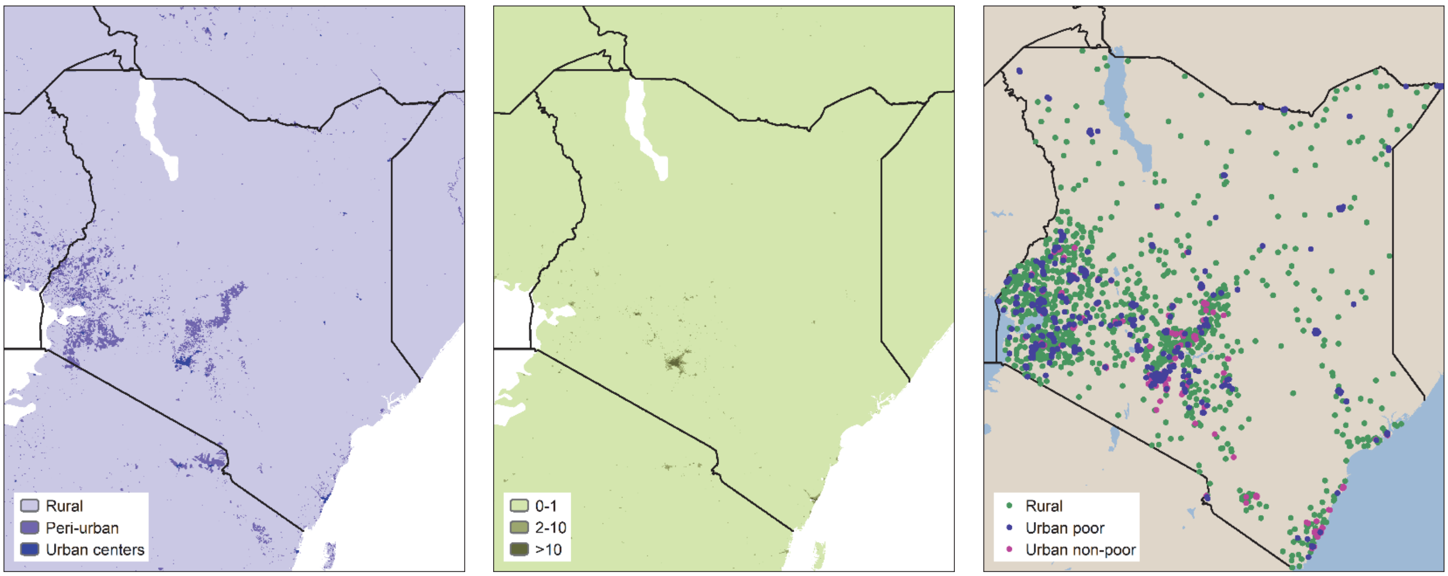
Figure 18 Unadjusted and adjusted odds ratios of the urbanicity variables and MAD in India 2015-16 DHS



3.4 Kenya

Figure 19 displays the geographic distribution of SMOD, nightlights, and urban poor cluster variables in Kenya based on 2014 DHS data. Across these three indicators, urbanicity appears to cluster in and around Nairobi and Kisumu, with variation of urbanicity appearing more prominently along main arterial roads according to SMOD and the urban poor cluster variables. In the surrounding Nairobi area, for example, there are more urban centers and peri-urban areas along major roads (see Figure 19 (a)).

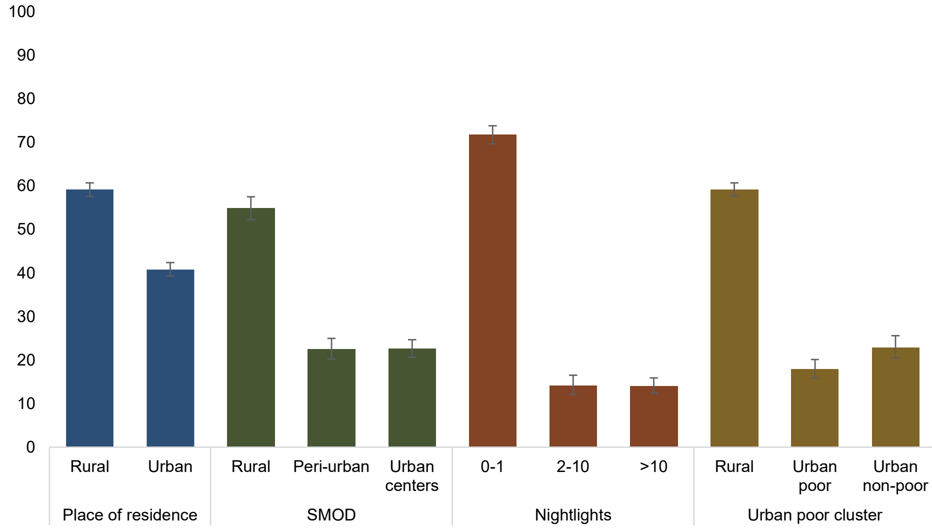
Figure 19 Maps showing the geographic distribution of (a) SMOD, (b) nightlights, and (c) urban poor cluster variables in Kenya 2014 DHS



(a) SMOD (b) Nightlights (c) Urban poor cluster

Figure 20 presents the percent distribution of women age 15-49 according to the four indicators. There is some variation in the rural category across the indicators, ranging from 55% for SMOD to 72% in the lowest (0-1) nightlights category. According to the SMOD indicator, 23% of women in Kenya resided in urban centers and peri-urban areas. The distribution of women in Kenya living in the middle (2-10) nightlights category as well as in the highest (greater than 10) nightlights category was 14% in both subgroups. Based on the urban poor cluster indicator, 18% of women lived in urban poor clusters, and more than one-fifth (23%) in urban non-poor clusters. The percentage of women living in the highest urban area categories across the urbanicity indicators had a wider range compared to their rural counterparts, from 14% in clusters with greater than 10 nightlights to 41% in the urban place of residence.

Figure 20 Percent distribution of the urbanicity variables in Kenya 2014 DHS



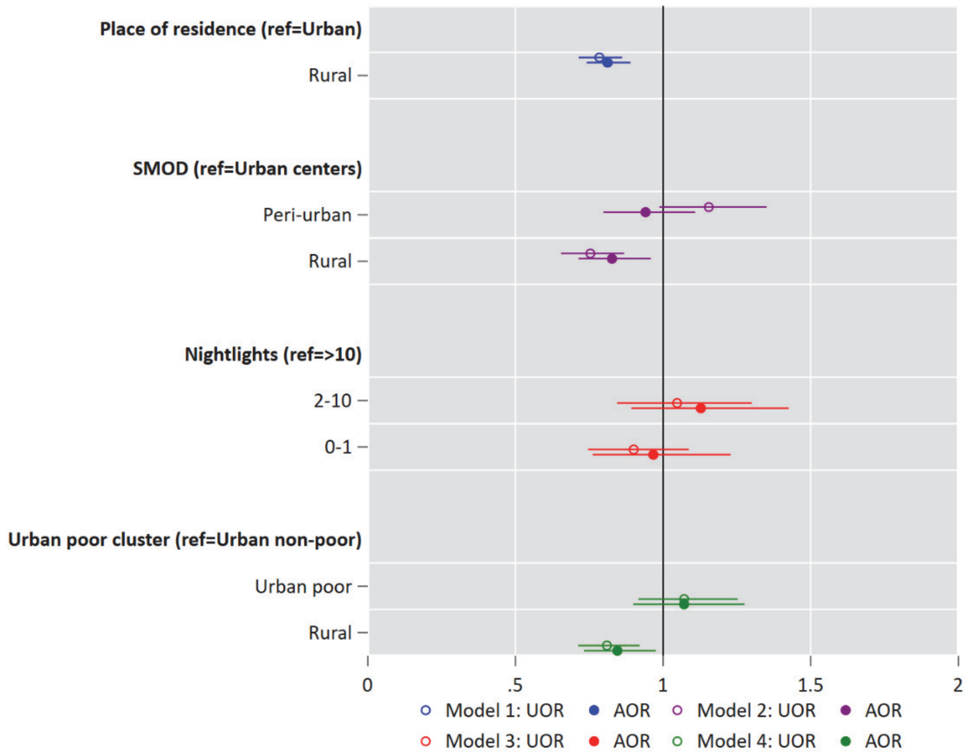
Over half (53%) of women age 15-49 in Kenya use a modern contraceptive method. This differed significantly by place of residence, SMOD, and urban poor cluster variables, but not by nightlights (Table 5). However, the differences were small with ranges from approximately 50% in rural areas to 58% in urban areas, and 60% in the peri-urban areas. The regressions summarized in Figure 21 show that in Models 1, 2, and 4, women living in rural clusters had approximately 20% lower odds of mCPR compared to the reference categories. The remaining categories were not significant in the unadjusted and adjusted models. This indicates that there was no difference in mCPR between women living in peri-urban and urban centers (Model 1) and the urban poor and urban non-poor (Model 4). Nightlights were not a significant predictor of mCPR (Model 3).

Table 5 Crosstabulations of urbanicity variables with health outcomes in Kenya 2014 DHS

	Modern contraceptive use		At least four ANC visits		Three doses of DPT vaccine		Minimum acceptable diet	
Variable	**% [C.I.]**	**p-value**	**% [C.I.]**	**p-value**	**% [C.I.]**	**p-value**	**% [C.I.]**	**p-value**
Total	53.2 [52.1,54.3]		54.7 [53.2,56.3]		89.9 [88.5,91.1]		10.9 [9.8,12.1]	
Place of residence		***		***				***
Rural	50.9 [49.5,52.2]		48.7 [46.8,50.6]		89.2 [87.5,90.7]		8.1 [7.1,9.2]	
Urban	56.9 [55.0,58.7]		65.6 [63.1,68.1]		91.2 [88.3,93.3]		16.0 [13.5,18.9]	
SMOD		***		***				***
Rural	49.4 [48.0,50.7]		50.9 [49.0,52.9]		89.0 [87.2,90.5]		8.7 [7.6,10.0]	
Peri-urban	59.9 [57.8,61.9]		52.5 [49.4,55.6]		91.9 [89.1,94.0]		11.0 [8.9,13.5]	
Urban centers	56.4 [53.3,59.5]		69.7 [65.7,73.4]		90.5 [85.7,93.9]		18.2 [14.1,23.1]	
Nightlights				***				***
0-1	52.4 [51.2,53.6]		50.4 [48.7,52.1]		89.8 [88.4,91.1]		9.0 [8.0,10.2]	
2-10	56.1 [53.6,58.7]		68.9 [65.0,72.5]		89.0 [82.9,93.1]		15.2 [11.4,19.8]	
>10	55.0 [50.4,59.5]		69.4 [63.5,74.8]		91.1 [84.6,95.0]		20.0 [13.9,27.7]	
Urban poor cluster		***		***				***
Rural	50.9 [49.5,52.2]		48.7 [46.8,50.6]		89.2 [87.5,90.7]		8.1 [7.1,9.2]	
Urban poor	57.8 [55.4,60.1]		59.5 [56.1,62.8]		90.8 [87.0,93.6]		12.6 [9.5,16.5]	
Urban non-poor	56.1 [53.3,58.9]		71.5 [67.8,74.8]		91.5 [86.9,94.5]		19.3 [15.5,23.7]	

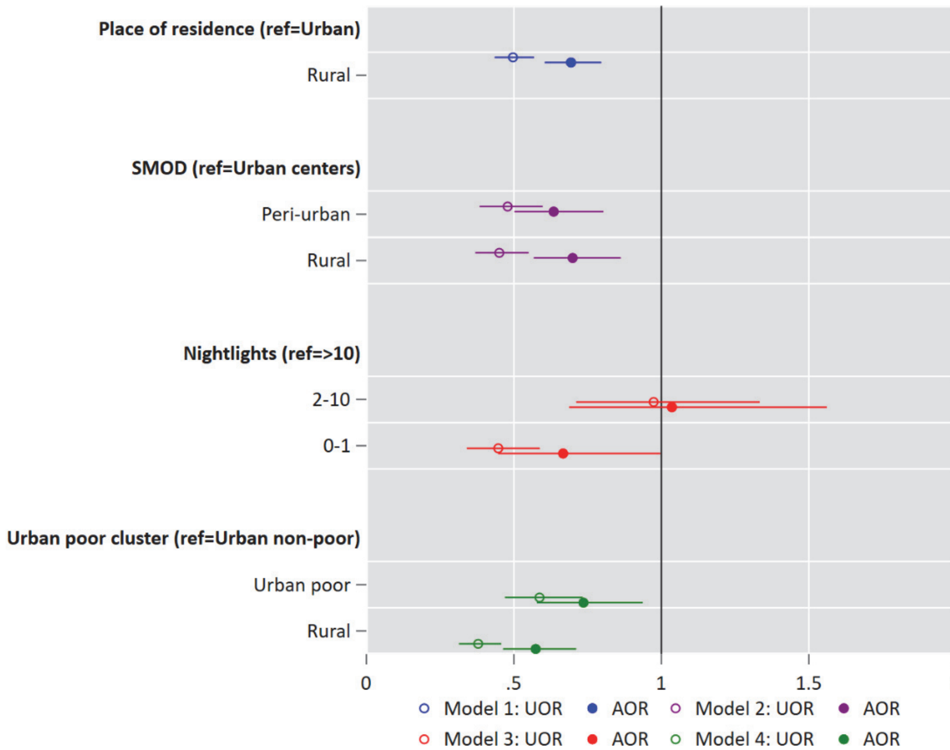
Note: *p<0.05,**p<0.01, ***p<0.001

Figure 21 Unadjusted and adjusted odds ratios of the urbanicity variables and mCPR in Kenya 2014 DHS



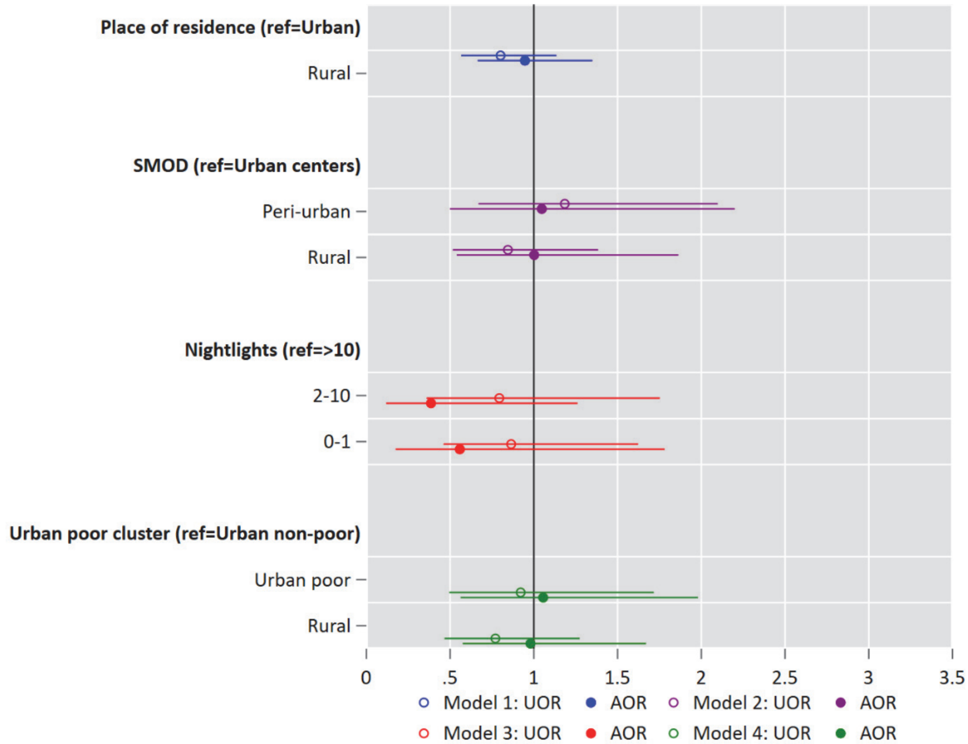
Over half (55%) of women age 15-49 had at least four ANC visits for their most recent birth. This differed significantly by all the urbanicity variables and ranged from approximately 49% in rural areas to the highest percentage of 72% found in women living in urban non-poor clusters (Table 5). The regression results in Figure 22 show that in Models 1-4, women living in rural clusters have lower odds of ANC4 compared to the reference categories (approximately 30% lower odds in Models 1-3 and 40% in Model 4). In adjusted Model 2, women living in peri-urban clusters have approximately 40% lower odds of ANC4 and women living in rural clusters have 30% lower odds of ANC4 compared to women living in urban clusters. In Model 3, there was no statistical difference in ANC4 between women living in clusters with 2-10 nightlights and those with greater than 10 nightlights. In adjusted Model 4, women living in urban poor clusters had approximately 25% lower odds of ANC4 and women living in rural clusters had approximately 40% lower odds of ANC4 compared to women living in urban non-poor clusters.

Figure 22 Unadjusted and adjusted odds ratios of the urbanicity variables and ANC4 in Kenya 2014 DHS



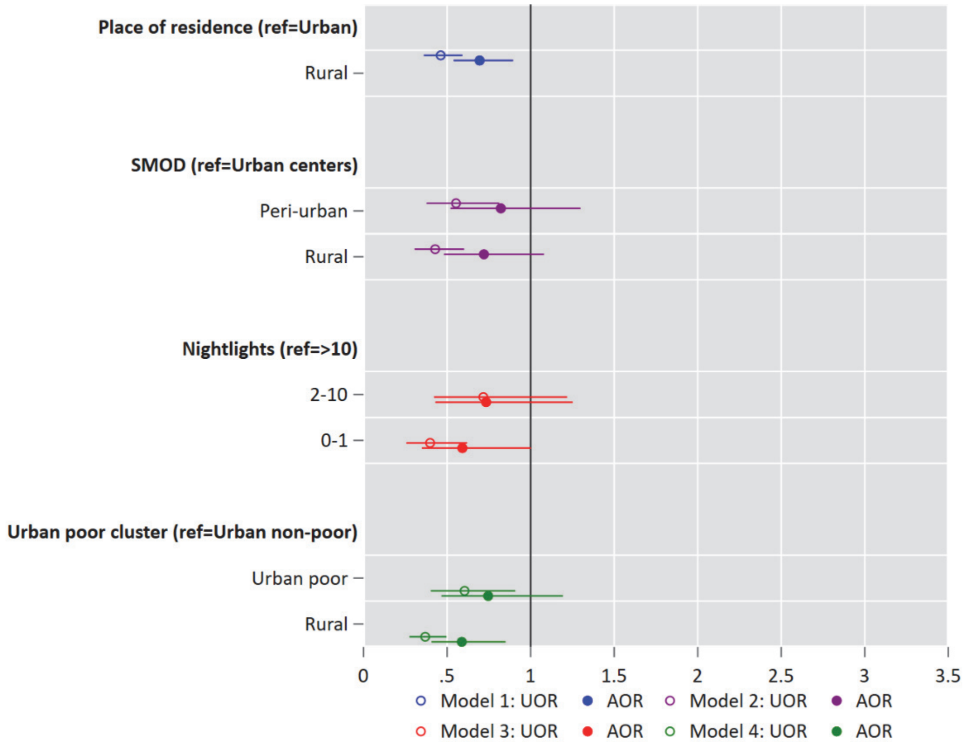
Approximately 90% of children age 12-23 months in Kenya had three doses of DPT. This did not differ significantly by the urbanicity variables shown in Table 5. The regression results in Figure 23 confirmed this finding. None of the urbanicity variables was found to be a significant predictor of DPT3 in either the unadjusted or adjusted models.

Figure 23 Unadjusted and adjusted odds ratios of the urbanicity variables and DPT3 in Kenya 2014 DHS



Only 11% of children age 6-23 months in Kenya had a MAD. This differed significantly by all the urbanicity variables with ranges from 8% in rural areas to a high of 20% for children living in clusters with greater than 10 nightlights (Table 5). In Figure 24, for Model 1 and Model 4, children living in rural areas had 40% lower odds of MAD compared to children living in urban and urban non-poor clusters respectively. In Model 2, children in rural and peri-urban clusters had lower odds of MAD compared to urban centers in the unadjusted models, although this significance was lost in the adjusted models. The SMOD and nightlights variables (Models 2 and 3) were not significant predictors of MAD. In Model 4, there was no significant difference in MAD between children living in urban poor clusters and the urban non-poor clusters.

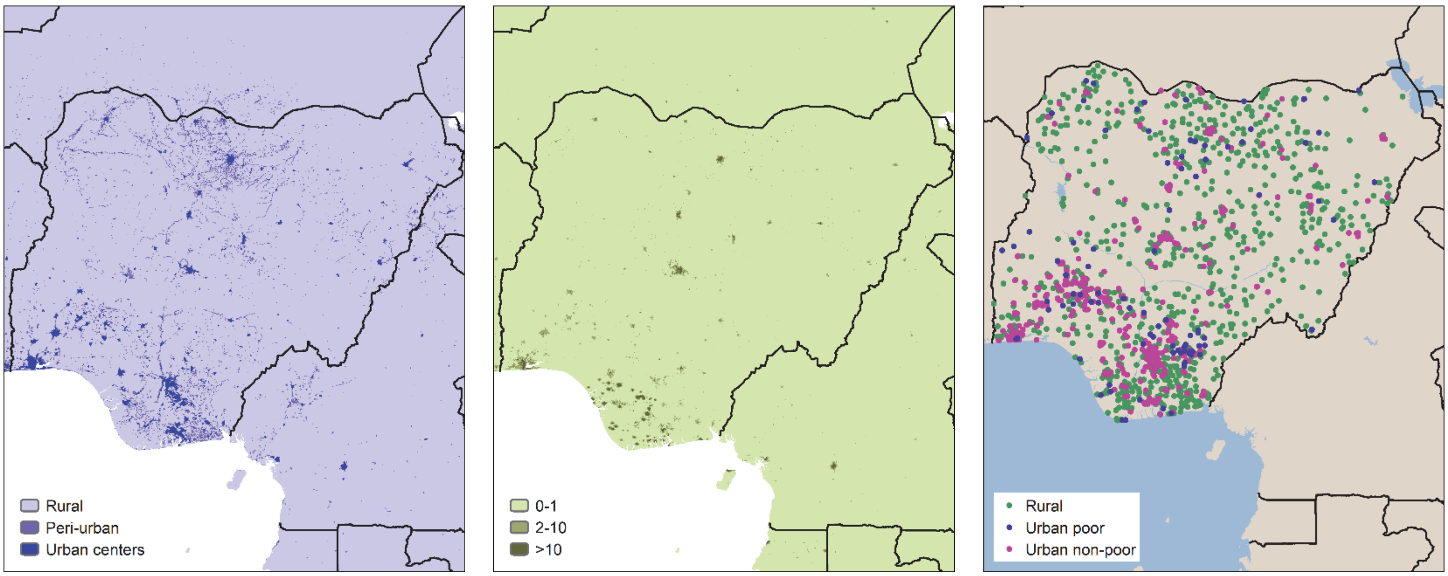
Figure 24 Unadjusted and adjusted odds ratios of the urbanicity variables and MAD in Kenya 2014 DHS



3.5 Nigeria

Figure 25 displays the geographic distribution of SMOD, nightlights, and urban poor cluster variables in Nigeria based on 2018 DHS data. Urbanicity indicators appear to cluster in cities like Abuja, Lagos, Ibadan, and Kano, as well as in other places with access to a main road. According to the urban poor cluster indicator map (Figure 25(c)), there is a large prevalence of people—across the variable categories—living in the southwestern section of Nigeria.

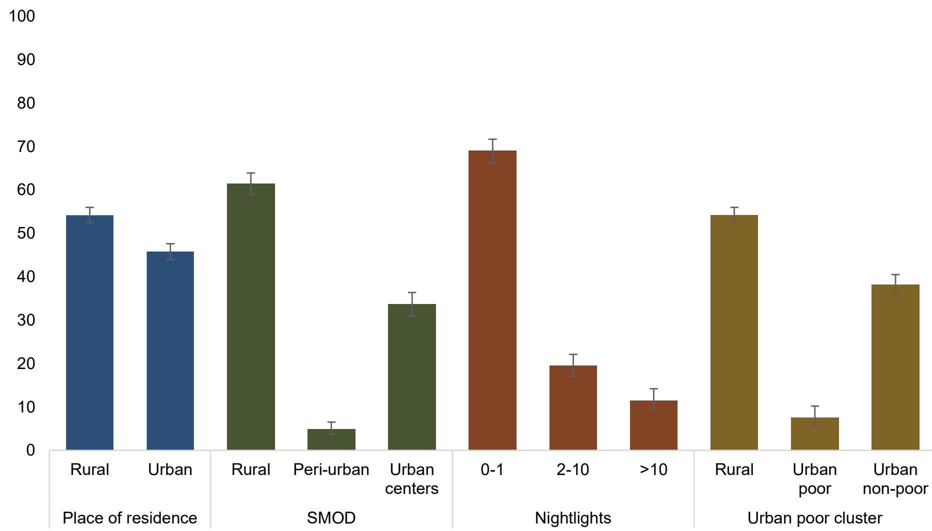
Figure 25 Maps showing the geographic distribution of (a) SMOD, (b) nightlights, and (c) urban poor cluster variables in Nigeria 2018 DHS



(a) SMOD (b) Nightlights (c) Urban poor cluster

Figure 26 presents the percent distribution of women age 15-49 according to the four urbanicity indicators. There appears to be some variation in the rural category across the indicators, ranging from 55% for place of residence and urban poor cluster indicators to 69% in the lowest (0-1) nightlights category. According to the SMOD indicator, more than one-third (34%) of women in Nigeria reside in urban centers, compared to 5% who live in peri-urban areas. One-fifth of women in Nigeria live in the middle (2-10) nightlights category, and 12% live in the highest (greater than 10) nightlights category. Based on the urban poor cluster indicator, 8% of women lived in urban poor clusters, compared with 38% who live in urban non-poor clusters. The percentage of women living in the highest urban area categories across the urbanicity indicators displayed a wider range compared to their rural counterparts, from 8% in urban poor clusters to 46% in the urban place of residence.

Figure 26 Percent distribution of the urbanicity variables in Nigeria 2018 DHS



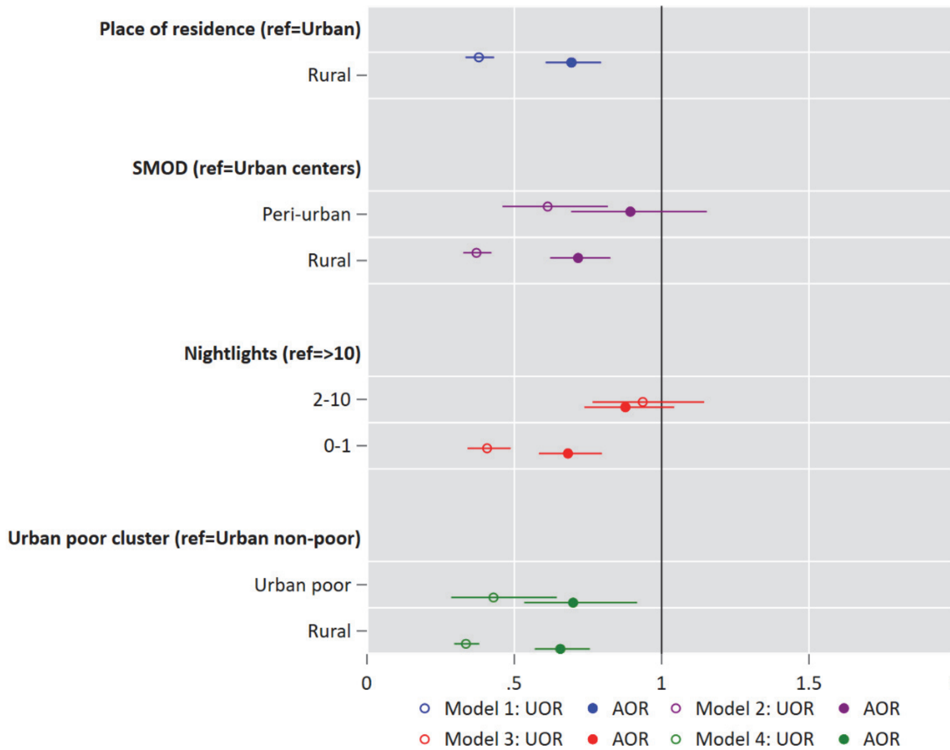
Only 12% of women age 15-49 use a modern contraceptive method. This differed significantly by all urbanicity variables and ranged from 8% in rural areas to 20% in highly urban areas and the urban non-poor (Table 6). Figure 27 shows that women living in rural clusters had lower odds of mCPR compared to the reference in Models 1-4 (approximately 30-35% lower odds). In Model 2, while women living in peri-urban clusters had lower odds of mCPR compared to urban centers in the unadjusted model, this significance was lost in the adjusted model. In Model 3, there was no statistical difference between women living in clusters with from 2-10 nightlights and women living in clusters with greater than 10 nightlights. In Model 4, women living in urban poor clusters had approximately 30% lower odds of mCPR compared to women living in urban non-poor clusters. The odds were similar to that of women in rural clusters who had approximately 35% lower odds of mCPR compared to women in the urban non-poor clusters.

Table 6 Crosstabulations of urbanicity variables with health outcomes in Nigeria 2018 DHS

	Modern contraceptive use		At least four ANC visits		Three doses of DPT vaccine		Minimum acceptable diet	
Variable	% [C.I.]	p-value	% [C.I.]	p-value	% [C.I.]	p-value	% [C.I.]	p-value
Total	12.0 [11.4,12.7]		56.2 [54.5,57.8]		50.1 [47.9,52.3]		11.0 [10.1,12.0]	
Place of residence		***		***		***		***
Rural	7.8 [7.1,8.6]		45.8 [43.8,47.9]		38.4 [35.9,41.0]		8.6 [7.7,9.5]	
Urban	18.2 [17.1,19.4]		72.7 [70.5,74.8]		67.9 [64.5,71.2]		14.8 [12.9,16.9]	
SMOD		***		***		***		***
Rural	8.6 [7.9,9.4]		48.5 [46.5,50.6]		40.9 [38.5,43.4]		9.0 [8.1,9.9]	
Peri-urban	13.5 [10.8,16.6]		62.7 [56.4,68.7]		50.4 [42.1,58.7]		11.1 [7.3,16.6]	
Urban centers	20.2 [19.0,21.6]		76.2 [73.9,78.4]		73.3 [69.1,77.2]		16.7 [14.3,19.6]	
Nightlights		***		***		***		***
0-1	9.3 [8.6,10.0]		51.3 [49.4,53.3]		44.3 [42.0,46.7]		9.3 [8.5,10.2]	
2-10	19.0 [17.4,20.8]		72.9 [69.8,75.9]		64.5 [59.5,69.2]		12.6 [10.2,15.4]	
>10	20.1 [18.0,22.4]		66.8 [61.7,71.6]		69.8 [61.6,76.9]		21.7 [16.9,27.4]	
Urban poor cluster		***		***		***		***
Rural	7.8 [7.1,8.6]		45.8 [43.8,47.9]		38.4 [35.9,41.0]		8.6 [7.7,9.5]	
Urban poor	9.8 [7.1,13.3]		61.1 [55.3,66.5]		54.1 [41.8,66.0]		12.6 [7.7,20.0]	
Urban non-poor	20.1 [19.0,21.3]		75.6 [73.5,77.6]		71.3 [67.9,74.5]		15.4 [13.4,17.5]	

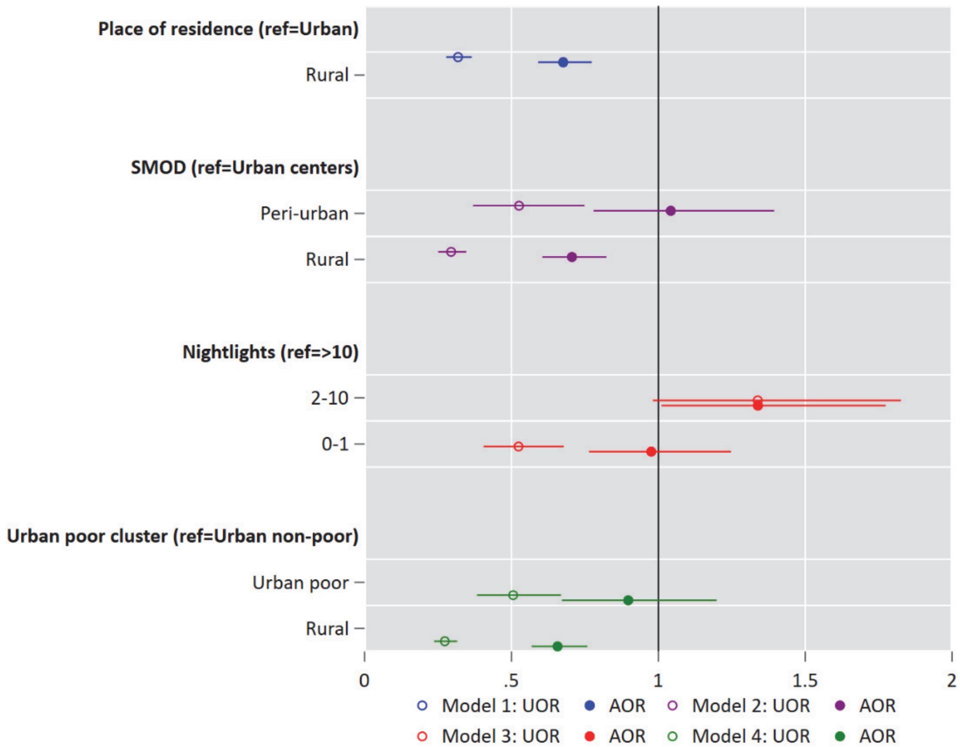
Note: *p<0.05,**p<0.01, ***p<0.001

Figure 27 Unadjusted and adjusted odds ratios of the urbanicity variables and mCPR in Nigeria 2018 DHS



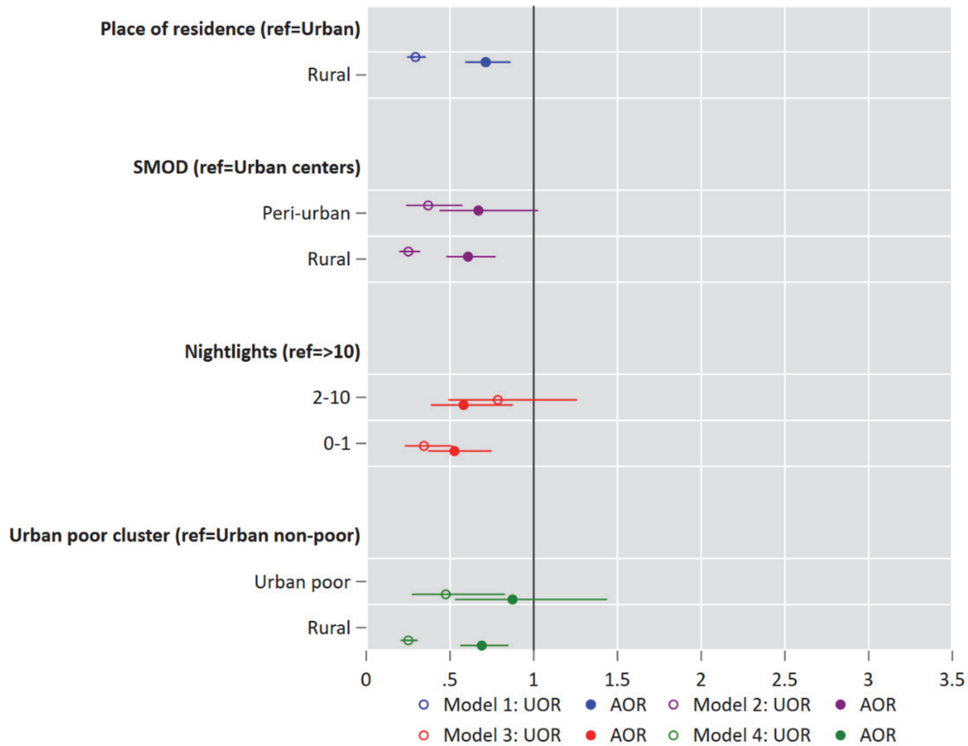
More than half of women (56%) age 15-49 had at least four ANC visits for their most recent birth. This differed by all urbanicity variables with ranges from 46% in rural areas to 76% in urban centers and urban non-poor clusters (Table 6). The regression results in Figure 28 show that in Models 1, 2, and 4, women in rural areas had significantly lower odds of ANC4 compared to the reference. In Model 3, women living in clusters with 0-1 nightlights had lower odds of ANC4 compared to women living in clusters with greater than 10 nightlights, but this was found only in the unadjusted model. All remaining categories for the urbanicity variables were not significant except for a marginal significance of the 2-10 nightlights category in the adjusted model (OR 1.3, 95% C.I. 1.0,1.8). Therefore, there was no statistical difference in ANC4 found between women living in peri-urban clusters compared to urban centers and between the urban poor and the urban non-poor.

Figure 28 Unadjusted and adjusted odds ratios of the urbanicity variables and ANC4 in Nigeria 2018 DHS



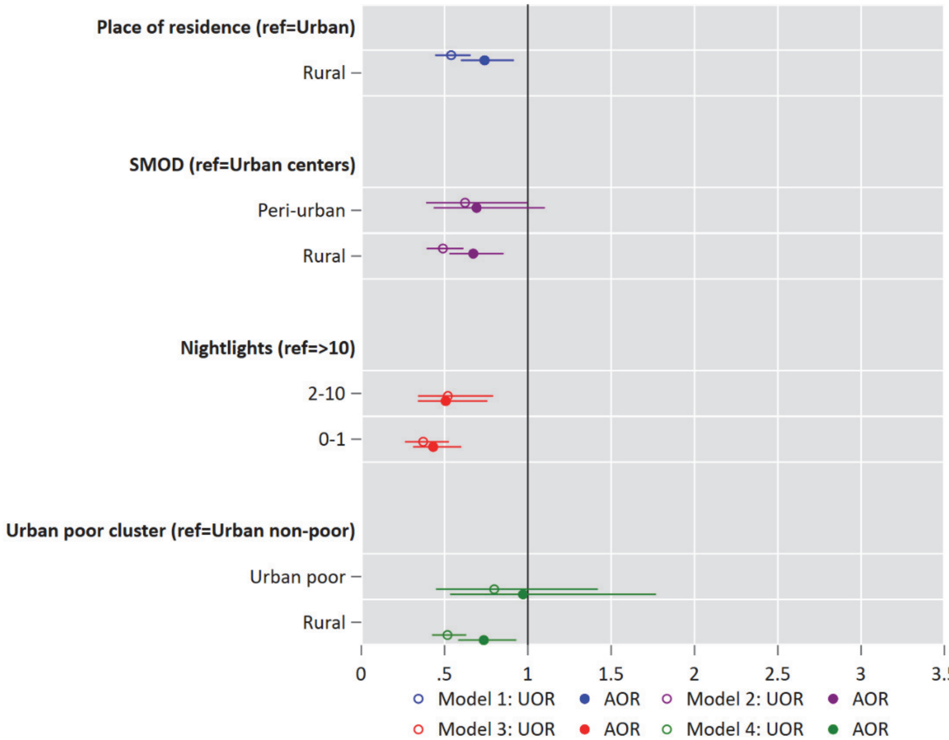
Half of children age 12-23 in Nigeria had three doses of DPT. This differed by all urbanicity variables and ranged from 38% in rural areas to 73% in urban centers (Table 6). The results in Figure 29 show that children living in rural areas had lower odds of receiving DPT compared to the reference in Models 1-4 (between 30-50% lower odds). In the unadjusted Model 2, children living in peri-urban areas had lower odds of DPT3 compared to urban centers, although this significance was lost in the adjusted model. In Model 3, children living in clusters with 2-10 nightlights had approximately 40% lower odds of DPT3 compared to children living in clusters with greater than 10 nightlights in the adjusted model. In the unadjusted Model 4, children living in urban poor clusters had lower odds of DPT3 compared to children living in urban non-poor clusters. This significance was lost in the adjusted model.

Figure 29 Unadjusted and adjusted odds ratios of the urbanicity variables and DPT3 in Nigeria 2018 DHS



Only 11% of children age 6-23 months in Nigeria had a minimum acceptable diet. This differed significantly across all urbanicity variables and ranged from 9% in rural areas to a high of 22% in clusters with greater than 10 nightlights (Table 6). The range of children age 6-23 months who had a MAD was between 15-17% in urban, urban centers, and urban non-poor clusters. In Figure 30, in all models, children living in rural clusters had lower odds of MAD compared to the reference (approximately 30-35% lower odds in Models 1, 2, and 4 and 57% lower odds in Model 3). In Model 2, there was no significant difference in MAD for children living in the peri-urban areas compared to urban centers. In Model 3, children living in clusters with 2-10 nightlights had 50% lower odds of MAD compared to children living in clusters with greater than 10 nightlights. This odds ratio was also similar to the odds ratio for the rural category. In Model 4, there was no statistical difference in MAD for children living in urban poor clusters compared to children living in the urban non-poor clusters.

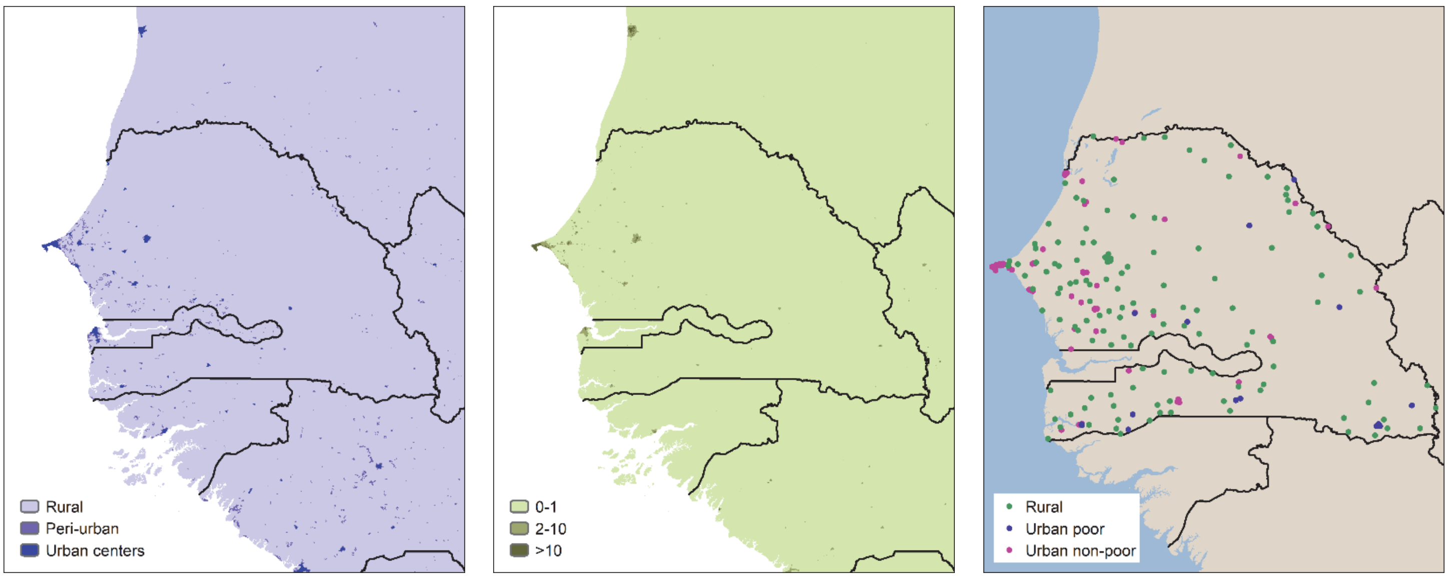
Figure 30 Unadjusted and adjusted odds ratios of the urbanicity variables and MAD in Nigeria 2018 DHS



3.6 Senegal

Figure 31 displays the geographic distribution of SMOD, nightlights, and urban poor cluster variables in Senegal based on 2016 DHS data. Urbanicity indicators appear on the western part of the country, most notably in Dakar, where we see the highest prevalence of urban centers according to SMOD, the highest (>10) nightlights category, and the highest concentration of urban poor non-poor clusters.

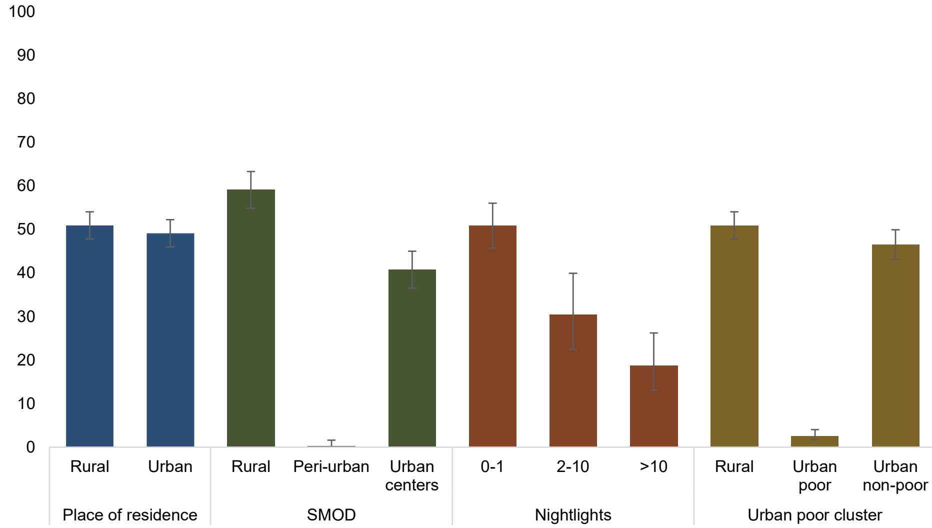
Figure 31 Maps showing the geographic distribution of (a) SMOD, (b) nightlights, and (c) urban poor cluster variables in Senegal 2016 DHS



(a) SMOD (b) Nightlights (c) Urban poor cluster

Figure 32 presents the percent distribution of women age 15-49 according to place of residence, SMOD, nightlights, and the urban poor cluster variable. There is general agreement in the rural category across the indicators, ranging from 51%—according to place of residence, the lowest (0-1) nightlights category, and urban poor cluster—to 59% according to SMOD. According to the SMOD indicator, the percentage of women living in peri-urban areas in Senegal is less than half a percent, compared to 41% living in urban centers. Thirty percent of women live in the middle (2-10) nightlights category, and 19% live in the highest (greater than 10) nightlights category. Based on the urban poor cluster indicator, 3% of women lived in urban poor clusters, compared with 47% who live in urban non-poor clusters. The percentage of women living in the highest urban area categories across the urbanicity indicators displayed a wider range compared to their rural counterparts, from 19% in clusters with greater than 10 nightlights to 49% in the urban place of residence.

Figure 32 Percent distribution of the urbanicity variables in Senegal 2016 DHS



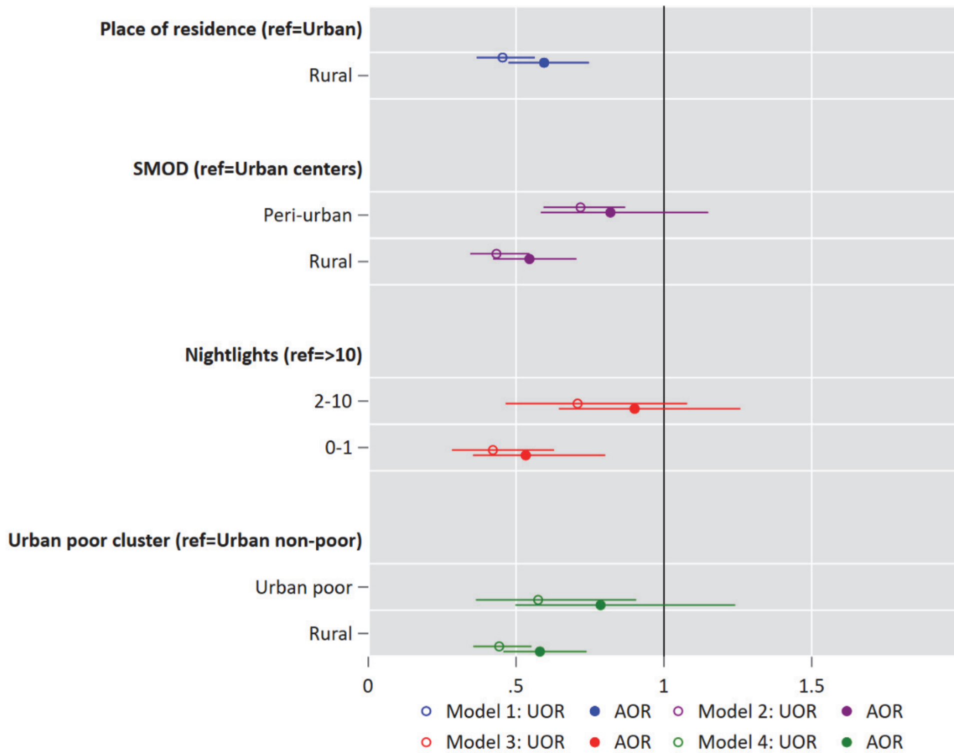
Fewer than a quarter (23%) of women age 15-49 use a modern contraceptive method. This differed significantly by all urbanicity variables and ranged from approximately 17% in rural areas to 34% in highly urban areas (Table 7). There were fewer than 50 unweighted observations for women living in peri-urban areas, which made it difficult to provide a reliable estimate. The regression results in Figure 33 show that women living in rural areas had approximately 40-50% lower odds of mCPR compared to the reference in Models 1-4. No other categories were significant. Therefore, there was no statistical difference in mCPR between women living in peri-urban clusters compared to urban centers, between 2-10 nightlights and greater than 10 nightlights, and urban poor compared to urban non-poor.

Table 7 Crosstabulations of urbanicity variables with health outcomes in Senegal 2016 DHS

	Modern contraceptive use		At least four ANC visits		Three doses of DPT vaccine		Minimum acceptable diet	
Variable	**% [C.I.]**	**p-value**	**% [C.I.]**	**p-value**	**% [C.I.]**	**p-value**	**% [C.I.]**	**p-value**
Total	23.1 [21.2,25.0]		52.2 [48.6,55.7]		89.5 [86.2,92.0]		6.9 [5.5,8.7]	
Place of residence		***		***		*		**
Rural	17.2 [15.4,19.1]		44.2 [40.2,48.3]		87.3 [82.9,90.7]		5.4 [4.2,7.0]	
Urban	31.3 [27.7,35.1]		67.9 [62.6,72.8]		94.0 [89.4,96.7]		10.0 [6.9,14.3]	
SMOD		***		***				
Rural	17.7 [16.0,19.6]		45.2 [41.5,49.0]		87.5 [83.4,90.6]		6.0 [4.8,7.4]	
Peri-urban	ND		ND		ND		ND	
Urban centers	33.2 [29.0,37.7]		71.3 [65.2,76.7]		95.1 [88.6,98.0]		9.7 [6.0,15.2]	
Nightlights		***		***		*		
0-1	18.0 [16.2,20.0]		43.9 [40.3,47.7]		86.1 [81.7,89.6]		6.2 [4.9,7.8]	
2-10	26.9 [24.3,29.8]		62.4 [54.9,69.3]		96.7 [92.9,98.5]		7.5 [4.5,12.1]	
>10	34.2 [25.4,44.4]		75.6 [62.8,85.1]		(94.1) [74.6,98.8]		9.7 [4.0,21.6]	
Urban poor cluster		***		***		*		*
Rural	17.2 [15.4,19.1]		44.2 [40.2,48.3]		87.3 [82.9,90.7]		5.4 [4.2,7.0]	
Urban poor	21.2 [14.1,30.7]		62.5 [50.5,73.2]		82.6 [59.4,93.9]		10.5 [4.1,24.1]	
Urban non-poor	31.9 [28.1,35.9]		68.2 [62.6,73.4]		94.9 [89.8,97.5]		9.9 [6.7,14.5]	

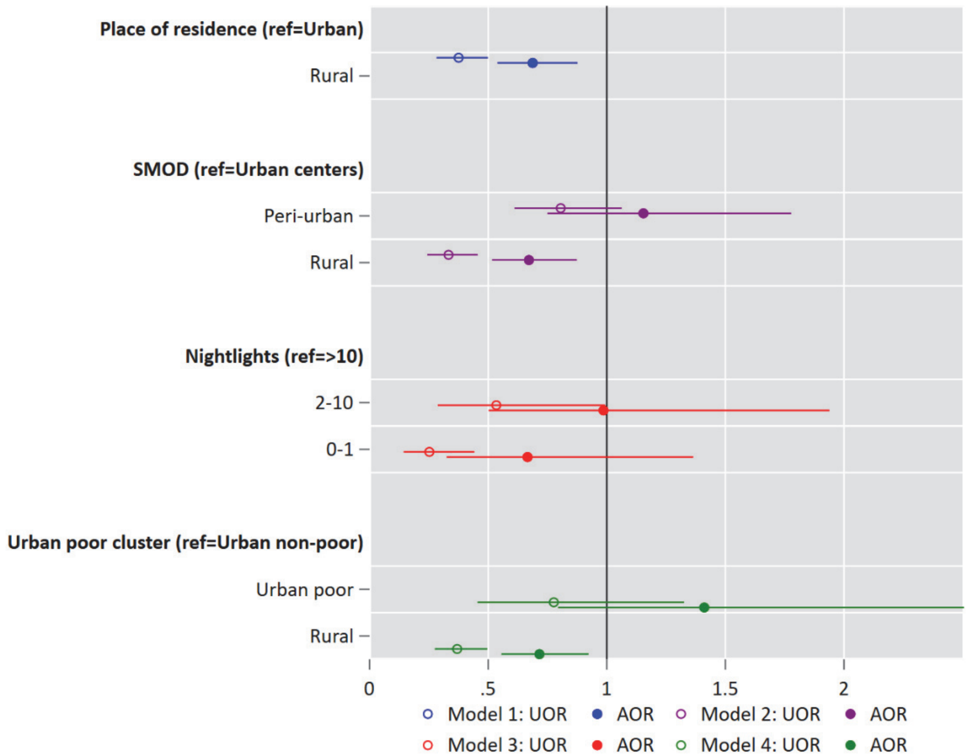
Notes: ND - not displayed because it is based on fewer than 25 observations. Figures in parentheses are based on 25-50 observations.
*p<0.05,**p<0.01, ***p<0.001

Figure 33 Unadjusted and adjusted odds ratios of the urbanicity variables and mCPR in Senegal 2016 DHS



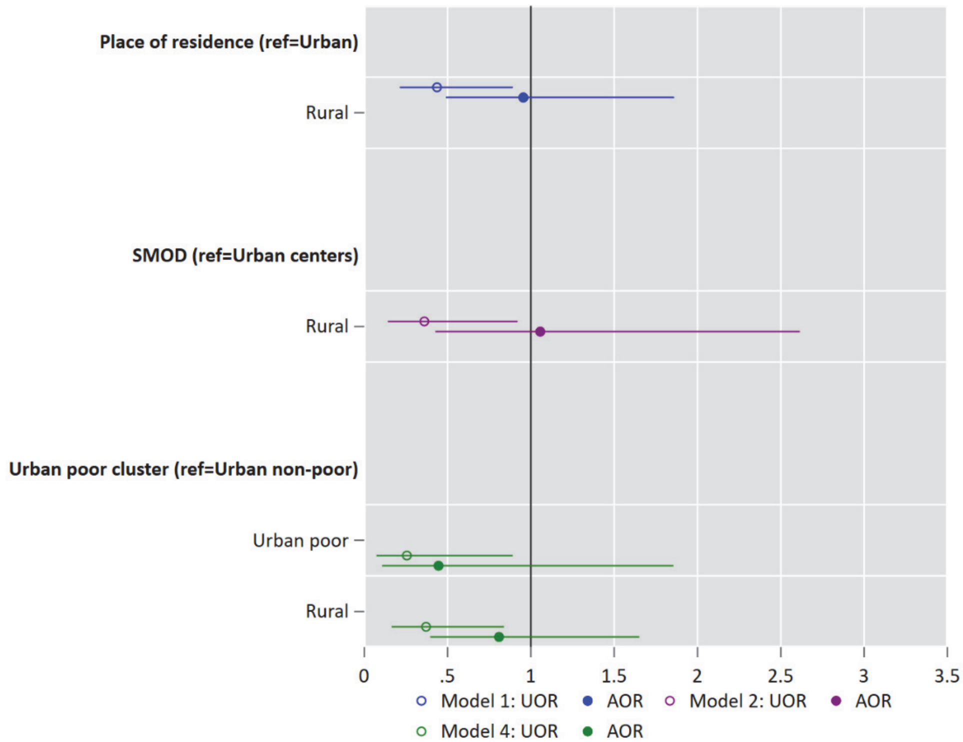
Slightly over half (52%) of women age 15-49 had at least four ANC visits for their most recent birth. This differed significantly by all urbanicity variables and ranged from approximately 44% in rural clusters to up to 76% in clusters with greater than 10 nightlights (Table 7). There were fewer than 50 unweighted observations for women living in peri-urban areas, which made it difficult to provide a reliable estimate. In Figure 34, women living in rural areas in Models 1, 2, and 4 had approximately 30% lower odds of ANC4 compared to the reference. In Model 2, we find no significant difference in ANC4 between women living in peri-urban clusters compared to urban centers. In Model 4, there was no significant difference in ANC4 between women living in urban poor clusters compared to urban non-poor clusters. Nightlights was not a significant predictor of ANC4.

Figure 34 Unadjusted and adjusted odds ratios of the urbanicity variables and ANC4 in Senegal 2016 DHS



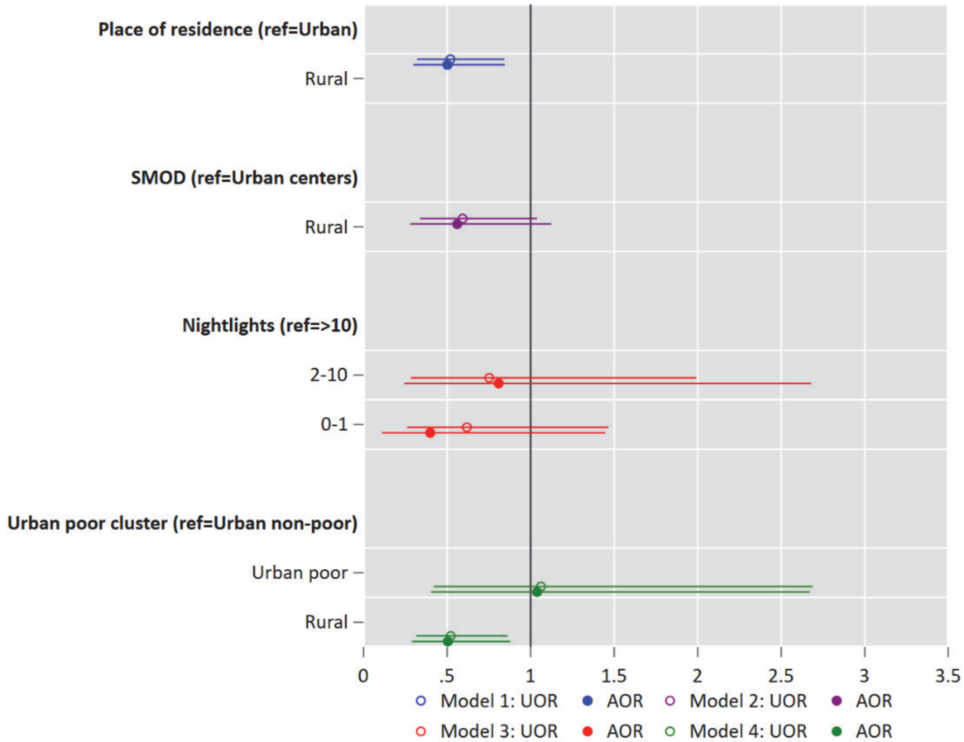
Almost 90% of children age 12-23 months had all three doses of DPT vaccine. This differed with a marginal significance by place of residence, nightlights, and the urban poor variable, but did not differ significantly by the SMOD variable, which had an insufficient number of observations in the peri-urban category to provide a reliable estimate (Table 7). The differences were also small and ranged from approximately 87% in rural areas to 94% in highly urban areas and the urban non-poor. Figure 35 summarizes the regression results for Models 1, 2, and 4. Model 3 was omitted from the figure since the confidence interval for the 2-10 nightlights category was too wide to be displayed and can be found in Appendix Table 7. In this table, children living in clusters with 2-10 nightlights had 7 times the odds of DPT3 compared to children living in clusters with greater than 10 nightlights. However, since the confidence interval for this estimate was very large (95% C.I. 1.5, 36.6), this marginal significance should be viewed with caution. Figure 35 shows that in Models 1, 2, and 4—all models presented in this figure—children living in rural areas had lower odds of DPT3 compared to the reference in the unadjusted models. However, this significance was lost in the adjusted models. In Model 2, the peri-urban category was automatically omitted from the regression due to the small number of observations. In Model 4, there was no statistical difference in DPT3 between children living in urban poor clusters compared to children in the urban non-poor clusters.

Figure 35 Unadjusted and adjusted odds ratios of the urbanicity variables and DPT3 in Senegal 2016 DHS



Only 7% of children age 6-23 months in Senegal had a minimum acceptable diet. This differed significantly by place of residence and the urban poor cluster variable but not by SMOD or nightlights (Table 7). Percentages ranged from approximately 5% in rural areas to 10% in urban and urban non-poor clusters. The results in Figure 36 show that in Model 1 and 4, children in rural clusters had 50% lower odds of MAD compared to children living in urban and urban non-poor clusters respectively. In Model 3, nightlights was not a significant predictor of MAD. In Model 2, the peri-urban category was automatically omitted from the model due to the few available observations. In Model, 4, there was no statistically significant difference in MAD between children in living in urban poor clusters and children in the urban non-poor clusters.

Figure 36 Unadjusted and adjusted odds ratios of the urbanicity variables and MAD in Senegal 2016 DHS



3.7 Summary of in-depth analysis

The results across most surveys and outcomes show that women and children who live in rural areas had worse outcomes compared to their urban counterparts. However, the differences among urban sub-categories were not always apparent. These generalizations should be viewed with caution because the analysis includes only six countries. For the SMOD variable, there were no significant differences in mCPR, DPT3, and MAD between women or children living in peri-urban clusters and urban centers across all countries. For ANC4, only in the DRC and Kenya was there a significant difference between women living in peri-urban clusters and urban centers. For the nightlights variable, there were few significant differences in the outcomes between clusters with 2-10 nightlights and those greater than 10 nightlights, for mCPR only in India, for ANC4 only in India and marginally significant in Nigeria, and for only MAD in Nigeria.

Differences between the urban poor and urban non-poor were mostly apparent for the ANC4 outcome. Significant differences between these two categories were found in Bangladesh, the DRC, India, and Kenya. For mCPR, significant differences between the urban poor and urban non-poor were only found in India and Nigeria, and for DPT3 only in the DRC and India. No significant differences in MAD between the urban poor and urban non-poor were found in any country.

For India, a slum variable available in the dataset was included in the analysis. There was agreement only in the results between the slum variable and the urban poor cluster variable for the DPT3 outcome. Children living in urban poor clusters or in urban slums had lower odds of DPT3 compared to urban non-poor or urban non-slums. For mCPR and ANC4, a significant difference was found between women living in urban poor clusters and urban non-poor clusters, although no significant differences were found between urban slums and urban non-slums in the adjusted models. Finally, for the MAD outcome, there was no significant difference between children living in urban poor clusters compared to urban non-poor clusters. However, there were higher odds of children with MAD who live in urban slums compared to urban non-slums, although the significance was marginal.

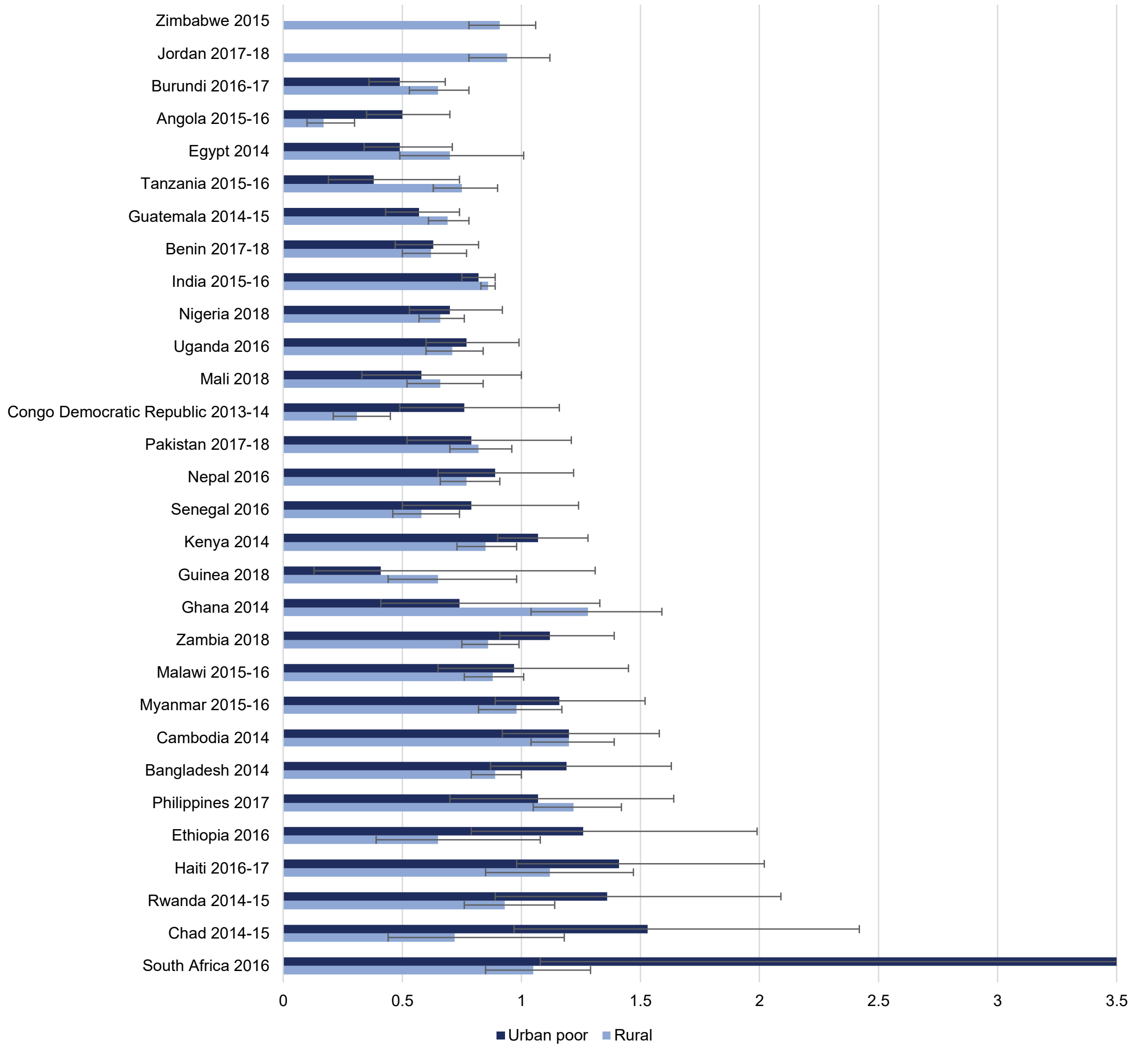
3.8 Results from further analysis of 30 surveys

A further analysis of 30 countries was performed with data from the surveys listed in Table 1. The analysis involved fitting adjusted logistic regressions for each outcome with the SMOD variable in one model and the urban poverty cluster variable in another model. The same control variables used for the in-depth regression analyses were used for these models. The results are summarized in Figures 37-44 below and Appendix Tables 8-11. The surveys in the figures are sorted by the upper bound of urban poor and peri-urban categories respectively for each outcome. This was done so that the surveys that show significance in these categories with respect to the outcome appear first in the list; if the Odds Ratios are below one, they will also have an asterisk next to the survey name on the y-axis. For some surveys there were no urban poor clusters identified among women and children.

3.8.1 Modern contraceptive use

Figure 37 shows the adjusted odds ratios for the urban poverty cluster variable and mCPR. For nine countries (Burundi, Egypt, Tanzania, Angola, Guatemala, Benin, India, Nigeria, and Uganda), women living in urban poor clusters had lower odds of mCPR compared to urban non-poor women. The lowest odds ratio was found in Tanzania, where women in urban poor clusters had 62% lower odds of mCPR compared to urban non-poor, while rural women had 25% lower odds compared to urban non-poor women. For the remaining countries where significance was found, the odds ranged from approximately 20% to 50% lower odds of mCPR for women residing in urban poor clusters compared to urban non-poor. For a few countries (Benin, India, Nigeria, and Uganda), the odd ratios of urban poor women were also similar to the odds ratios for women who reside in rural clusters. This implies that women who reside in rural and urban poor clusters have a similar risk of non-use of modern contraceptives compared to the urban non-poor. In South Africa we observe that women residing in urban poor clusters had more than 3 times the odds of mCPR compared to urban non-poor women. However, this significance was marginal and had a wide confidence interval, and therefore should be interpreted with caution. While significant differences in mCPR between the urban poor and urban non-poor were detected in 10 surveys, significant differences between rural and urban non-poor were found in 22 surveys.

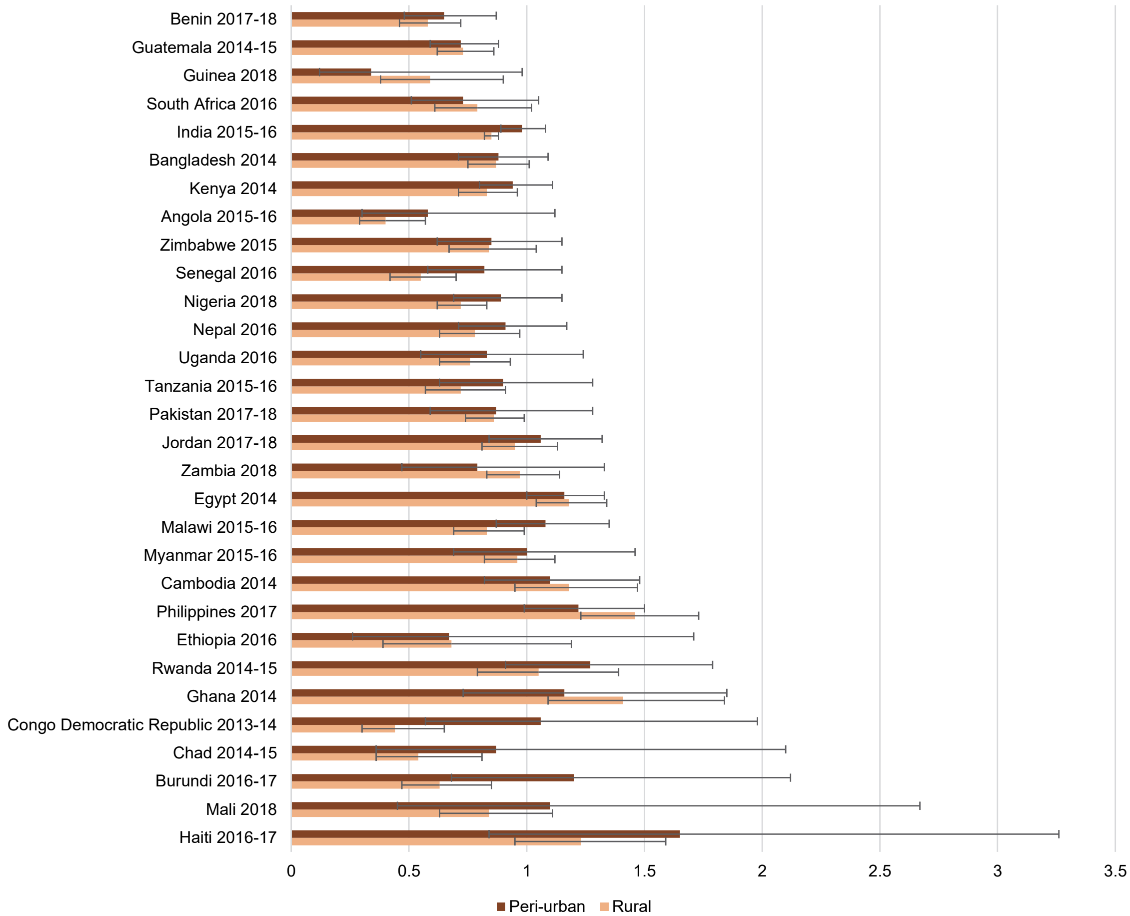
Figure 37 Adjusted odds ratios for the urban poor cluster variable (reference: urban non-poor) and mCPR in 30 DHS surveys



Note: South Africa had an upper bound that did not fit in the above figure. The adjusted odds ratio for peri-urban was 3.5 with 95% C.I. 1.1,11.3. Please see Appendix Table 8.

Figure 38 shows the adjusted odds ratios for the SMOD variable and mCPR. The figure shows that women who reside in peri-urban clusters in Guatemala, Benin, and Guinea had significantly lower odds of mCPR compared to women in the urban centers. In Guinea, women from peri-urban areas had 66% lower odds of using mCPR compared to urban centers, while women residing in rural areas had 41% lower odds. In Benin, the odds for peri-urban women for mCPR were 35% lower compared to women in urban centers, and in Guatemala the odds were 28% lower. Also, for both Benin and Guatemala, the odds ratios for peri-urban and rural categories were very similar, indicating a similar association with mCPR compared to urban centers. In Egypt, women from peri-urban areas had 16% higher odds of mCPR compared to women in urban centers. There was no significant difference in mCPR between women in peri-urban areas and urban centers for the remaining countries. While significant differences in mCPR between the peri-urban and urban centers were found in four surveys, significant differences between the rural and urban centers were found in 19 surveys.

Figure 38 Adjusted odds ratios for the SMOD variable (reference: urban centers) and mCPR in 30 DHS surveys



3.8.2 At least four ANC visits

Figure 39 shows the odds ratios of ANC4 for women living in urban poor and rural clusters compared to those in the urban non-poor category. Nine surveys from the 30 showed a significant difference between women living in urban poor versus urban non-poor clusters in ANC4. In the DRC, Pakistan, India, Benin, Angola, Kenya, and Bangladesh, women living in urban poor clusters had lower odds of ANC4 compared to women in urban non-poor clusters (ranging from 26% to 60% lower odds). For Pakistan, India and Benin, the odds ratios for the urban poor and the rural clusters were very similar, which were similarly decreased odds of mCPR compared to the urban non-poor. In Egypt and Guatemala, women from urban poor clusters had 81% and 64% higher odds respectively of ANC4 compared to the urban non-poor. For both these countries, there was no significant difference in ANC4 observed between women residing in rural clusters compared to urban non-poor clusters. While significant differences in ANC4 between the urban poor and urban non-poor were detected in nine surveys, significant differences between rural and urban non-poor were found in 20 surveys.

Figure 39 Adjusted odds ratios for the urban poor cluster variable (reference: urban non-poor) and ANC4 in 30 DHS surveys

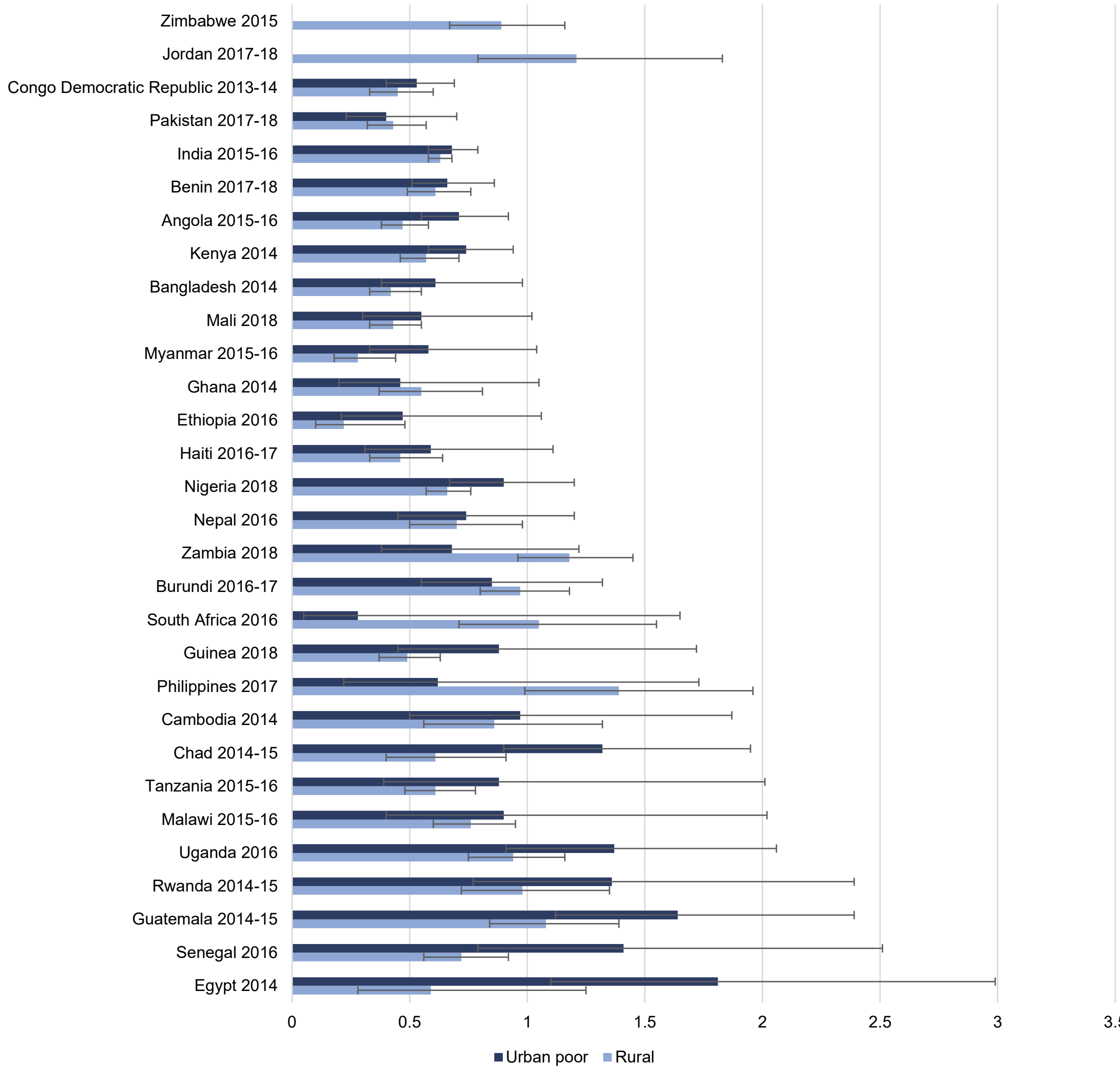
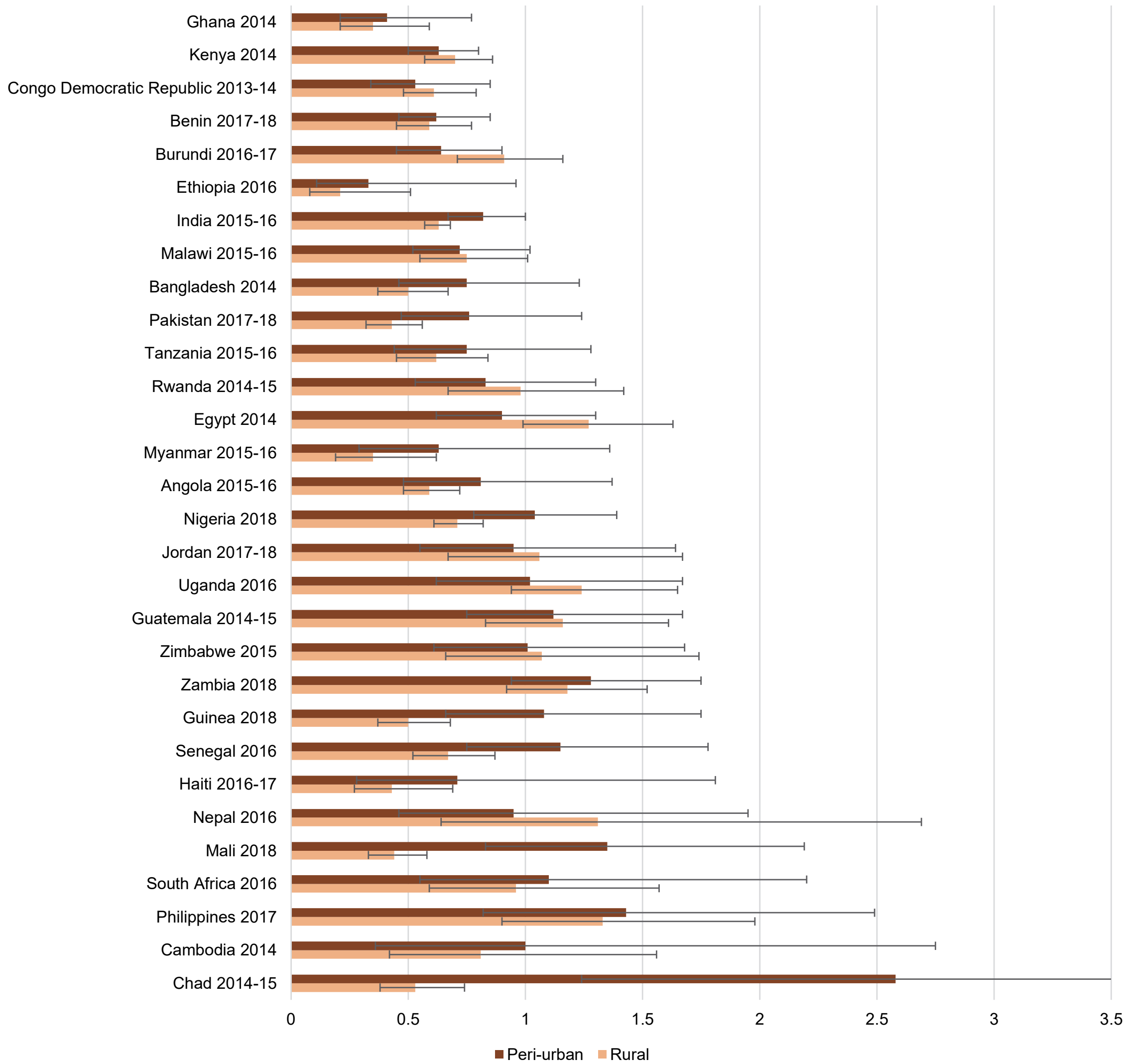


Figure 40 shows that women who reside in peri-urban clusters in Ghana, Kenya, the DRC, Benin, Burundi, and Ethiopia had lower odds of ANC4 compared to women in urban centers (between 36% to 67% lower odds). In Benin, the odds ratio for peri-urban and rural clusters was very similar; women from both categories had approximately 40% lower odds of ANC4 compared to urban centers. In Chad, women who lived in peri-urban areas had almost 2.6 times greater odds of ANC4 compared to women in urban centers, while rural women had approximately 50% lower odds of ANC4. Significant differences in ANC4 between the peri-urban and urban centers were detected in seven surveys, while significant differences between rural and urban centers were found in 17 surveys.

Figure 40 Adjusted odds ratios for the SMOD variable (reference: urban centers) and ANC4 in 30 DHS surveys

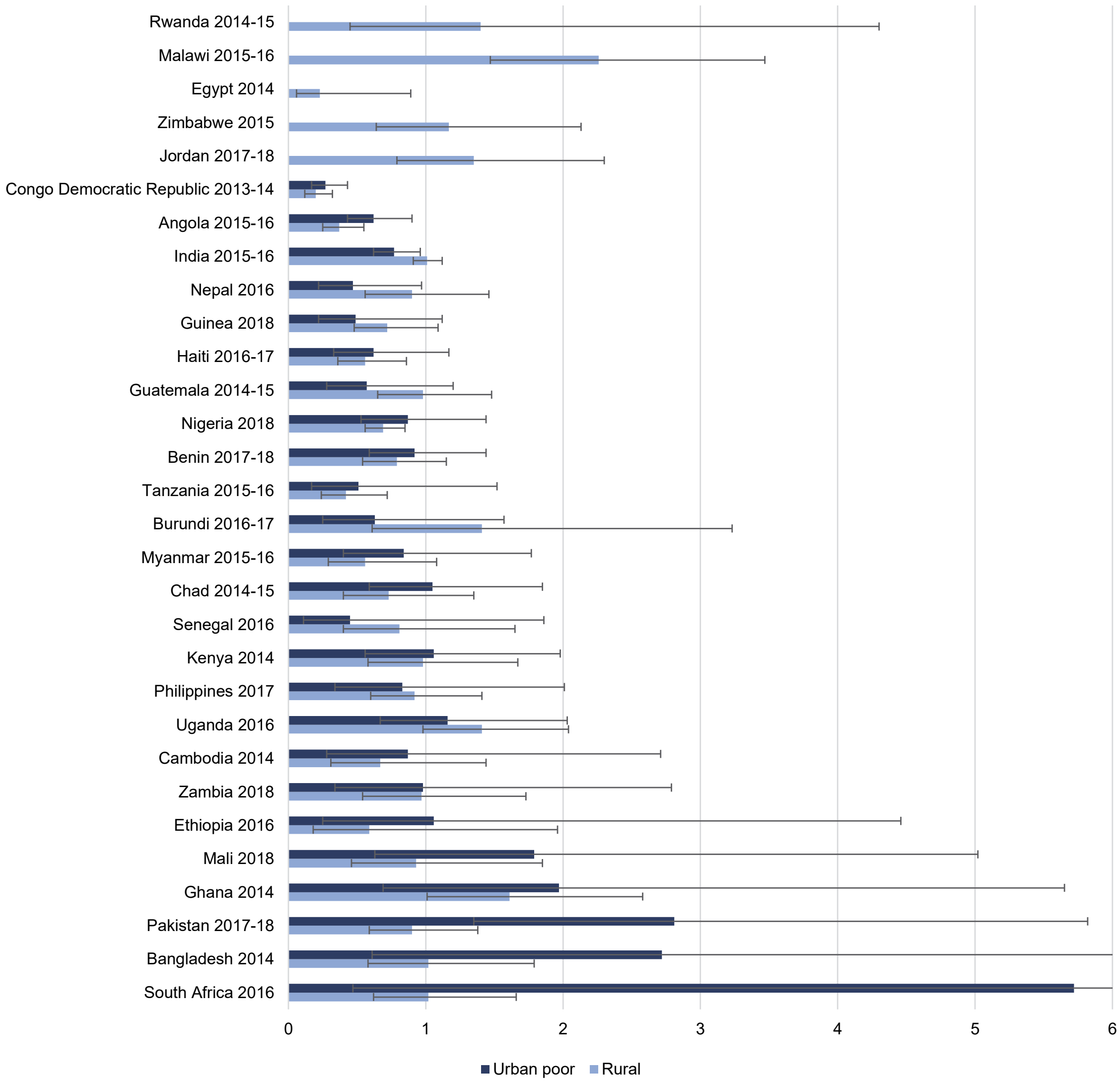


Note: Chad had an upper bound that did not fit in the above figure. The adjusted odds ratio for peri-urban was 2.6 with 95% C.I. 1.2, 5.3. Please see Appendix Table 9.

3.8.3 Three doses of DPT vaccine

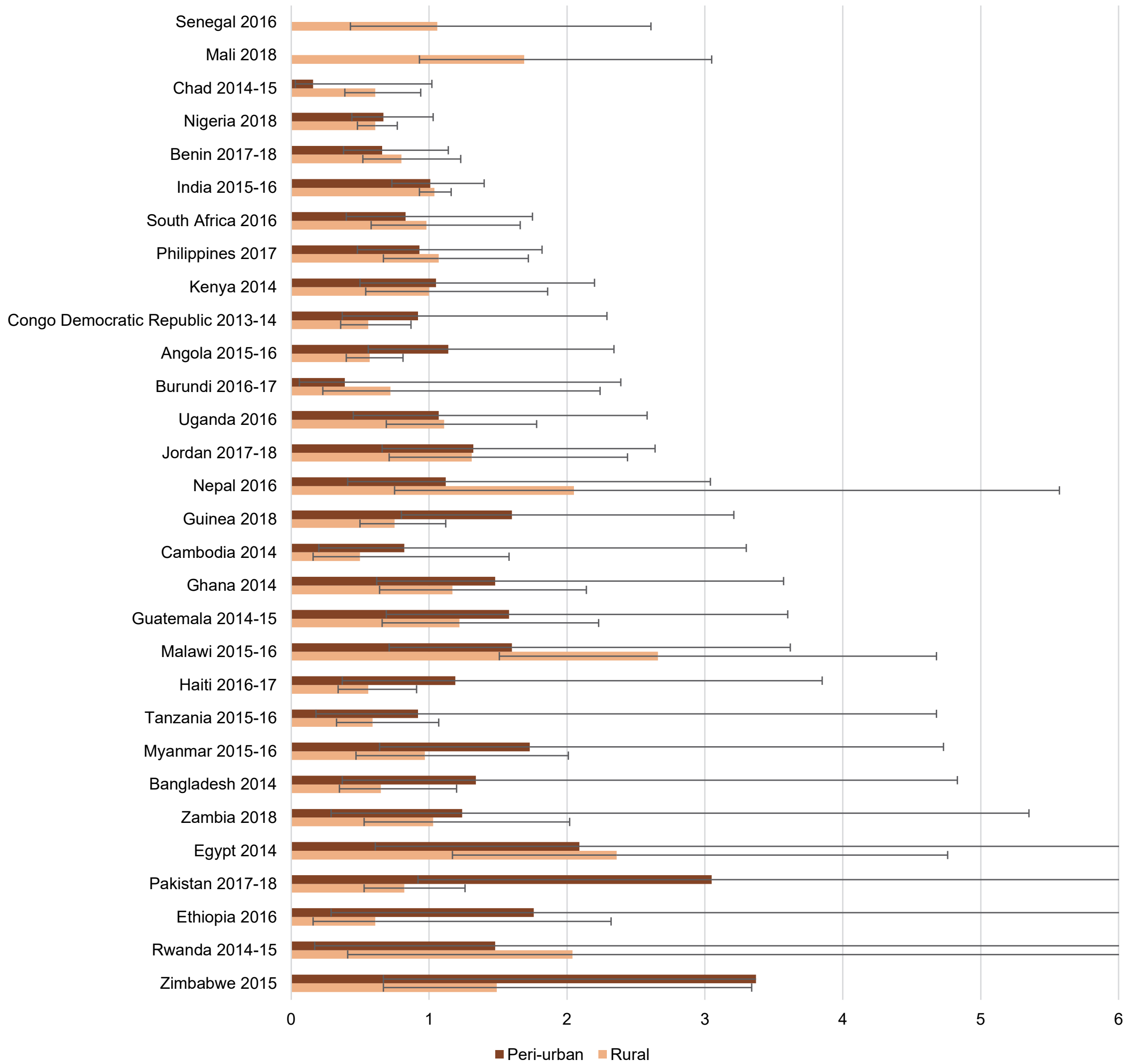
Figure 41 summarizes the results of the adjusted logistic regression for the urban poor cluster variable and DPT3 in children age 12-23 months. Children who reside in urban poor clusters in the DRC, Angola, India, and Nepal had lower odds of DPT3 compared to children from urban non-poor clusters. The largest differences were found in the DRC, where children in urban poor clusters had 73% lower odds and rural children 80% lower odds of DPT3 compared to the urban non-poor. In Pakistan, children living in urban poor clusters had 2.8 times higher odds of DPT3 compared to urban non-poor, although there was no significant difference found for rural children. Significant differences in DPT3 between the urban poor and urban non-poor were detected in five surveys, and in eight surveys between rural and urban non-poor. Figure 42 shows that there were no significant differences in DPT3 between children living in peri-urban clusters and urban centers for all the surveys in the analysis. Seven surveys showed a significant difference in DPT3 between rural children and children living in urban centers. Of interest was the higher odds of DPT3 found for children living in rural areas in Egypt and Malawi compared to the urban centers (more than twice the odds in both surveys).

Figure 41 Adjusted odds ratios for the urban poor cluster variable (reference: urban non-poor) and DPT3 in 30 DHS surveys



Note: Bangladesh and South Africa had upper bounds that did not fit in the above figure. Please see Appendix Table 10.

Figure 42 **Adjusted odds ratios for the SMOD variable (reference: urban centers) and DPT3 in 30 DHS surveys**



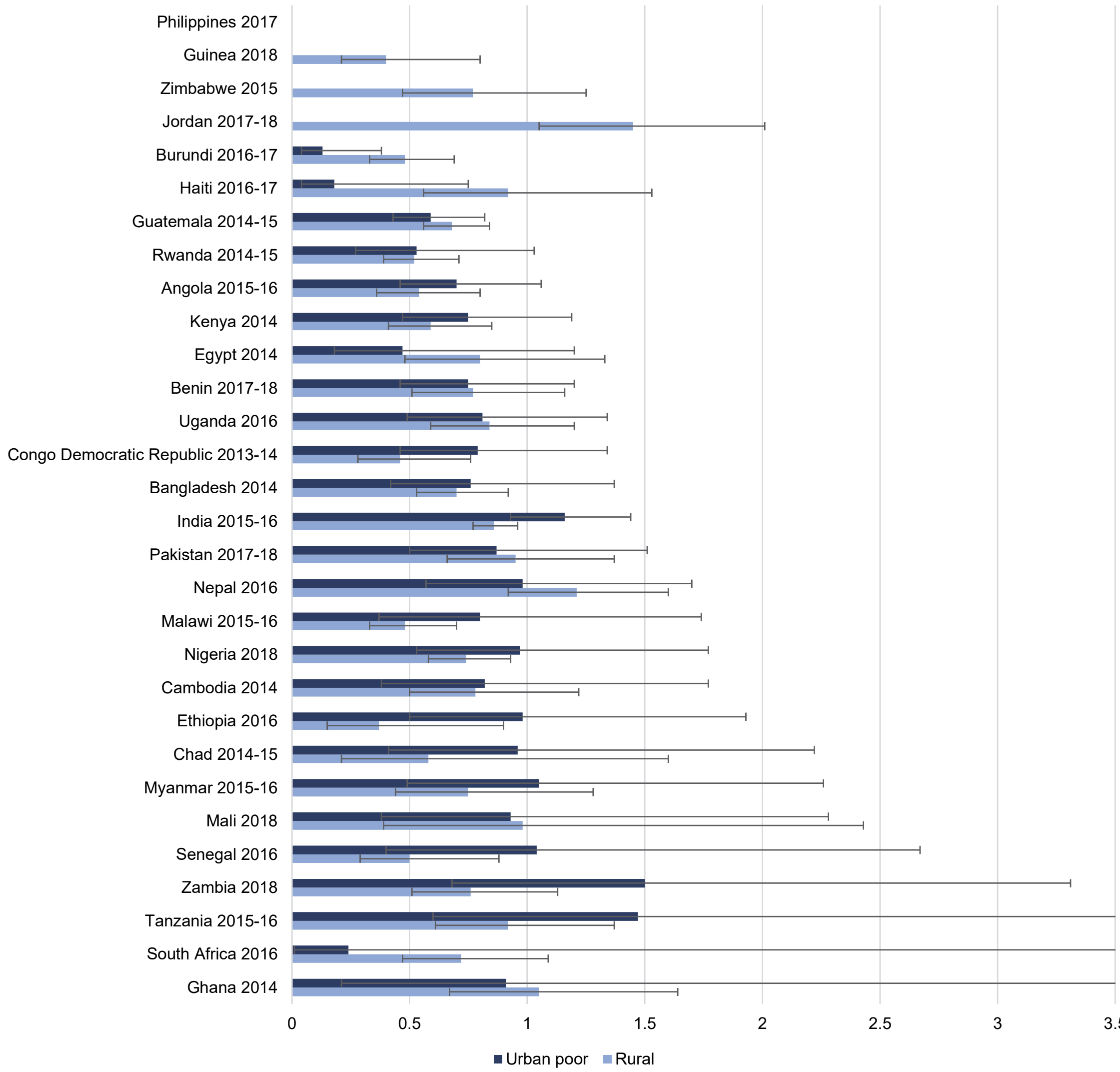
Note: Egypt, Pakistan, Ethiopia, Rwanda, and Zimbabwe had upper bounds that did not fit in the above figure. Please see Appendix Table 10.

3.8.4 Minimum acceptable diet

Figure 43 summarizes the results of the adjusted logistic regression for the urban poverty cluster and MAD in children age 6-23 months. In the Philippines, data were not collected on feeding practices for young children that are needed to compute this indicator. The results show that in Burundi, Haiti, and Guatemala, children living in urban poor clusters had lower odds of MAD compared to children in urban non-poor clusters. For Burundi and Guatemala, the odds of MAD were also lower for rural compared to urban non-poor children. In Haiti and Burundi, the differences were relatively large, with more than 80% lower odds of MAD for children living in urban poor clusters compared to urban non-poor in both surveys. In Burundi, this difference was larger than the difference between rural and urban non-poor children; rural children had approximately 50% lower odds of MAD compared to urban non-poor. In Haiti, there was no significant difference in MAD between the rural and urban non-poor children.

Significant differences in MAD between the urban poor and urban non-poor were detected in three surveys, and in 14 surveys between rural and urban non-poor.

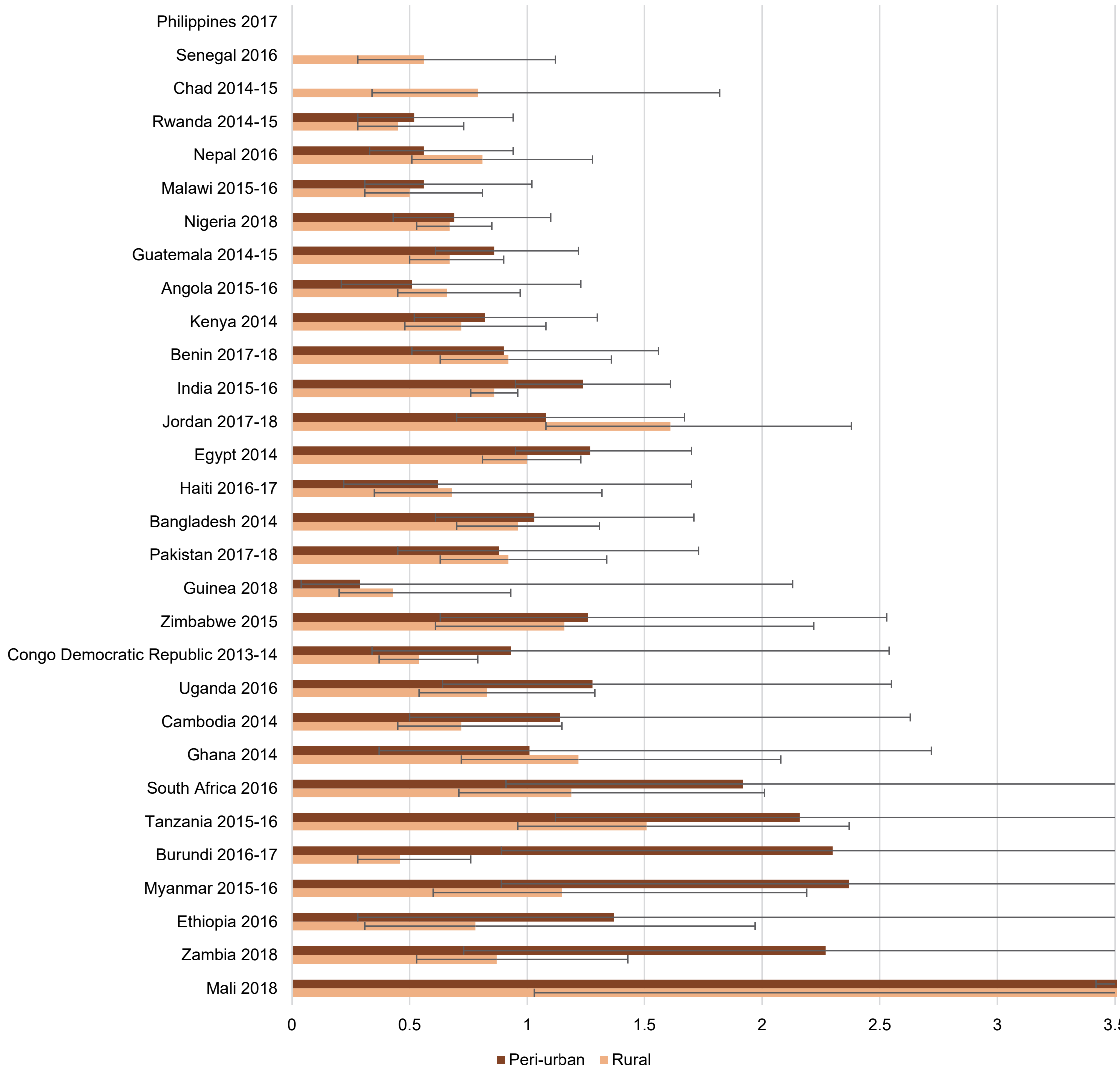
Figure 43 Adjusted odds ratios for the urban poor cluster variable (reference: urban non-poor) and MAD in 30 DHS surveys



Note: Tanzania, South Africa, and Ghana had upper bounds that did not fit in the above figure. Please see Appendix Table 11.

Figure 44 shows that only Rwanda had lower odds of MAD for children living in peri-urban clusters compared to urban centers. In addition, the odds ratio was similar to the odds ratio for rural children (approximately 50% lower odds of MAD for both categories). In Tanzania and Mali, there were higher odds of MAD for children living in peri-urban areas compared to the urban centers. In Mali, since the confidence interval was very wide due to the small sample size, the figure should be interpreted with caution. In Mali, rural children also had higher odds of MAD compared to urban centers, while there was no significant difference in MAD between rural children and children in urban centers in Tanzania. Significant differences in MAD between the peri-urban and urban centers were detected in three surveys, and in 11 surveys between rural and urban centers.

Figure 44 **Adjusted odds ratios for the SMOD variable (reference: urban centers) and MAD in 30 DHS surveys**



Note: Several countries had upper bounds that did not fit in the above figure. For Mali, the adjusted odds ratio for rural areas was 4.5 and for peri-urban it was 16.5. Please see Appendix Table 11. This indicator was not available for the Philippines.

DISCUSSION AND CONCLUSION

The world's population continues to grow, with two-thirds estimated to be living in urban areas by 2050, and even more rapid growth anticipated to take place in LMICs (Cyril, Oldroyd, and Renzaho 2013; DESA 2018; World Health Organization and UN-Habitat 2016). To date, numerous studies have sought to understand how the *process* of urbanization or the *impact* of living in urban areas, or urbanicity, affect various populations. However, many of these studies rely on the dichotomous urban/rural residence variable to convey the complex changes and conditions of environments.

In this study, we examine several measures of urbanicity through a 30-country analysis of DHS data that focused on indicators related to the health behavior and service provision outcomes of women and children in LMICs. Health indicators assessed were mCPR; mothers who presented for at least four ANC visits for their most recent birth; children who have completed three doses of the DPT vaccine; and children who have received the minimum acceptable diet. In addition to an analysis of the dichotomous urban/rural residence variable, we evaluate indicators with more nuance—considering country-specific context and including measures to gauge urban poor clusters, SMOD, and luminosity levels of nightlights. In our analysis of India, we also assessed a country-specific slum variable. Among the 30 countries in our study, we conducted a more in-depth analysis in six of these countries, and fit unadjusted and adjusted logistic regression models to evaluate the associations between the urbanicity indicators and health (and in some cases, service provision) outcomes. One aim of this in-depth analysis was to understand whether, and to what extent, associations were due to controls such as the woman's educational level or the region of residence.

We used urbanicity variables beyond the two-category urban/rural variable, and ascertained that rural areas generally have worse health outcomes, compared to their urban area counterparts. Moreover, inter-urban differentials are noteworthy. We detected differences between peri-urban and urban centers, as well as those between urban poor and urban non-poor areas. In Haiti and Burundi, the differences were notable—and worse in the urban poor category in terms of receiving the minimum acceptable diet. More specifically, there was an 80% reduction in the odds of children receiving the minimum acceptable diet among those in urban poor clusters compared to their urban non-poor counterparts. Across the urbanicity indicators, we found that the urban poor cluster classification or urbanicity exhibited the strongest statistical evidence of association with the health indicators, followed by SMOD, and the nightlights variable. Through an analysis of a number of urbanicity indicators in terms of health, one aim of this study was to assess whether, and to what extent, the needs of people living in varying types of environments can be better addressed.

As expected, health outcomes were better in the more highly urban areas and non-poor settings. A key finding of our study was how country-specific they were, with some countries exhibiting large significant differences in health outcomes in favor of those living in urban non-poor or urban centers. This meant that health was more improved in these areas. Based on the urban poor cluster and slum indicator in our analysis of India data, children living in urban poor clusters and in urban slums had significantly lower odds of completing three doses of the DPT immunization in both the unadjusted and adjusted models, compared to the urban non-poor and urban non-slums, respectively. Overarching patterns were difficult to determine because the indicators depended heavily on the health system's infrastructure of each country.

More specifically, our study examined health service provision indicators (specifically mCPR and ANC4), because these services may be more likely to be provided in urban areas as a whole. This is different from focusing on health indicators such as respiratory disease where inter-urban disparities may exist more prominently (Vlahov and Galea 2002). This also aligns with previous research that found access to and utilization of health services to be predictive of positive health outcomes such as lower rates of infant and child mortality and hypertension (Cyril, Oldroyd, and Renzaho 2013; Harttgen and Misselhorn 2006; Kyu et al. 2013; Vorster 2002). Our findings may not be related to population density or poverty. Rather, we posit that the availability and access to health services in urban versus rural areas are important for most countries in our analysis.

Some of our findings were more unexpected in terms of peri-urban and rural areas that we assumed would have worse health outcomes. Interestingly, and in contrast to what we might expect about better health service outcomes in more urban areas, we found statistical evidence in a few countries for better health service provision outcomes in the peri-urban areas. In Chad, for example, women who lived in peri-urban areas had nearly 2.6 times greater odds of having at least four ANC visits compared to women in the urban center areas, while rural women had approximately 50% lower odds of four ANC visits compared to their urban center counterparts. These findings may reflect decentralization efforts in countries like Chad, as well as enhanced policies and programming that were targeted to certain disadvantaged areas. Interestingly, we observed better outcomes in rural areas compared to urban areas in addition to the better outcomes observed in peri-urban areas. Children living in Indian slums also have almost twice the odds of receiving MAD compared to children living in urban non-slums. Previous research describes outreach efforts for reaching vulnerable populations of slum dwellers by delivering health services and education to areas where the residents live. More specifically, outreach that involves residents of slums as partners in redressing issues of inequity and disempowerment from living in slums has been important (Unger and Riley 2007).

Based on the literature and our in-depth analyses, we learned that socioeconomic factors could be more predictive of better health outcomes than the urbanicity indicators that reflect a more macro-level approach. When comparing the unadjusted and adjusted logistic regression models, we find that urbanicity variables lost significance after adding controls, such as attending at least four ANC visits in India. It could be that slum dwellers are socioeconomically disadvantaged, but are not necessarily less educated (Kyu et al. 2013), and therefore women are performing their ANC visits regardless of whether or not they live in slums. Kyu et al. (2013) studied the role of household wealth and maternal education in the maternal use of ANC services as a means to alleviate the harmful effects associated with living in a slum. It is important to consider and understand contextual and compositional effects of living in slums and their associations with child health outcomes. Relatedly, levels of maternal education and household wealth in this study were lower among peri-urban residents than their urban resident counterparts. This calls for the need to investigate and account for socioeconomic factors when examining urbanicity (Jones, Acharya, and Galway 2016).

Although this study extends our knowledge of gradients of urban environments and their relationships with health-related outcomes, there are limitations to our analyses. First, the nightlights variable performed poorly as an indicator that assessed the relationship between urbanicity and health outcomes. The manner in which the nightlights variable was categorized did not adequately capture differences, and it is possible that the measure does not capture differences in levels of urbanicity in these settings.

Furthermore, when comparing the highest nightlights (greater than 10) category with the other indicators that sought to measure the most densely populated areas, this particular category did not appear to align with corresponding categories in the other urbanicity indicators that denote the highest levels of urbanicity. The nightlights variable may have been limited by the small number of observations with high levels of luminosity in the countries that were analyzed. Other methods could have been used to categorize the nightlights variable; however, these methods would be country specific and not suitable for cross-country comparisons.

A second limitation of our study was sample size, particularly with the MAD and DPT3 health indicators and some other categories of the urbanicity variables. As a result, several odds ratios were automatically omitted from regressions because of an insufficient number of observations. A third limitation of this study is related to the displacement procedures followed by the DHS. Specifically, urban clusters are displaced by up to 2 km. Given that one of our main exposure variables was focused on urban area locations, this displacement may have potentially weakened the associations in our analyses. Similarly, displacement of these geolocated areas may increase the difficulty in identifying slums, including finding agreement in India between the urban poor cluster variable and the country-specific slum variable. Fourth, another possible limitation involved using data from 2015 for SMOD and nightlights when the DHS data were collected at different time periods. Given that urbanicity refers to the *impact* of living in urban areas at a given time (Cyril, Oldroyd, and Renzaho 2013; Vlahov and Galea 2002), it is possible that there is a temporal issue with possible rapid changes in development that we are unable to fully capture and adjust for at this time. The final possible limitation is in the construction of the urban poverty cluster variable. The place of residence variable available in the DHS data was used to identify rural and urban clusters as a first step in coding this variable. However, place of residence is determined by the statistical agency and usually using the most recent census for the country. This information may be out of date, and some rural clusters, for example, may have become urban clusters over time. This may cause some misclassification of clusters as rural or urban.

To our knowledge, this is the first time that DHS data has been used to examine the role of urbanicity on health and service provision outcomes through the use of the urban poor cluster variable and other urbanicity indicators. This study examines health outcomes in relation to more commonly used indicators such as the dichotomous urban/rural residence variable as well as less frequently used indicators such as SMOD. Based on our multi-country analyses, we suggest that more research is needed to further examine why some countries showed strong statistical evidence of association between gradients of urbanicity and their health outcomes. We hypothesize that more health services are required in the urban poor cluster or peri-urban areas based on our study's findings. For example, in countries such as Angola and India, the urban poor category had lower odds of modern contraceptive uptake, at least 4 ANC visits, and receiving the required number of DPT immunizations among children, compared to their urban non-poor counterparts. These key findings add to the current literature that suggests the importance of focusing on this urban poor subgroup (Crocker-Buque et al. 2017; Menon, Ruel, and Morris 2000; Pörtner and Su 2018), chiefly in terms of health facility-based interventions that we examined. Finally, we suggest that more research be conducted to examine the relationship between urbanicity variables and health indicators that are not related to service provision. This could help to explain the effect of the urban environment on the physical health of individuals.

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APPENDIX

Appendix Table 1 Description of urbanicity variables among all interviewed women age 15-49 for Bangladesh 2014 DHS, DRC 2013-14 DHS, India 2015-16 DHS, Kenya 2014 DHS, Nigeria 2018 DHS, and Senegal 2016 DHS

	Bangladesh 2014		DRC 2013-14		India 2015-16	
Variable	% [C.I.]	N	% [C.I.]	N	% [C.I.]	N
Place of residence						
Rural	71.7 [69.4,73.9]	11,696	61.6 [57.6,65.5]	12,000	65.4 [65.0,65.8]	494,951
Urban	28.3 [26.1,30.6]	6,167	38.4 [34.5,42.4]	6,827	34.6 [34.2,35.0]	204,735
SMOD						
Rural	65.3 [60.9,69.4]	12,081	64.7 [60.3,68.8]	12,070	68.8 [68.3,69.4]	540,371
Peri-urban	4.9 [3.2,7.5]	727	3.6 [1.9,6.9]	611	3.0 [2.7,3.3]	20,855
Urban centers	29.8 [26.0,33.9]	5,022	31.7 [27.8,35.8]	4,718	28.2 [27.6,28.7]	135,271
Nightlights						
Median [min, max]	0.3 [0,23.2]	17,830	0 [0,36.8]	17,399	0.8 [0,106.2]	696,497
0-1	72.6 [68.7,76.3]	12,862	70.5 [65.5,75.0]	14,424	56.7 [56.1,57.3]	443,444
2-10	18.6 [15.2,22.6]	3,872	8.7 [5.6,13.3]	1,162	25.3 [24.6,25.9]	177,879
>10	8.7 [6.9,11.0]	1,129	20.8 [16.8,25.6]	3,241	18.1 [17.5,18.6]	78,363
Urban poor cluster						
Rural	71.7 [69.4,73.9]	11,696	61.6 [57.6,65.5]	12,000	65.4 [65.0,65.8]	494,951
Urban poor	2.5 [1.5,4.1]	641	16.5 [13.3,20.3]	3,433	3.1 [2.8,3.3]	23,605
Urban non-poor	25.8 [23.4,28.3]	5,526	21.9 [18.1,26.2]	3,394	31.6 [31.1,32.0]	181,130
Slum variable for India						
Rural	-	-	-	-	65.4 [65.0,65.8]	494,951
Slum	-	-	-	-	1.6 [1.4,1.9]	5,201
Non-slum	-	-	-	-	33.0 [32.6,33.4]	199,534

	Kenya 2014		Nigeria 2018		Senegal 2016	
Variable	% [C.I.]	N	% [C.I.]	N	% [C.I.]	N
Place of residence						
Rural	59.2 [57.6,60.7]	19,465	54.2 [52.4,56.0]	24,837	50.9 [47.8,54.0]	5,578
Urban	40.8 [39.3,42.4]	11,614	45.8 [44.0,47.6]	16,984	49.1 [46.0,52.2]	3,287
SMOD						
Rural	54.9 [52.2,57.5]	19,946	61.4 [58.9,63.9]	27,423	59.1 [54.8,63.3]	6,882
Peri-urban	22.5 [20.2,25.0]	7,192	4.9 [3.7,6.5]	1,988	0.2 [00.0,1.6]	42
Urban centers	22.6 [20.6,24.7]	3,778	33.7 [31.0,36.4]	11,442	40.7 [36.5,45.0]	1,941
Nightlights						
Median [min, max]	0.1 [0,51.2]	30,916	0.1 [0,36.4]	40,853	0.9 [0,40.7]	8,865
0-1	71.8 [69.7,73.8]	25,634	69.0 [66.2,71.7]	30,800	50.9 [45.7,56.0]	6,502
2-10	14.1 [12.1,16.5]	3,826	19.5 [17.1,22.1]	7,396	30.4 [22.4,39.9]	1,964
>10	14.0 [12.4,15.9]	1,619	11.5 [9.3,14.2]	3,625	18.7 [13.0,26.2]	399
Urban poor cluster						
Rural	59.2 [57.6,60.7]	19,465	54.2 [52.4,56.0]	24,837	50.9 [47.8,54.0]	5,578
Urban poor	17.9 [15.9,20.1]	6,804	7.6 [5.6,10.2]	2,989	2.6 [1.7,4.0]	586
Urban non-poor	22.9 [20.5,25.6]	4,810	38.2 [36.0,40.5]	13,995	46.5 [43.1,49.9]	2,701
Slum variable for India						
Rural	-	-	-	-	-	-
Slum	-	-	-	-	-	-
Non-slum	-	-	-	-	-	-

Appendix Table 2 Unadjusted and adjusted odds ratios of the urbanicity variables with health outcomes in Bangladesh 2014 DHS

	Modern contraceptive use		At least four ANC visits		Three doses of DPT vaccine		Minimum acceptable diet	
Variable	UOR [C.I.]	AOR [C.I.]	UOR [C.I.]	AOR [C.I.]	UOR [C.I.]	AOR [C.I.]	UOR [C.I.]	AOR [C.I.]
Place of residence								
Rural	0.89* [0.8,0.98]	0.87* [0.78,0.98]	0.39*** [0.31,0.51]	0.45*** [0.35,0.57]	0.65 [0.38,1.11]	0.89 [0.51,1.54]	0.65** [0.5,0.84]	0.71* [0.55,0.93]
Urban	1	1	1	1	1	1	1	1
SMOD								
Rural	0.95 [0.84,1.08]	0.87 [0.75,1.01]	0.48*** [0.36,0.63]	0.5*** [0.37,0.67]	0.54* [0.31,0.95]	0.65 [0.35,1.2]	0.92 [0.7,1.22]	0.96 [0.7,1.31]
Peri-urban	0.84 [0.68,1.03]	0.88 [0.71,1.09]	0.67 [0.39,1.15]	0.75 [0.46,1.23]	1.2 [0.35,4.11]	1.34 [0.37,4.83]	0.96 [0.56,1.62]	1.03 [0.61,1.71]
Urban centers	1	1	1	1	1	1	1	1
Nightlights								
0-1	0.88 [0.74,1.05]	0.81* [0.67,0.98]	0.34*** [0.2,0.6]	0.37*** [0.21,0.64]	0.5 [0.22,1.16]	0.74 [0.31,1.78]	0.63 [0.4,1.01]	0.59* [0.36,0.96]
2-10	1.04 [0.85,1.28]	0.96 [0.78,1.19]	0.76 [0.42,1.38]	0.69 [0.39,1.22]	0.84 [0.33,2.14]	0.95 [0.36,2.49]	0.68 [0.41,1.13]	0.57* [0.35,0.94]
>10	1	1	1	1	1	1	1	1
Urban poor cluster								
Rural	0.89* [0.8,0.99]	0.89 [0.79,1]	0.36*** [0.28,0.47]	0.42*** [0.33,0.55]	0.66 [0.37,1.15]	1.02 [0.58,1.79]	0.62*** [0.47,0.81]	0.7* [0.53,0.92]
Urban poor	1.02 [0.8,1.29]	1.19 [0.87,1.63]	0.42*** [0.26,0.67]	0.61* [0.38,0.98]	1.15 [0.32,4.19]	2.72 [0.61,12.12]	0.59 [0.34,1.04]	0.76 [0.42,1.37]
Urban non-poor	1	1	1	1	1	1	1	1

Note: *p<0.05, **p<0.01, ***p<0.001

Appendix Table 3 Unadjusted and adjusted odds ratios of the urbanicity variables with health outcomes in DRC 2013-14 DHS

	Modern contraceptive use		At least four ANC visits		Three doses of DPT vaccine		Minimum acceptable diet	
Variable	UOR [C.I.]	AOR [C.I.]	UOR [C.I.]	AOR [C.I.]	UOR [C.I.]	AOR [C.I.]	UOR [C.I.]	AOR [C.I.]
Place of residence								
Rural	0.28*** [0.21,0.38]	0.37*** [0.27,0.5]	0.5*** [0.42,0.6]	0.69*** [0.56,0.84]	0.41*** [0.31,0.54]	0.52*** [0.37,0.72]	0.53** [0.37,0.76]	0.54** [0.37,0.8]
Urban	1	1	1	1	1	1	1	1
SMOD								
Rural	0.33*** [0.25,0.44]	0.44*** [0.3,0.65]	0.43*** [0.35,0.52]	0.61*** [0.48,0.79]	0.39*** [0.29,0.53]	0.56* [0.36,0.87]	0.54** [0.36,0.81]	0.54** [0.37,0.79]
Peri-urban	1.18 [0.58,2.37]	1.06 [0.57,1.98]	0.43*** [0.28,0.68]	0.53** [0.34,0.85]	0.73 [0.27,1.96]	0.92 [0.37,2.29]	1.33 [0.62,2.84]	0.93 [0.34,2.54]
Urban centers	1	1	1	1	1	1	1	1
Nightlights								
0-1	0.62** [0.44,0.86]	0.94 [0.62,1.43]	0.53*** [0.44,0.66]	0.74* [0.59,0.93]	0.69 [0.43,1.09]	0.91 [0.53,1.56]	0.72 [0.46,1.11]	0.7 [0.39,1.25]
2-10	1.88** [1.22,2.9]	1.57 [0.97,2.55]	0.98 [0.65,1.49]	0.95 [0.65,1.4]	1.92* [1.04,3.53]	1.46 [0.68,3.12]	1.64 [0.8,3.35]	1.4 [0.61,3.2]
>10	1	1	1	1	1	1	1	1
Urban poor cluster								
Rural	0.23*** [0.17,0.31]	0.31*** [0.21,0.45]	0.33*** [0.26,0.42]	0.45*** [0.33,0.6]	0.18*** [0.12,0.26]	0.2*** [0.12,0.32]	0.49** [0.3,0.79]	0.46** [0.28,0.76]
Urban poor	0.62** [0.43,0.89]	0.76 [0.49,1.16]	0.46*** [0.36,0.59]	0.53*** [0.4,0.69]	0.25*** [0.16,0.37]	0.27*** [0.17,0.43]	0.85 [0.49,1.45]	0.79 [0.46,1.34]
Urban non-poor	1	1	1	1	1	1	1	1

Note: *p<0.05, **p<0.01, ***p<0.001

Appendix Table 4 Unadjusted and adjusted odds ratios of the urbanicity variables with health outcomes in India 2015-16 DHS

	Modern contraceptive use		At least four ANC visits		Three doses of DPT vaccine		Minimum acceptable diet	
Variable	**UOR [C.I.]**	**AOR [C.I.]**	**UOR [C.I.]**	**AOR [C.I.]**	**UOR [C.I.]**	**AOR [C.I.]**	**UOR [C.I.]**	**AOR [C.I.]**
Place of residence								
Rural	0.81*** [0.79,0.83]	0.87*** [0.85,0.9]	0.41*** [0.39,0.43]	0.66*** [0.62,0.71]	0.86** [0.79,0.94]	1.05 [0.96,1.15]	0.72*** [0.65,0.79]	0.84** [0.76,0.93]
Urban	1	1	1	1	1	1	1	1
SMOD								
Rural	0.78*** [0.75,0.8]	0.85*** [0.82,0.88]	0.37*** [0.34,0.39]	0.63*** [0.57,0.68]	0.8*** [0.72,0.89]	1.04 [0.93,1.16]	0.73*** [0.65,0.82]	0.86** [0.76,0.96]
Peri-urban	1.09 [0.99,1.2]	0.98 [0.89,1.08]	1.06 [0.88,1.27]	0.82 [0.67,1]	1.33 [0.99,1.79]	1.01 [0.73,1.4]	1.69*** [1.32,2.15]	1.24 [0.95,1.61]
Urban centers	1	1	1	1	1	1	1	1
Nightlights								
0-1	0.75*** [0.72,0.78]	0.78*** [0.74,0.81]	0.35*** [0.32,0.38]	0.56*** [0.49,0.63]	0.81** [0.7,0.93]	0.96 [0.83,1.12]	0.84* [0.71,0.98]	0.86 [0.73,1.01]
2-10	0.91*** [0.87,0.95]	0.91** [0.87,0.96]	0.55*** [0.5,0.61]	0.73*** [0.65,0.84]	1.08 [0.92,1.26]	1.15 [0.98,1.35]	0.98 [0.83,1.17]	0.89 [0.75,1.06]
>10	1	1	1	1	1	1	1	1
Urban poor cluster								
Rural	0.79*** [0.77,0.82]	0.86*** [0.83,0.89]	0.36*** [0.34,0.39]	0.63*** [0.58,0.68]	0.8*** [0.73,0.88]	1.01 [0.91,1.12]	0.71*** [0.64,0.79]	0.86** [0.77,0.96]
Urban poor	0.78*** [0.72,0.85]	0.82*** [0.75,0.89]	0.42*** [0.36,0.49]	0.68*** [0.58,0.79]	0.61*** [0.5,0.75]	0.77* [0.62,0.96]	0.96 [0.76,1.21]	1.16 [0.93,1.44]
Urban non-poor	1	1	1	1	1	1	1	1
Indian slums								
Rural	0.82*** [0.8,0.84]	0.87*** [0.84,0.9]	0.42*** [0.4,0.44]	0.67*** [0.63,0.72]	0.83*** [0.76,0.91]	1.03 [0.93,1.13]	0.73*** [0.66,0.8]	0.87** [0.79,0.96]
Urban slum	1.13 [0.98,1.31]	0.85 [0.71,1.02]	1.65** [1.24,2.19]	1.4 [0.99,1.96]	0.56* [0.35,0.9]	0.61* [0.38,0.98]	1.29 [0.82,2.03]	1.89* [1.11,3.22]
Urban non-slum	1	1	1	1	1	1	1	1

Note: *p<0.05, **p<0.01, ***p<0.001

Appendix Table 5 Unadjusted and adjusted odds ratios of the urbanicity variables with health outcomes in Kenya 2014 DHS

	Modern contraceptive use		At least four ANC visits		Three doses of DPT vaccine		Minimum acceptable diet	
Variable	**UOR [C.I.]**	**AOR [C.I.]**	**UOR [C.I.]**	**AOR [C.I.]**	**UOR [C.I.]**	**AOR [C.I.]**	**UOR [C.I.]**	**AOR [C.I.]**
Place of residence								
Rural	0.78*** [0.71,0.86]	0.81*** [0.74,0.89]	0.5*** [0.43,0.57]	0.69*** [0.6,0.8]	0.8 [0.57,1.13]	0.95 [0.66,1.35]	0.46*** [0.36,0.59]	0.69** [0.54,0.9]
Urban	1	1	1	1	1	1	1	1
SMOD								
Rural	0.75*** [0.65,0.87]	0.83* [0.71,0.96]	0.45*** [0.37,0.55]	0.7** [0.57,0.86]	0.84 [0.52,1.38]	1 [0.54,1.86]	0.43*** [0.31,0.6]	0.72 [0.48,1.08]
Peri-urban	1.15 [0.99,1.35]	0.94 [0.8,1.11]	0.48*** [0.38,0.6]	0.63*** [0.5,0.8]	1.18 [0.67,2.1]	1.05 [0.5,2.2]	0.55** [0.38,0.81]	0.82 [0.52,1.3]
Urban centers	1	1	1	1	1	1	1	1
Nightlights								
0-1	0.9 [0.75,1.09]	0.97 [0.76,1.23]	0.45*** [0.34,0.59]	0.67* [0.45,1]	0.86 [0.46,1.62]	0.56 [0.17,1.78]	0.4*** [0.26,0.62]	0.59 [0.35,1]
2-10	1.05 [0.84,1.3]	1.13 [0.89,1.43]	0.97 [0.71,1.33]	1.04 [0.69,1.56]	0.79 [0.36,1.75]	0.39 [0.12,1.26]	0.72 [0.42,1.22]	0.73 [0.43,1.25]
>10		1						
Urban poor cluster								
Rural	0.81** [0.71,0.92]	0.85* [0.73,0.98]	0.38*** [0.31,0.46]	0.57*** [0.46,0.71]	0.77 [0.47,1.27]	0.98 [0.58,1.67]	0.37*** [0.27,0.5]	0.59** [0.41,0.85]
Urban poor	1.07 [0.92,1.25]	1.07 [0.9,1.28]	0.59*** [0.47,0.73]	0.74* [0.58,0.94]	0.92 [0.49,1.72]	1.06 [0.56,1.98]	0.6* [0.4,0.91]	0.75 [0.47,1.19]
Urban non-poor	1	1	1	1	1	1	1	1

Note: *p<0.05, **p<0.01, ***p<0.001

Appendix Table 6 **Unadjusted and adjusted odds ratios of the urbanicity variables with health outcomes in Nigeria 2018 DHS**

	Modern contraceptive use		At least four ANC visits		Three doses of DPT vaccine		Minimum acceptable diet	
Variable	**UOR [C.I.]**	**AOR [C.I.]**	**UOR [C.I.]**	**AOR [C.I.]**	**UOR [C.I.]**	**AOR [C.I.]**	**UOR [C.I.]**	**AOR [C.I.]**
Place of residence								
Rural	0.38*** [0.33,0.43]	0.69*** [0.61,0.79]	0.32*** [0.28,0.36]	0.68*** [0.59,0.77]	0.29*** [0.24,0.35]	0.71*** [0.59,0.86]	0.54*** [0.44,0.66]	0.74** [0.6,0.92]
Urban	1	1	1	1	1	1	1	1
SMOD								
Rural	0.37*** [0.33,0.42]	0.72*** [0.62,0.83]	0.29*** [0.25,0.35]	0.71*** [0.61,0.82]	0.25*** [0.2,0.32]	0.61*** [0.48,0.77]	0.49*** [0.39,0.61]	0.67** [0.53,0.85]
Peri-urban	0.61** [0.46,0.82]	0.89 [0.69,1.15]	0.53*** [0.37,0.75]	1.04 [0.78,1.39]	0.37*** [0.24,0.58]	0.67 [0.44,1.03]	0.62* [0.39,1]	0.69 [0.43,1.1]
Urban centers	1	1	1	1	1	1	1	1
Nightlights								
0-1	0.41*** [0.34,0.49]	0.68*** [0.58,0.8]	0.52*** [0.41,0.68]	0.98 [0.76,1.25]	0.34*** [0.23,0.51]	0.53*** [0.37,0.75]	0.37*** [0.26,0.53]	0.43*** [0.31,0.6]
2-10	0.94 [0.77,1.14]	0.88 [0.74,1.04]	1.34 [0.98,1.83]	1.34* [1.01,1.77]	0.79 [0.49,1.26]	0.58** [0.39,0.87]	0.52** [0.34,0.79]	0.51** [0.34,0.76]
>10	1	1	1	1	1	1	1	1
Urban poor cluster								
Rural	0.34*** [0.3,0.38]	0.66*** [0.57,0.76]	0.27*** [0.24,0.31]	0.66*** [0.57,0.76]	0.25*** [0.21,0.31]	0.69*** [0.56,0.85]	0.52*** [0.43,0.63]	0.74* [0.58,0.93]
Urban poor	0.43*** [0.29,0.64]	0.70* [0.53,0.92]	0.51*** [0.38,0.67]	0.9 [0.67,1.2]	0.48** [0.27,0.83]	0.87 [0.53,1.44]	0.8 [0.45,1.42]	0.97 [0.53,1.77]
Urban non-poor	1	1	1	1	1	1	1	1

Note: *p<0.05, **p<0.01, ***p<0.001

Appendix Table 7 **Unadjusted and adjusted odds ratios of the urbanicity variables with health outcomes in Senegal 2016 DHS**

	Modern contraceptive use		At least four ANC visits		Three doses of DPT vaccine		Minimum acceptable diet	
Variable	**UOR [C.I.]**	**AOR [C.I.]**	**UOR [C.I.]**	**AOR [C.I.]**	**UOR [C.I.]**	**AOR [C.I.]**	**UOR [C.I.]**	**AOR [C.I.]**
Place of residence								
Rural	0.45*** [0.37,0.56]	0.59*** [0.47,0.75]	0.38*** [0.28,0.5]	0.69** [0.54,0.88]	0.44* [0.21,0.89]	0.95 [0.49,1.86]	0.52** [0.32,0.84]	0.5* [0.3,0.84]
Urban	1	1	1	1	1	1	1	1
SMOD								
Rural	0.43*** [0.35,0.54]	0.55*** [0.42,0.7]	0.33*** [0.24,0.46]	0.67** [0.52,0.87]	0.36* [0.14,0.92]	1.06 [0.43,2.61]	0.59 [0.34,1.04]	0.56 [0.28,1.12]
Peri-urban	0.72** [0.59,0.87]	0.82 [0.58,1.15]	0.81 [0.61,1.06]	1.15 [0.75,1.78]	-	-	-	-
Urban centers	1	1	1	1	1	1	1	1
Nightlights								
0-1	0.42*** [0.28,0.63]	0.53** [0.35,0.8]	0.25*** [0.14,0.44]	0.67 [0.32,1.36]	0.39 [0.09,1.73]	3.06 [0.53,17.82]	0.62 [0.26,1.47]	0.4 [0.11,1.45]
2-10	0.71 [0.46,1.08]	0.9 [0.64,1.26]	0.53* [0.29,0.99]	0.99 [0.5,1.94]	1.83 [0.36,9.44]	7.39* [1.49,36.58]	0.75 [0.28,1.99]	0.81 [0.24,2.68]
>10	1	1	1	1	1	1	1	1
Urban poor cluster								
Rural	0.44*** [0.36,0.55]	0.58*** [0.46,0.74]	0.37*** [0.28,0.5]	0.72* [0.56,0.92]	0.37* [0.16,0.84]	0.81 [0.4,1.65]	0.52* [0.32,0.86]	0.5* [0.29,0.88]
Urban poor	0.57* [0.36,0.91]	0.79 [0.5,1.24]	0.78 [0.46,1.33]	1.41 [0.79,2.51]	0.26* [0.07,0.89]	0.45 [0.11,1.86]	1.06 [0.42,2.69]	1.04 [0.4,2.67]
Urban non-poor	1	1	1	1	1	1	1	1

Note: *p<0.05, **p<0.01, ***p<0.001

Appendix Table 8 Adjusted odds ratios for modern contraceptive use

Country	Urban poor cluster (ref. urban non-poor)		SMOD (ref. urban centers)	
	Rural	Urban poor	Rural	Peri-urban
Angola 2015-16	0.17*** [0.1,0.3]	0.5*** [0.35,0.7]	0.4*** [0.29,0.57]	0.58 [0.3,1.12]
Bangladesh 2014	0.89 [0.79,1]	1.19 [0.87,1.63]	0.87 [0.75,1.01]	0.88 [0.71,1.09]
Benin 2017-18	0.62*** [0.5,0.77]	0.63** [0.47,0.82]	0.58*** [0.46,0.72]	0.65** [0.48,0.87]
Burundi 2016-17	0.65*** [0.53,0.78]	0.49*** [0.36,0.68]	0.63** [0.47,0.85]	1.2 [0.68,2.12]
Cambodia 2014	1.2* [1.04,1.39]	1.2 [0.92,1.58]	1.18 [0.95,1.47]	1.1 [0.82,1.48]
Chad 2014-15	0.72 [0.44,1.18]	1.53 [0.97,2.42]	0.54** [0.36,0.81]	0.87 [0.36,2.1]
Congo Democratic Republic 2013-14	0.31*** [0.21,0.45]	0.76 [0.49,1.16]	0.44*** [0.3,0.65]	1.06 [0.57,1.98]
Egypt 2014	0.7 [0.49,1.01]	0.49*** [0.34,0.71]	1.18** [1.04,1.34]	1.16* [1,1.33]
Ethiopia 2016	0.65 [0.39,1.08]	1.26 [0.79,1.99]	0.68 [0.39,1.19]	0.67 [0.26,1.71]
Ghana 2014	1.28* [1.04,1.59]	0.74 [0.41,1.33]	1.41* [1.09,1.84]	1.16 [0.73,1.85]
Guatemala 2014-15	0.69*** [0.61,0.78]	0.57*** [0.43,0.74]	0.73*** [0.62,0.86]	0.72** [0.59,0.88]
Guinea 2018	0.65* [0.44,0.98]	0.41 [0.13,1.31]	0.59* [0.38,0.9]	0.34* [0.12,0.98]
Haiti 2016-17	1.12 [0.85,1.47]	1.41 [0.98,2.02]	1.23 [0.95,1.59]	1.65 [0.84,3.26]
India 2015-16	0.86*** [0.83,0.89]	0.82*** [0.75,0.89]	0.85*** [0.82,0.88]	0.98 [0.89,1.08]
Jordan 2017-18	0.94 [0.78,1.12]	-	0.95 [0.81,1.13]	1.06 [0.84,1.32]
Kenya 2014	0.85* [0.73,0.98]	1.07 [0.9,1.28]	0.83* [0.71,0.96]	0.94 [0.8,1.11]
Malawi 2015-16	0.88 [0.76,1.01]	0.97 [0.65,1.45]	0.83* [0.69,0.99]	1.08 [0.87,1.35]
Mali 2018	0.66** [0.52,0.84]	0.58 [0.33,1]	0.84 [0.63,1.11]	1.1 [0.45,2.67]
Myanmar 2015-16	0.98 [0.82,1.17]	1.16 [0.89,1.52]	0.96 [0.82,1.12]	1 [0.69,1.46]
Nepal 2016	0.77** [0.66,0.91]	0.89 [0.65,1.22]	0.78* [0.63,0.97]	0.91 [0.71,1.17]
Nigeria 2018	0.66*** [0.57,0.76]	0.7* [0.53,0.92]	0.72*** [0.62,0.83]	0.89 [0.69,1.15]
Pakistan 2017-18	0.82* [0.7,0.96]	0.79 [0.52,1.21]	0.86* [0.74,0.99]	0.87 [0.59,1.28]
Philippines 2017	1.22* [1.05,1.42]	1.07 [0.7,1.64]	1.46*** [1.23,1.73]	1.22 [0.99,1.5]
Rwanda 2014-15	0.93 [0.76,1.14]	1.36 [0.89,2.09]	1.05 [0.79,1.39]	1.27 [0.91,1.79]
Senegal 2016	0.58*** [0.46,0.74]	0.79 [0.5,1.24]	0.55*** [0.42,0.7]	0.82 [0.58,1.15]
South Africa 2016	1.05 [0.85,1.29]	3.52* [1.1,11.28]	0.79 [0.61,1.02]	0.73 [0.51,1.05]
Tanzania 2015-16	0.75** [0.63,0.9]	0.38** [0.19,0.74]	0.72** [0.57,0.91]	0.9 [0.63,1.28]
Uganda 2016	0.71*** [0.6,0.84]	0.77* [0.6,0.99]	0.76** [0.63,0.93]	0.83 [0.55,1.24]
Zambia 2018	0.86* [0.75,0.99]	1.12 [0.91,1.39]	0.97 [0.83,1.14]	0.79 [0.47,1.33]
Zimbabwe 2015	0.91 [0.78,1.06]	-	0.84 [0.67,1.04]	0.85 [0.62,1.15]

Note: *p<0.05, **p<0.01, ***p<0.001

Appendix Table 9 Adjusted odds ratios for having at least four ANC visits

	Urban poor cluster (ref. urban non-poor)		SMOD (ref. urban centers)	
Country	**Rural**	**Urban poor**	**Rural**	**Peri-urban**
Angola 2015-16	0.47*** [0.38,0.58]	0.71** [0.55,0.92]	0.59*** [0.48,0.72]	0.81 [0.48,1.37]
Bangladesh 2014	0.42*** [0.33,0.55]	0.61* [0.38,0.98]	0.5*** [0.37,0.67]	0.75 [0.46,1.23]
Benin 2017-18	0.61*** [0.49,0.76]	0.66** [0.51,0.86]	0.59*** [0.45,0.77]	0.62** [0.46,0.85]
Burundi 2016-17	0.97 [0.8,1.18]	0.85 [0.55,1.32]	0.91 [0.71,1.16]	0.64* [0.45,0.9]
Cambodia 2014	0.86 [0.56,1.32]	0.97 [0.5,1.87]	0.81 [0.42,1.56]	1 [0.36,2.75]
Chad 2014-15	0.61* [0.4,0.91]	1.32 [0.9,1.95]	0.53*** [0.38,0.74]	2.58* [1.24,5.37]
Congo Democratic Republic 2013-14	0.45*** [0.33,0.6]	0.53*** [0.4,0.69]	0.61*** [0.48,0.79]	0.53** [0.34,0.85]
Egypt 2014	0.59 [0.28,1.25]	1.81* [1.1,2.99]	1.27 [0.99,1.63]	0.9 [0.62,1.3]
Ethiopia 2016	0.22*** [0.1,0.48]	0.47 [0.21,1.06]	0.21** [0.08,0.51]	0.33* [0.11,0.96]
Ghana 2014	0.55** [0.37,0.81]	0.46 [0.2,1.05]	0.35*** [0.21,0.59]	0.41** [0.21,0.77]
Guatemala 2014-15	1.08 [0.84,1.39]	1.64* [1.12,2.39]	1.16 [0.83,1.61]	1.12 [0.75,1.67]
Guinea 2018	0.49*** [0.37,0.63]	0.88 [0.45,1.72]	0.5*** [0.37,0.68]	1.08 [0.66,1.75]
Haiti 2016-17	0.46*** [0.33,0.64]	0.59 [0.31,1.11]	0.43** [0.27,0.69]	0.71 [0.28,1.81]
India 2015-16	0.63*** [0.58,0.68]	0.68*** [0.58,0.79]	0.63*** [0.57,0.68]	0.82 [0.67,1]
Jordan 2017-18	1.21 [0.79,1.83]	-	1.06 [0.67,1.67]	0.95 [0.55,1.64]
Kenya 2014	0.57*** [0.46,0.71]	0.74* [0.58,0.94]	0.7** [0.57,0.86]	0.63*** [0.5,0.8]
Malawi 2015-16	0.76* [0.6,0.95]	0.9 [0.4,2.02]	0.75 [0.55,1.01]	0.72 [0.52,1.02]
Mali 2018	0.43*** [0.33,0.55]	0.55 [0.3,1.02]	0.44*** [0.33,0.58]	1.35 [0.83,2.19]
Myanmar 2015-16	0.28*** [0.18,0.44]	0.58 [0.33,1.04]	0.35*** [0.19,0.62]	0.63 [0.29,1.36]
Nepal 2016	0.7* [0.5,0.98]	0.74 [0.45,1.2]	1.31 [0.64,2.69]	0.95 [0.46,1.95]
Nigeria 2018	0.66*** [0.57,0.76]	0.9 [0.67,1.2]	0.71*** [0.61,0.82]	1.04 [0.78,1.39]
Pakistan 2017-18	0.43*** [0.32,0.57]	0.4** [0.23,0.7]	0.43*** [0.32,0.56]	0.76 [0.47,1.24]
Philippines 2017	1.39 [0.99,1.96]	0.62 [0.22,1.73]	1.33 [0.9,1.98]	1.43 [0.82,2.49]
Rwanda 2014-15	0.98 [0.72,1.35]	1.36 [0.77,2.39]	0.98 [0.67,1.42]	0.83 [0.53,1.3]
Senegal 2016	0.72* [0.56,0.92]	1.41 [0.79,2.51]	0.67** [0.52,0.87]	1.15 [0.75,1.78]
South Africa 2016	1.05 [0.71,1.55]	0.28 [0.05,1.65]	0.96 [0.59,1.57]	1.1 [0.55,2.2]
Tanzania 2015-16	0.61*** [0.48,0.78]	0.88 [0.39,2.01]	0.62** [0.45,0.84]	0.75 [0.44,1.28]
Uganda 2016	0.94 [0.75,1.16]	1.37 [0.91,2.06]	1.24 [0.94,1.65]	1.02 [0.62,1.67]
Zambia 2018	1.18 [0.96,1.45]	0.68 [0.38,1.22]	1.18 [0.92,1.52]	1.28 [0.94,1.75]
Zimbabwe 2015	0.89 [0.67,1.16]	-	1.07 [0.66,1.74]	1.01 [0.61,1.68]

Note: *p<0.05, **p<0.01, ***p<0.001

Appendix Table 10 Adjusted odds ratios for having all three DPT vaccination doses

	Urban poor cluster (ref. urban non-poor)		SMOD (ref. urban centers)	
Country	Rural	Urban poor	Rural	Peri-urban
Angola 2015-16	0.37*** [0.25,0.55]	0.62* [0.43,0.9]	0.57** [0.4,0.81]	1.14 [0.56,2.34]
Bangladesh 2014	1.02 [0.58,1.79]	2.72 [0.61,12.12]	0.65 [0.35,1.2]	1.34 [0.37,4.83]
Benin 2017-18	0.79 [0.54,1.15]	0.92 [0.59,1.44]	0.8 [0.52,1.23]	0.66 [0.38,1.14]
Burundi 2016-17	1.41 [0.61,3.23]	0.63 [0.25,1.57]	0.72 [0.23,2.24]	0.39 [0.06,2.39]
Cambodia 2014	0.67 [0.31,1.44]	0.87 [0.28,2.71]	0.5 [0.16,1.58]	0.82 [0.2,3.3]
Chad 2014-15	0.73 [0.4,1.35]	1.05 [0.59,1.85]	0.61* [0.39,0.94]	0.16 [0.03,1.02]
Congo Democratic Republic 2013-14	0.2*** [0.12,0.32]	0.27*** [0.17,0.43]	0.56* [0.36,0.87]	0.92 [0.37,2.29]
Egypt 2014	0.23* [0.06,0.89]	-	2.36* [1.17,4.76]	2.09 [0.61,7.14]
Ethiopia 2016	0.59 [0.18,1.96]	1.06 [0.25,4.46]	0.61 [0.16,2.32]	1.76 [0.29,10.6]
Ghana 2014	1.61* [1.01,2.58]	1.97 [0.69,5.65]	1.17 [0.64,2.14]	1.48 [0.62,3.57]
Guatemala 2014-15	0.98 [0.65,1.48]	0.57 [0.28,1.2]	1.22 [0.66,2.23]	1.58 [0.69,3.6]
Guinea 2018	0.72 [0.48,1.09]	0.49 [0.22,1.12]	0.75 [0.5,1.12]	1.6 [0.8,3.21]
Haiti 2016-17	0.56** [0.36,0.86]	0.62 [0.33,1.17]	0.56* [0.34,0.91]	1.19 [0.37,3.85]
India 2015-16	1.01 [0.91,1.12]	0.77* [0.62,0.96]	1.04 [0.93,1.16]	1.01 [0.73,1.4]
Jordan 2017-18	1.35 [0.79,2.3]	-	1.31 [0.71,2.44]	1.32 [0.66,2.64]
Kenya 2014	0.98 [0.58,1.67]	1.06 [0.56,1.98]	1 [0.54,1.86]	1.05 [0.5,2.2]
Malawi 2015-16	2.26*** [1.47,3.47]	-	2.66** [1.51,4.68]	1.6 [0.71,3.62]
Mali 2018	0.93 [0.46,1.85]	1.79 [0.63,5.02]	1.69 [0.93,3.05]	-
Myanmar 2015-16	0.56 [0.29,1.08]	0.84 [0.4,1.77]	0.97 [0.47,2.01]	1.73 [0.64,4.73]
Nepal 2016	0.9 [0.56,1.46]	0.47* [0.22,0.97]	2.05 [0.75,5.57]	1.12 [0.41,3.04]
Nigeria 2018	0.69*** [0.56,0.85]	0.87 [0.53,1.44]	0.61*** [0.48,0.77]	0.67 [0.44,1.03]
Pakistan 2017-18	0.9 [0.59,1.38]	2.81** [1.35,5.82]	0.82 [0.53,1.26]	3.05 [0.92,10.04]
Philippines 2017	0.92 [0.6,1.41]	0.83 [0.34,2.01]	1.07 [0.67,1.72]	0.93 [0.48,1.82]
Rwanda 2014-15	1.4 [0.45,4.3]	-	2.04 [0.41,10.2]	1.48 [0.17,13.05]
Senegal 2016	0.81 [0.4,1.65]	0.45 [0.11,1.86]	1.06 [0.43,2.61]	-
South Africa 2016	1.02 [0.62,1.66]	5.72 [0.47,69.34]	0.98 [0.58,1.66]	0.83 [0.4,1.75]
Tanzania 2015-16	0.42** [0.24,0.72]	0.51 [0.17,1.52]	0.59 [0.33,1.07]	0.92 [0.18,4.68]
Uganda 2016	1.41 [0.98,2.04]	1.16 [0.67,2.03]	1.11 [0.69,1.78]	1.07 [0.45,2.58]
Zambia 2018	0.97 [0.54,1.73]	0.98 [0.34,2.79]	1.03 [0.53,2.02]	1.24 [0.29,5.35]
Zimbabwe 2015	1.17 [0.64,2.13]	-	1.49 [0.67,3.34]	3.37 [0.67,17]

Note: *p<0.05, **p<0.01, ***p<0.001

Appendix Table 11 Adjusted odds ratios for minimum acceptable diet

	Urban poor cluster (ref. urban non-poor)		SMOD (ref. urban centers)	
Country	Rural	Urban poor	Rural	Peri-urban
Angola 2015-16	0.54** [0.36,0.8]	0.7 [0.46,1.06]	0.66* [0.45,0.97]	0.51 [0.21,1.23]
Bangladesh 2014	0.7* [0.53,0.92]	0.76 [0.42,1.37]	0.96 [0.7,1.31]	1.03 [0.61,1.71]
Benin 2017-18	0.77 [0.51,1.16]	0.75 [0.46,1.2]	0.92 [0.63,1.36]	0.9 [0.51,1.56]
Burundi 2016-17	0.48*** [0.33,0.69]	0.13*** [0.04,0.38]	0.46** [0.28,0.76]	2.3 [0.89,5.95]
Cambodia 2014	0.78 [0.5,1.22]	0.82 [0.38,1.77]	0.72 [0.45,1.15]	1.14 [0.5,2.63]
Chad 2014-15	0.58 [0.21,1.6]	0.96 [0.41,2.22]	0.79 [0.34,1.82]	-
Congo Democratic Republic 2013-14	0.46** [0.28,0.76]	0.79 [0.46,1.34]	0.54** [0.37,0.79]	0.93 [0.34,2.54]
Egypt 2014	0.8 [0.48,1.33]	0.47 [0.18,1.2]	1 [0.81,1.23]	1.27 [0.95,1.7]
Ethiopia 2016	0.37* [0.15,0.9]	0.98 [0.5,1.93]	0.78 [0.31,1.97]	1.37 [0.28,6.84]
Ghana 2014	1.05 [0.67,1.64]	0.91 [0.21,4.05]	1.22 [0.72,2.08]	1.01 [0.37,2.72]
Guatemala 2014-15	0.68*** [0.56,0.84]	0.59** [0.43,0.82]	0.67** [0.5,0.9]	0.86 [0.61,1.22]
Guinea 2018	0.4** [0.21,0.8]	-	0.43* [0.2,0.93]	0.29 [0.04,2.13]
Haiti 2016-17	0.92 [0.56,1.53]	0.18* [0.04,0.75]	0.68 [0.35,1.32]	0.62 [0.22,1.7]
India 2015-16	0.86** [0.77,0.96]	1.16 [0.93,1.44]	0.86** [0.76,0.96]	1.24 [0.95,1.61]
Jordan 2017-18	1.45* [1.05,2.01]	-	1.61* [1.08,2.38]	1.08 [0.7,1.67]
Kenya 2014	0.59** [0.41,0.85]	0.75 [0.47,1.19]	0.72 [0.48,1.08]	0.82 [0.52,1.3]
Malawi 2015-16	0.48*** [0.33,0.7]	0.8 [0.37,1.74]	0.5** [0.31,0.81]	0.56 [0.31,1.02]
Mali 2018	0.98 [0.39,2.43]	0.93 [0.38,2.28]	4.53* [1.03,19.86]	16.48** [3.42,79.41]
Myanmar 2015-16	0.75 [0.44,1.28]	1.05 [0.49,2.26]	1.15 [0.6,2.19]	2.37 [0.89,6.28]
Nepal 2016	1.21 [0.92,1.6]	0.98 [0.57,1.7]	0.81 [0.51,1.28]	0.56* [0.33,0.94]
Nigeria 2018	0.74* [0.58,0.93]	0.97 [0.53,1.77]	0.67** [0.53,0.85]	0.69 [0.43,1.1]
Pakistan 2017-18	0.95 [0.66,1.37]	0.87 [0.5,1.51]	0.92 [0.63,1.34]	0.88 [0.45,1.73]
Philippines 2017	NA	NA	NA	NA
Rwanda 2014-15	0.52*** [0.39,0.71]	0.53 [0.27,1.03]	0.45** [0.28,0.73]	0.52* [0.28,0.94]
Senegal 2016	0.5* [0.29,0.88]	1.04 [0.4,2.67]	0.56 [0.28,1.12]	-
South Africa 2016	0.72 [0.47,1.09]	0.24 [0.01,3.93]	1.19 [0.71,2.01]	1.92 [0.91,4.08]
Tanzania 2015-16	0.92 [0.61,1.37]	1.47 [0.6,3.58]	1.51 [0.96,2.37]	2.16* [1.12,4.16]
Uganda 2016	0.84 [0.59,1.2]	0.81 [0.49,1.34]	0.83 [0.54,1.29]	1.28 [0.64,2.55]
Zambia 2018	0.76 [0.51,1.13]	1.5 [0.68,3.31]	0.87 [0.53,1.43]	2.27 [0.73,7.05]
Zimbabwe 2015	0.77 [0.47,1.25]	-	1.16 [0.61,2.22]	1.26 [0.63,2.53]

NA = Not available

Note: *p<0.05, **p<0.01, ***p<0.001