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.

Socio-economic equity in access to malaria prevention and treatment in Nigeria: temporal and geographic variations

Degree Project in Medicine

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Abbreviations

ACT - Artemisinin-based Combination Therapy

A. - Anopheles

CI – Confidence interval

DHS – Demographic Health Survey

EA – Enumeration Area (cluster)

FCT – Federal Capital Territory

IRS – Indoor Residual Spraying

ITN – Insecticide Treated Net

LGA – Local Government Area

LLIN – Long Lasting Insecticide-treated Net

MIS - Malaria Indicators Survey

NMEP – National Malarian Elimination Programme

OR – Odds Ratio

P. – Plasmodium

RBM – Roll Back Malaria

RDT – Rapid Diagnostic Test

SDG – Sustainable Development Goal

SMC – Seasonal Malaria Chemoprevention

USAID – United States Agency for International Development

WHO – World Health Organization

WMR – World Malaria Report

Abstract

Degree Project, Programme in Medicine

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Background: Malaria affects millions and kills over 400,000 people globally each year, two-thirds of whom are children under five years. The disease is concentrated in socio-economically vulnerable populations. Nigeria accounted for more than a quarter of the global malaria cases in 2019.

Aims: Analyse the socio-economic equity in coverage of malaria preventions and treatment among children under 5 years in Nigeria's 37 states, comparing the years 2008 to 2018.

Method: Data was obtained from open access Demographic Health Surveys implemented in 2008 and 2018. Socio-economic status was defined using principal component analysis of selected household assets to construct a wealth index. Coverage of malaria prevention and treatment interventions were compared between the poorest and least poor quintiles. A concentration index was used to calculate the distribution of inequality by intervention.

Results: Access to and use of insecticide-treated bed nets (ITNs) was more concentrated among rich in 2008 but slightly concentrated among poor in 2018, with the index closer to equality. In some states access and use of ITNs was still in favour of the wealthier household

in 2008 and 2018, despite malaria prevalence being generally concentrated in poorest households. The access to care for children under 5 years that had fever and those who got appropriate treatment was overall still concentrated among the rich, although fever prevalence was higher in poorer households.

Conclusions: The poor are the most vulnerable and the most exposed to malaria infection and disease. Despite some improvements in 2018 compared to 2008, inequity is still high in many states in access and use of malaria preventions and treatment. Further measures are needed to reduce this inequity with better targeting of interventions to the poorer households, including expansion of community level treatment of malaria.

Key words: malaria, socioeconomic, equity, Nigeria.

Background

Global malaria burden

Despite significant progress in reducing the burden of malaria in recent years, malaria still remains a major health problem, causing an estimated 229 million cases and 409000 deaths worldwide in 2019 (1). Countries in the African region bear the largest share of the disease burden, accounting for 94% of reported cases and deaths, with children and pregnant women being the most affected. It is worth noting that five countries (Nigeria, the Democratic Republic of Congo, Uganda, Niger and Mozambique) contribute to half of the world's malaria cases (1).

Malaria infection and transmission

Malaria is a parasitic infectious disease caused by protozoan parasites of the genus *Plasmodium*. There are five plasmodium species which cause malaria in humans. *Plasmodium (P.) falciparum, P. vivax, P. ovale, P. malariae and P. knowlesi* (2). *P. falciparum* and *P. vivax* pose the greatest threat (3). *P. falciparum* is found worldwide, mainly in tropical and subtropical areas (2). In 2019, *P. falciparum* accounted for 99.7% of the malaria cases in the WHO African Region. *P. vivax* is the predominant parasite in the American region (1).

Most commonly, malaria is transmitted by the bites of an infected female *Anopheles* mosquito. Of the 400 species of *Anopheles* mosquitoes, only 30 are of major importance as malaria vectors (4). Different species occur in different parts of the world, and the most efficient vector species prevalent in Africa are *Anopheles (A.) gambiae*, *A. arabiensis*, and *A. funestus* (5). Malaria can also be transmitted by blood transfusion, needle stick injury, and by congenital transmission from mother to child (6).

Malaria infection begins when an infected female *Anopheles* mosquito bites humans and injects sporozoites. The sporozoites travel through the bloodstream to the liver, where they invade hepatocytes and mature into tissue schizonts. The tissue schizonts replicate and produce thousands of merozoites that are released from the liver and infect human red blood cells. Some of these merozoites specialize into gametocytes, necessary for the reproductive cycle in the mosquito. In the mosquito, the gametocytes continue to develop and eventually produce sporozoites that migrate into the mosquito's salivary glands and subsequently reinfect humans. In the life cycle of *P. vivax* and *P. ovale*, some sporozoites may remain dormant in liver cells for months or years after initial infection via the bloodstream, during which time they cause no symptoms during this time. The dormant forms eventually mature into tissue schizonts that release infectious merozoites, leading to clinical relapse (7). Malarial symptoms correlate with the bursting of infected erythrocytes, releasing pyrogenic substances and causing both brief attacks and anemia. Anemia results from phagocytosis of erythrocytes in the spleen, bone marrow depression, and immunologic hemolysis (2).

Climatic factors and malaria transmission

Temperature, precipitation and humidity are the most important climatic factors that directly affect malaria transmission. Temperature affects the development of both malaria parasites and vectors. The parasite development in the mosquito takes about 10 days. This time increases as the temperature decreases and vice versa, though 27°C is the optimum. Temperature also affects the development of the mosquito larva, which develops faster at higher temperatures. The optimal temperature is 25-27 °C. Precipitation provides a place for the mosquito to fertilize and breed resulting in more persistent malaria transmission. Relative humidity affects the development of malaria parasites in *Anopheles* mosquitoes (8). Mean

monthly relative humidity of less than 60% shortens the life span of malaria vector mosquitoes, resulting in low malaria transmission rates. Humidity also influences the development of malaria parasites in Anopheles (9).

Clinical manifestations

Clinically, malaria can be classified as uncomplicated and severe malaria. Uncomplicated malaria is symptomatic malaria with parasitemia without signs of severity or evidence of vital organ dysfunction. The main clinical manifestations of uncomplicated malaria include fever, chills, rigors, headaches, and body pains. Others are nausea, vomiting, and joint weakness. Physical examination may reveal pallor and hepatosplenomegaly. Severe malaria refers to acute *P. falciparum* with signs of vital organ dysfunction. Clinical features include altered consciousness or coma, prostration, repeated convulsions, respiratory distress, circulatory collapse or shock, clinical jaundice, abnormal spontaneous bleeding and pulmonary oedema. Laboratory characteristics of severe malaria are hypoglycemia, metabolic acidosis, severe anemia, hemoglobinuria, hyperparasitemia, hyperlactatemia and renal impairment (10).

In a pregnant woman, malaria infection can lead to severe disease and death, and placental sequestration of the parasite which can lead to maternal anemia. Placental infection can also lead to poor fetal growth and low birthweight as well as being a major risk factor for perinatal, neonatal and infant mortality (11, 12)

Malaria interventions in malaria endemic countries

The key recommended malaria measures according to the WHO include adequate case management (early and prompt treatment with effective treatment) and the use of appropriate vector control measures, particularly the use of insecticide-treated nets (ITNs/LLINs) and

indoor residual spraying (IRS) (10). Other situation-specific interventions include intermittent preventive treatment for infants and pregnant women living in areas of moderate to high transmission, and seasonal malaria chemoprevention for children in areas of high seasonal transmission during the malaria season (10).

Malaria diagnosis and treatment

Clinical suspicion of malaria is mainly based on fever (≥37.5°C) or fever in the history in settings where exposure to infection may have occurred. A parasitological diagnosis is required to confirm the diagnosis of malaria. Two different types of parasitological tests are used, light microscopy and rapid diagnostic test (RDT). Treatment based on clinical suspicion alone should only be considered when a parasitological diagnosis is not accessible (10).

Currently, artemisinin-based combination therapies (ACTs) are recommended for the treatment of uncomplicated *P. falciparum* malaria (10). Artemisinin and its derivatives have a short half-life (1-3 hours) and would result in poor cure rates if used as monotherapy (13). Combination with another drug with a long half-life provides sustained antimalarial activity. Resulting in increased treatment efficacy and reduced selective resistance pressure (14). The currently recommended artemisinin-based combination therapies (ACTs) are given over three consecutive days to all malaria patients, except pregnant women in their first trimester (10). In the first trimester of pregnancy, quinine should be used instead of ACTs. ACTs are also effective against *P. vivax* (including chloroquine-resistant) and are recommended to all patients (except pregnant women in their first trimester). Chloroquine is treated chloroquine-sensitive *P. vivax* infections as well as *P. ovale* and *P. malariae* infections (10). Artesunate injectables (first option) or artemether injectables (second option) or quinine injectables (third option) are recommended for the treatment of severe malaria (15).

Vector control

ITNs and IRS are the recommended core vector control measures for all malaria-prone populations. ITNs are most effective where the malaria vectors bite predominantly at night. To achieve the desired effect, the population at risk of malaria infection should have access to ITNs and use the nets regularly. To increase access to ITNs, nets are distributed through a combination of channels: mass distribution of free nets through campaigns, antenatal care clinics, and the expanded programme on immunization. IRS consists of the application of residual insecticides to the interior surfaces of dwellings where many vector species of the *anopheline* mosquito tend to rest after taking a blood meal. IRS must be sprayed several times to achieve protection for the population. Supplementary vector control measures such as larviciding, topical repellents, insecticide-treated clothing are also recommended where optimal coverage with ITNs or IRS has been achieved (10).

Preventive treatment

In areas of moderate to high malaria transmission in Africa, WHO recommends that all pregnant women receive intermittent preventive treatment with sulfadoxine/pyrimethamine (16). Similarly, intermittent preventive treatment is recommended for infants (17). In areas of high seasonal malaria transmission in the Sahel subregion of Africa, seasonal malaria chemoprevention (SMC) with monthly amodiaquine+sulfadoxine/pyrimethamine is recommended for children under six years of age during transmission season (18).

Major global actions against malaria

The Director General of WHO launched the Roll Back Malaria (RBM) initiative in 1998 with the aim of coordinating global action against malaria and helping governments achieve their own targets for controlling the disease in their countries (19) RBM pledged to reduce malaria

deaths to 50% by 2010, which was endorsed by African heads of state at the Abuja submit in Nigeria, in 2000 (20). These leaders signed the Abuja Declaration to halve malaria mortality in Africa by implementing effective malaria interventions and ensuring that at least 60% of the continent's population at-risk is protected or treated with appropriate methods (21).
The Global Fund, an international multistakeholder organization, was established in 2002 with the aim of raising, managing, and investing additional resources to combat AIDS, tuberculosis and malaria. Such resources enabled low-income countries to intensify malaria control efforts and achieve their goal of reducing the burden of malaria (22).

In 2015, the WHO developed the *WHO Global Technical Strategy for Malaria 2016–2030* to accelerate the work towards to control and eliminate malaria (23). The strategy sets targets to reduce global malaria incidence and mortality by at least 90% by 2030 and to achieve malaria elimination in at least 35 countries by 2030. To achieve these targets, the WHO has formed a strategy consisting of three main pillars. The first pillar is about enable access to prevention, diagnosis and treatment for malaria to all people, including vector control and prompt treatment once diagnosis is confirmed. The second pillar is that all countries need to increase their efforts in eliminating malaria. Finally, the third pillar is that further research should be conducted to find new or more effective ways to eliminate malaria. One of the main principles that the work is based upon is that equity should be achieved. It is utterly important that the most vulnerable and people living far off have the same access health facilities as others (23).
The Global Technical Strategy was developed in close alignment with the RBM Partnership's *Action and Investment to defeat Malaria 2016-2030 – for a malaria-free world* to ensure common goals and complementarity. The aims of the evidence-based medicine plan include mobilizing resources; strengthening multisectoral and intercountry collaboration; putting

people at the center of the response; strengthening enabling environments, and fostering and sharing innovations and solutions, and facilitating change (24).

In 2000, the United Nations set eight Millennium Development Goals to be achieved by 2015. Four of these goals are directly related to health: #4-Reduce child mortality, #5-Improve maternal health and #6-Combat HIV/AIDS, malaria and other diseases. Children and pregnant women are the most affected population groups and, therefore, gains in malaria control impacts positively child and maternal mortality (25). In 2015, the United Nations General Assembly set 17 Sustainable Development Goals (SDGs) to be achieved by 2030. Ensuring healthy lives and promoting well-being at all ages (SDG #3) and reduce inequality (SDG #10) are essential for sustainable development (26).

Socioeconomic equity and malaria

Most of the malaria disease burden occur in the poorest countries, especially in sub-Saharan Africa (1), where poverty has been shown to hinder further economic development (27, 28). Socioeconomic inequalities are defined as inequalities related to differences in income and wealth index, social class, occupational background, and educational attainment. In 2001, Gallup and Sachs analyzed the relationship between malaria and the level and growth of per capita income for the period 1965–1995 (29). Taking into account historical, geographical, social, economic, and institutional country characteristics, they found that countries per capita income in countries without malaria was 70% lower than in countrieswithout malaria, and that a decline in malaria incidence was associated with an increase in per capita income growth rates (29). Analysis of more recent data covering the period 2000–2017 also showed that a decline in malaria incidence was associated with an increase in per capita income (30). These results may be explained by the fact that healthier people are more beneficial at work, learn

more at school, making it easier for people to earn and save money. Poor people are also the ones who are most likely to contract malaria (30) and carry a higher burden of disease compared to richer people (31). Poor people also have to spend a larger proportion of their income on treatment and access to health care, which reduces their chances of getting out of poverty (32). Laboratory-confirmed malaria cases and wealth quintiles have been used to assess the association between socioeconomic status and malaria infection in children and the general population. A recent systematic review and meta-analysis showed that lack of education, low income, low wealth index, and living in poorly constructed houses, were associated with increased risk of Plasmodium infection among people in sub Saharan Africa (31). Understanding the relationship between household socioeconomic status and inequality in access to and use of malaria interventions is critical to mitigating constraining factors in the delivery of these interventions and improving the performance of the national malaria programme to meet national targets. Inequality is often assessed by socioeconomic status measured in asset-based wealth quintiles, residence, gender, age, and ethnicity (33).

Nigeria

Demographic and socio-economic status

Nigeria is located in West Africa and borders Benin to the west, Chad to the northeast, Niger to the north, Cameroon to the east and Atlantic Ocean in the south (34). Administratively, the country is divided into 37 states (34) with 215 million inhabitants (35) of many ethnic groups with different cultures. Over 40% of the population are below 15 years of age (36). The average years of schooling was 6.8 in 2019. In 2019, neonatal diseases, malaria and diarrheal diseases were the top three causes of most deaths and disabilities in Nigeria. Mortality rate in children under five was 102 children per 1000 live births in 2019 (35). In 2017, $78 per

person was spent on health, of which $60 dollars was out-of-pocket expenditure. GDP was $448 billion US dollars in 2019. Nigeria is the biggest exporter of oil in Africa. Oil is accounting for 80 % of Nigeria's exports, followed by agriculture. As a result of the COVID-19 pandemic, global oil prices have fallen massively in 2020 significantly impacting on Nigeria's economy. Unemployment rates in the country exceed 8%. Prior to the pandemic, 40% of Nigeria's population were estimated to below the poverty line, while additional 25% of the population were at risk of falling into poverty, due to COVID-19 (36).

Malaria risk and response

The climate in Nigeria varies between dry in the north with a rainy season between June and September and humid in the south with a rainy season between March and November. The peak of malaria usually correlates with the rainy seasons. In recent years, rainfall has increased leading to increased flooding, especially in regions Niger Delta and communities near rivers (34). In a study conducted in Nigeria the prevalence of malaria was higher within a radius of 4 km to an open water source. The places in Nigeria with the highest malaria prevalence were areas in the Niger Delta and the junction between Niger and Benue (37). Malaria is a major cause of illness and death in Nigeria causing nearly 61 million cases, 27% of global malaria cases in 2019, and 95418 deaths, 25% of global malaria deaths (1). The burden of disease varies widely by geography, gender and age (38, 39), with pregnant women and young children being the most affected and 13 densely populated states accounting for 42 percent of the country's malaria prevalence in 2015 (34). Furthermore, malaria prevalence was highest in rural areas and among the lowest socio-economic group in 2015 (34). The efforts to eliminate malaria in Nigeria were at first only made through sporadic and pointwise attempts to distribute nets. Later, realising this was not effective enough, an understanding

grew that a coordinated strategy was needed to win the battle against malaria (40). The national malaria elimination programme (NMEP) in Nigeria set a goal to distribute 63 million LLINs and reach at least 80% utilization of these between 2009 and 2013 and planned and coordinated this. At least 58 million of these LLINs were received by people through different campaigns (41). Next, Nigerian Strategic Plan 2014-2020 was made, formed out of the WHOs recommendation for national strategic plans. The Nigerian Strategic Plan calls for multiple prevention strategies including scaling up IRS, universal coverage of ITNs and strategic use of larval source management; use of the fist-line treatment, use of intermittent preventive treatment and seasonal malaria chemoprevention (SMC) and access to appropriate case management. The Objectives of the National Malaria Elimination Programme (NMEP) for this Strategic Plan are summarized in the box below (41).

Table 1 The goals of National Malaria Strategic plan 2014-2020

Goals of the Federal Ministry of Health, *National Malaria Strategic Plan 2014-2020*, 2014, Nigeria, page 33-34 (41)
1. That 80% of the targeted population uses suitable preventive measures before 2020.
2. People seeking care where one can suspect malaria should all be tested for malaria infection before 2020.
3. All people that have got tested positive for malaria should be treated with an effective antimalarial drug by 2020.
4. Distribute information to all Nigerians so 80% will know how to protect themselves from malaria and what treatment to use.
5. Ensure availability to care and to appropriate drugs and preventions mean by 2018.
6. That 80% of all health facilities report malaria cases consistently and data will be used to improve the malaria programme.

In addition to the goals above another important issue for NMEP is to fulfil these goals in equity. To achieve this Nigeria has increased their national government budget assigned for malaria control, and Nigeria also receives financial support from the Roll Back Malaria partners. Different private sectors in Nigeria have helped and have provided advertising that highlights the ACT treatment that follow the national guidelines. Committees in Nigeria are working to identify areas there the distribution and the strategy needs improvements. There in it has been noted that even although ACT availability has increased - the use of ACT for children under 5 years are still unacceptably low. (41).

Malaria commodities have become harder to distribute in 2020 and 2021 due to travel restrictions, while access to care has been reduced due to both the restrictions and fear of contracting COVID-19 at health facilities. In addition, as the pandemic reduces economic opportunities making people even more vulnerable, their ability to afford care has been disrupted (1).

Socio-economic equity in malaria prevention and treatment

As previously described, malaria is a major health issue in Nigeria (1). ITNs, SMC and prompt treatment of malaria with effective medication are the key interventions to fight malaria in Nigeria (41). Even though access to these interventions have improved during the last years, less than 50% of children under 5 years slept under a bed net in 2015, and most children with fever get treatment by the private sector where they have to pay for care (34). There have been different results in earlier studies regarding how socio-economic status impacted on the differences in malaria prevention and treatment. A study conducted in the southeast of Nigeria 2009 showed people with better socio-economic status and people living in the urban areas had self-reported higher incidence of malaria (27). The study participants also reported that it took, on average, two days between onset of symptoms and treatment seeking (42). Another study also conducted in Southeast Nigeria from 2009 although malaria constituted an important burden in all socio-economic groups self-reported incidence was higher in the poorest households. The poorest households also spent a bigger proportion of their financial income on the malaria preventions and treatment than the people with higher socio-economic status (43).

Despite the previous studies looking at the various aspects of socio-economic equity in access to malaria prevention and treatment, there has not been a national comparison, using

empirical data, of the changes in equity by state and time. One of WHO's and NMEP's main strategies to eliminate and reduce malaria includes to increase the populations access to ITNs, enable access to care and appropriate treatment. In addition, according to WHO and NMEP this should be done with a focus on equity so that the most vulnerable get reached. Children under 5 years are one of the vulnerable groups.

The purpose of this analysis is to help identify gaps in equity to help inform the response to malaria in Nigeria. This report will perform an analysis of changes in socio-economic inequity for children under 5 years in Nigeria and how it is presented related to access and use of ITNs, prevalence of fever, prevalence of malaria, treatment seeking, diagnosis and treatment. The analysis compares results from 37 states in Nigeria in 2008 before the start of the big scale up of malaria activities and 2018, ten years after significant investment in the fight against malaria.

Research questions

Considering the goals and strategies of WHO and NMEP, this report intends to answer the following research questions:

Firstly, is the access and use of malaria prevention equitable from a socioeconomic point of view? Secondly, is there a variation in access to ITNs among socio-economic-groups in the 37 different states of Nigeria? Thirdly, is there a variation in use of ITNs for children under 5 years, among socio-economic-groups in the 37 different states of Nigeria? Fourthly, is there a variation of access in care for children under 5 years with fever, among socio-economic-groups in the 37 different states of Nigeria? Fifthly, is there a variation of receiving ACT, appropriate treatment, for children under five years with fever among socio-economic-groups

in the 37 different states of Nigeria? Additionally, for all four questions: Has it changed from 2008 to 2018?

Material and method

Study area

Nigeria has 36 states plus the Federal Capital Territory (FCT). Each state is subdivided into Local Government Areas (LGAs), each LGA is subdivided into localities and lastly each locality is divided into census Enumeration Areas (EAs) also called clusters (44).

Surveys and sampling procedures

Demographic and Health Surveys (DHS) are nationally representative household surveys conducted every 5 years. The survey uses validated standard data collection tools to generate indictors for monitoring and impact evaluation in the areas of population, health, and nutrition. These data are for key public health stakeholders, including programme managers and policy makers to evaluate programme performance and take action to improve public health. The DHS sample is generally representative at national, residence (urban-rural), and regional/state/provincial levels. The DHS surveys use a mix of survey tools including questionnaires, biomarkers, geographic information, and demographic and socioeconomic characteristics of the population. Further details on these tools can be found at https://dhsprogram.com.

For this project work, data from the 2008 DHS (prior to the 2009 upscaling of net distribution) and the 2018 DHS (most recent survey) were used to examine changes over time. The 2008 Nigerian DHS was conducted between June and October, while the 2018 DHS was conducted five years later (August to December 2018). Both the DHS 2008 and 2018

were based on similar sampling approaches and survey instruments. A stratified two-stage cluster design was used: selecting sample of EAs from the national census data (1st stage), and then a sample of households from each EA (2nd stage). The sampling frame used was generated from the 2006 National Population and Housing Census of Nigeria. The sample design began with distinguishing which areas were urban and which were rural (44, 45). An urban area was defined as a locality containing a population of 20,000 people or more (44).

For the 2008 DHS, 888 EAs (602 rural and 286 urban), were selected. Using equal probability systematic sampling, an average of 41 households per EA were selected, distributing households in the sample proportionally to the actual urban and rural proportions. Some houses were unoccupied and the response rate of the occupied households was 98% and finally 34,070 households were successfully surveyed (45). For the 2018 DHS survey, a total of 1400 EAs were selected and 41668 households (approximately about 30 households per EA) were selected. Of these, 40666 were occupied, of which 40427 (99% response rate) were successfully surveyed. There were security problems especially in Borno State, where only 16 of the selected 27 LGAs were successfully surveyed (44).

The DHS 2008 contained three different questionnaires: the Household Questionnaire, the Women's Questionnaire and the Men's Questionnaire (45). Likewise, the DHS 2018 had the same three questionnaires with some upgrades and in addition the Biomarker Questionnaire. To begin with, the Household Questionnaire purpose is to map the living situation, the education level, different kind of assets as running water, type of toilet and access and use of malaria nets. Moreover, the Woman's Questionnaire (asked to women between 15 and 49 years) was getting information about the education level of the women, if intermittent

preventive treatment in pregnancy was used during the latest pregnancy, questions about their knowledge and use of preventive means and treatment against malaria for themselves and for their children. In the absence of a child's mother, available adults aged 15-49 years and related at the time of surveys were considered to be guardians. Lastly the Biomarker Questionnaire included testing of the children under 5 years to see if they were infected with malaria or if they had anemia.

Selection of variable for analysis

The variables extracted from the 2008 and 2018 DHS data and their definitions are described below.

1. Malaria-related variables

1.1. ITN access: mean household access to ITNs of all households were defined through the number of ITN per household divided by the potential users of ITNs in the same household.

1.2. ITN use: proportion of children under five years that slept under an ITN the night before the survey.

1.3. Access to care: proportion of children under five years with fever in the last two weeks who sought any care for their fever (government health facility, private medical health facility/pharmacy or other sectors).

1.4. Access to ACT: proportions of children under five years with fever the last two weeks who got ACT among the children who got any antimalarial treatment. (Since ACT is the standard treatment for *P. falciparum* malaria according to WHO guidelines (10).)

1.5. Malaria parasite prevalence: proportion of children aged 6–59 months with malaria parasites confirmed by RDT. This variable was only available in the 2018 DHS.

2. Sociodemographic and economic variables

Data on age, gender, number of rooms used for sleeping, children under 5 years in the household and education of the mother and household head were extracted. The wealth index was constructed through principal component analysis (PCA) and the asset index contained information on household living conditions and assets such as drinking water, toilet facilities, radio, television, mobile phone, fridge, and car, housing materials (floor, roof and walls), cooking materials were extracted (40). The wealth index was determined by scoring each household based on its assets. Each household was given a composite score and each resident in that household received the same index. The survey population was then divided into five quintiles: quintile one (lowest-poorest) to quintile five (highest-wealthiest). Details can be accessed at DHS guide (46). Slightly more variables were used in the PCA index for 2018 than 2008 (47, 48).

3. Geographic variables

Information on states and place of residence (urban or rural) was also extracted.

The data for this work can be accessed on the DHS website. Available at: https://dhsprogram.com/data/dataset/Nigeria_Standard-DHS_2008.cfm?flag=1; https://dhsprogram.com/data/dataset/Nigeria_Standard-DHS_2018.cfm?flag=1.

Statistical methods

The analysis was done using a stepwise approach. First, a descriptive analysis was undertaken to summate the key survey variable by state and overall. These variables were at household and individual levels. The relevant data from the different questionnaires were merged into one file for each year using STATA version 16.1. SVYSET command was used to adjust for

the sampling units and weights and to take account to unequal probabilities. One weight was used regarding household level variables and another regarding the children or the mother on individual level. Strata was set due to the stratification in the data collection. An analysis of difference in proportions, using command SVY to get confidence intervals (CIs) (95%), was implemented in Stata comparing 2008 and 2018 DHS. Non-overlapping CIs showed statistical significance. However, it was not possible to use the SVY command calculating the outcome ACT treatment due to small sampling size. Therefore, regular binomial confidence intervals were calculated for that outcome instead.

Wealth index was as previous described in the method already computed in the DHS material through PCA. Further information on socio-economic differences was received through calculating Concentration Indices with STATA. Concentration index was used to compare if there were any inequality comparing people from the poorer households with people in the richer households with each of the four outcomes. Wealth index was used to calculate the concentration index with each of the four outcomes to see if the malaria preventions or treatment was equal distributed or if it was used more by either the poorer or the richer. The concentration index ranges between -1 to 1. Zero will indicate that there is complete equality in distribution. A negative number indicates that the outcome is more concentrated among the poor ones while a positive number will suggest that the outcome is concentrated more among the richer people (49).

Concentration (Lorenz's) curves for each outcome was also constructed. A 45-degree line indicates perfect equality. If the concentration curve is over the straight 45-degree line it will measure that the outcome is more concentrated among poorer people (which is from here on

described as “pro-poor”). If the concentration curve is under the 45 degree line it will mean that the outcome is more concentrated among the richer people (which is from here on described as “pro-rich”) (49). The CONINDEX-function in Stata was used to compute both concentration indices and construct the concentration curves for 2008 and 2018. The confidence interval was calculated using the robust standard error that were received in the calculation of concentration index. Lower CI 95% = Concentration index - (robust standard error) * 1.96. Upper CI 95% = Concentration index + (robust standard error) * 1.96 (50).

Ethics

The data for the project was taken from DHS open access survey data (though a registration process was needed to get access to the raw data). The surveys have already received ethical approval from relevant national review boards and have been put online with agreement of the Nigeria government. All information on households and individual respondents have been anonymized. The participants were informed about the survey and that the participation was voluntary (51). All children that tested positive for malaria and did not show any signs for severe malaria were offered ACT by a nurse that belonged to the field team (44). Children with signs of severe malaria were referred to a health care facility (51).

Results

A total of 34,070 and 40,427 households were successfully surveyed in 2008 and 2018 DHS surveys respectively. The 2008 DHS data contained 28,647 under-five children compared to 33,924 children in 2018 survey. Table 2 presents the under-five children reported of having fever during the preceding two weeks at national level, with 13,8% and 22.2%.

Tabell 2 Children under five years reported of having fever during the preceding two weeks prior to the surveys.

History of fever	DHS 2008		DHS 2018	
	No.	%	No.	%
Fever 2 weeks preceding the survey	3,965	13.8%	7,536	22.2%
NO fever 2 weeks preceding the survey	24,682	86.2%	26,338	77.6%
Total	28,647	100	33,924	100
Percentages shown in this table are unweighted and will differ slightly from those shown in subsequent sections				

Key variables for the children under five years by state and residence for 2008 and 2018 surveys are summarized in Table 3. The proportion of children with fever during the two weeks preceding the survey had a significant change in 24 states from 2008 to 2018 (the 95% CI did not overlap). Five states had a decrease in proportion and 19 states had an increase. At national level proportion of under-five children with history of fewer was significantly higher in 2018 survey compared to the 2008 one. Children in Yobe and Bauchi had the highest proportion of self-reported fever in 2018. Nationally, the proportion of self-reported fever was 24.6% in 2018 compared to 16.4% in 2008. At national level, the parasite prevalence among the tested children 6-59 months was 36.2% in 2018. The states with the highest parasite prevalence were Kebbi (76.7%), Katsina (55.4%), Osun (54.9%) and Sokoto (54.7%), all of them had populations with over 80% living in rural areas except for Osun there only 24.4% lived in urban areas. In contrast, the more urbanized states of Lagos (3.4%), Imo (15.6%) and Anambra (15.2%) had the lowest parasite prevalence. These states had less than 35% of the population living in rural areas as illustrated in Table 3. Children in rural areas had a significantly higher parasite prevalence (47.2% CI: 45.4-48.9) than the children in urban areas (22.3% CI: 19.8-24.9).

Table 3 History of fever and test positivity rate among children below five years by residence and state, 2008 and 2018 DHS surveys.

	Female %		Rural %		Had fever in the last two weeks % (95% CI)		Parasite prevalence % (95% CI)
State	2008	2018	2008	2018	2008	2018	2018
Sokoto	51.1	51.4	89.0	83.0	**10.0 (8.3-11.9)***	**33.3 (31.1-35.7)***	54.7 (48.3-60.9)
Zamfara	46.5	49.1	90.2	74.0	16.7 (14.5-19.2)	14.2 (11.5-17.3)	51.8 (45.3-58.1)
Katsina	50.2	49.7	83.9	81.1	**19.7 (18.2-21.4)***	**29.5 (26.7-32.6)***	55.3 (48.9-61.5)
Jigawa	50.1	50.9	93.2	88.0	**14.4 (12.5-16.7)***	**34.1 (30.9-37.4)***	49.4 (42.3-56.6)

Yobe	49.1	48.8	69.5	78.6	**13.6 (11.6-15.9)***	**44.6 (39.6-49.7)***	29.9 (25.0-35.4)
Borno	52.0	48.8	68.8	50.6	**22.9 (21.0-24.8)***	**16.4 (14.3-18.6)***	16.0 (11.3-22.3)
Adamawa	51.9	50.0	79.2	78.9	**12.3 (10.2-14.8)***	**28.4 (25.0-32.0)***	38.7 (30.7-47.2)
Gombe	48.1	48.8	78.7	79.5	**14.0 (11.4-17.0)***	**38.0 (34.8-41.3)***	51.8 (46.7-56.9)
Bauchi	48.5	50.6	72.3	87.6	**36.9 (34.5-39.3)***	**49.6 (47.0-52.2)***	48.6 (44.1-53.1)
Kano	51.3	47.8	76.1	61.8	**22.0 (19.8-24.3)***	**27.0 (24.8-29.3)***	43.0 (37.1-49.2)
Kaduna	48.1	48.1	69.7	64.0	**10.4 (8.3-13.0)***	**25.3 (22.2-28.8)***	34.3 (26.0-43.7)
Kebbi	47.8	49.4	81.3	86.5	**8.4 (6.6-10.7)***	**39.5 (36.4-42.8)***	76.8 (71.3-81.5)
Niger	45.7	49.6	80.7	78.0	**11.9 (9.2-15.1)***	**28.5 (25.6-31.6)***	43.8 (38.2-49.5)
FCT Abuja	51.0	52.5	33.1	35.6	**5.3 (3.7-7.4)***	**23.7 (20.4-27.5)***	31.3 (21.8-42.7)
Nasarawa	52.0	50.1	82.5	64.6	9.6 (7.5-12.2)	10.5 (8.3-13.2)	32.1 (25.0-40.1)
Plateau	48.3	52.9	78.5	76.2	**5.7 (4.8-6.7)***	**19.6 (16.9-22.7)***	37.2 (30.7-44.2)
Taraba	48.6	50.2	82.7	81.7	**20.9 (18.5-23.5)***	**29.5 (26.4-32.7)***	34.9 (30.5-39.6)
Benue	53.1	49.6	87.6	85.2	17.5 (15.3-20.0)	12.4 (9.5-16.0)	26.0 (21.9-30.6)
Kogi	45.1	48.3	62.6	61.4	**4.4 (2.3-8.2)***	**12.7 (9.9-16.1)***	46.0 (38.0-54.1)
Kwara	49.3	49.9	66.8	25.0	**7.1 (5.7-8.7)***	**11.9 (8.9-15.7)***	43.7 (37.3-50.3)
Oyo	50.4	47.7	59.2	20.7	6.6 (5.3-8.3)	7.0 (4.6-10.5)	33.9 (27.5-40.9)
Osun	46.5	47.0	33.2	24.4	9.4 (7.1-12.3)	14.3 (10.9-18.5)	54.9 (49.3-60.5)
Ekiti	45.5	51.4	62.0	20.4	15.9 (13.0-19.2)	19.0 (14.4-24.7)	46.5 (39.4-53.8)
Ondo	44.3	44.6	63.1	46.3	**7.7 (6.2-9.7)***	**13.4 (10.4-17.2)***	41.6 (34.8-48.8)
Edo	52.5	50.2	51.2	40.7	14.5 (12.1-17.3)	19.1 (14.5-24.7)	19.1 (13.4-26.3)
Anambra	48.9	49.5	18.3	13.5	11.7 (10.3-13.1)	13.9 (11.6-16.5)	15.2 (11.5-19.8)
Enugu	49.5	47.2	69.7	19.7	**28.4 (25.1-32.0)***	**15.0 (12.5-17.8)***	30.2 (24.7-36.3)
Ebonyi	49.1	49.7	70.0	15.2	31.3 (28.4-34.4)	32.7 (30.0-35.5)	49.2 (46.4-52.1)
Cross River	49.0	43.8	82.6	81.1	20.9 (19.0-22.9)	17.5 (14.1-21.5)	26.8 (22.4-31.8)
Akwa Ibom	49.3	50.3	90.5	93.3	**21.7 (17.7-26.3)***	**38.6 (35.3-42.0)***	34.0 (29.3-39.0)
Abia	53.4	49.3	50.8	84.2	**27.5 (21.7-34.3)***	**7.7 (6.4-9.3)***	20.7 (16.0-26.2)
Imo	45.2	47.4	79.7	33.3	26.0 (21.1-31.6)	27.7 (23.8-32.0)	15.7 (11.6-21.0)
Rivers	48.6	51.9	69.6	46.5	**31.2 (26.5-36.3)***	**42.5 (39.5-45.6)***	22.3 (16.4-29.7)
Bayelsa	49.4	47.6	74.5	67.3	**19.0 (17.0-21.2)***	**9.7 (7.7-12.2)***	30.1 (24.7-36.1)
Delta	45.8	46.0	67.2	46.8	**16.0 (11.3-22.2)***	**5.3 (3.4-8.3)***	24.9 (17.7-33.9)
Lagos	50.5	45.7	8.5	2.9	7.8 (6.0-9.9)	7.2 (4.8-10.6)	3.4 (1.5-7.5)
Ogun	52.0	50.0	79.4	56.1	7.7 (5.0-11.6)	5.1 (3.5-7.4)	32.2 (25.3-39.9)
Total	49.4	49.1	69.1	60.4	**16.4 (15.4-17.4)***	**24.6 (23.4-25.8)***	36.2 (34.2-38.2)

Malaria prevalence were only available from 2018. CI - confidence interval. *Significant difference between the years (non-overlapping 95% CIs)

Children in households with the lowest socioeconomic status have the highest rates of both self-reported fever and parasite prevalence while children with the highest socioeconomic status had the lowest rates (Table 4). However, self-reported fever was only significant different between the poorest and the richest quintiles in 2008. It can be seen that there was a significant change in reported fever between 2008 and 2018 in all wealth quintiles except the richest quintile.

Table 4. Proportions of under-five children reported of having fever during the last two weeks and percentage of children under five years tested positive on Rapid Diagnostics Test (RDT) for P. Falciparum.

Wealth quintile	Children under five years of age with fever in the last two weeks		Parasite prevalence
	2008 DHS % (95% CI)	2018 DHS % (95% CI)	2018 DHS % (95% CI)
Poorest	**18.2 (16.7-19.8)***	**32.9 (30.9-34.9)***	56.9 (54.1-59.6)
Poorer	**17.5 (16.0-19.2)***	**28.9 (27.4-30.4)***	50.3 (47.8-52.9)
Middle	**16.6 (15.4-17.9)***	**24.2 (22.8-25.7)***	38.5 (36.2-40.8)

Richer	**15.4 (14.0-16.8)***	**19.8 (18.2-21.6)***	26.0 (23.6-28.5)
Richest	13.2 (11.5-15.3)	14.5 (12.6-16.5)	10.8 (9.0-12.8)
Total	**16.3 (15.4-17.4)***	**24.6 (23.4-25.8)***	36.2 (34.2-38.2)
CI - confidence interval, *Significant difference between the years (non-overlapping 95% CIs)			

The malaria prevalence is highly concentrated among the children (age 6-59 months) in households with low socioeconomic status (Figure 1).

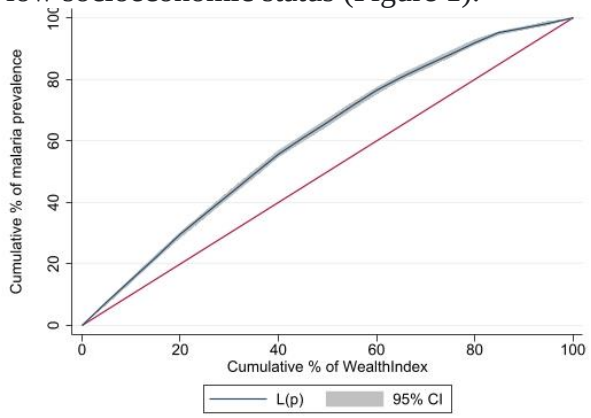


Figure 1 Concentration curve, national malaria prevalence in 2018. The red 45° line indicates total equality. A concentration curve above the red line indicates that the malaria prevalence is concentrated in the poorer households (and

As can be seen in Table 5, both access and use of ITNs increased significantly in all states and at national level from 2008 to 2018. At the national level, household access to ITNs in all ages was 4.8% in 2008 and increased significantly (non-overlapping 95% CI) to 47.5% in 2018. Similarly, a significant increase was observed in the use of ITNs among children under five years of age in 2018 compared to 2008 (Table 4). Katsina had the lowest access to ITNs in 2008 (0.8%) and was among the lowest in use of ITNs among children under 5 years (1.1%) and increased to those with highest access to ITNs (71.3%) and use of ITNs (72.5%) in 2018. Jigawa, on the other hand, was among the highest in both access and use in both 2008 and 2018. Lagos had a low increase in access to ITNs (5.9% to 20.9%) and ITN use (6.5% to 21.3%) and was the state with the lowest access and use of ITNs in 2018.

Table 5. ITN access and use by state.

	Mean household access to ITN % (95% CI)		Usage of ITN among children under 5 % (95% CI)	
State	2008	2018	2008	2018
Sokoto	**3.0 (2.5-3.4)***	**61.0 (57.6-64.4)***	**2.5 (1.9-3.3)***	**56.0 (51.1-60.8)***
Zamfara	**3.2 (2.9-3.5)***	**49.7 (47.3-52.2)***	**2.8 (2.3-3.5)***	**55.7 (51.5-59.9)***
Katsina	**0.8 (0.7-1.0)***	**71.3 (68.9-73.7)***	**1.1 (0.5-2.0)***	**72.5 (68.8-75.8)***

Jigawa	**12.2 (11.7-12.7)***	**86.1 (84.5-87.7)***	**11.3 (8.9-14.1)***	**89.1 (87.0-90.8)***
Yobe	**3.4 (2.9-3.)***	**53.2 (50.4-56.0)***	**2.0 (1.3-3.0)***	**59.9 (54.1-65.4)***
Borno	**1.8 (1.4-2.2)***	**42.2 (38.2-46.2)***	**1.1 (0.5-2.2)***	**49.2 (42.0-56.3)***
Adamawa	**2.3 (2.1-2.4)***	**45.2 (43.9-46.4)***	**2.1 (1.5-2.9)***	**46.8 (43.2-50.5)***
Gombe	**10.6 (10.2-11.1)***	**48.3 (45.7-50.8)***	**11.8 (10.4-13.3)***	**37.1 (32.8-41.4)***
Bauchi	**4.3 (4.0-4.5)***	**55.5 (52.5-58.4)***	**3.8 (2.7-5.3)***	**52.7 (48.5-57.0)***
Kano	**3.6 (3.2-4.0)***	**63.3 (61.7-65.0)***	**3.3 (2.7-4.1)***	**74.5 (71.2-77.5)***
Kaduna	**5.5 (5.4-5.7)***	**51.0 (48.1-53.9)***	**6.0 (5.0-7.2)***	**67.1 (62.2-71.6)***
Kebbi	**3.5 (3.2-3.7)***	**77.6 (75.6-79.6)***	**3.5 (2.6-4.7)***	**93.5 (90.9-95.4)***
Niger	**2.8 (2.6-3.1)***	**29.0 (27.3-30.8)***	**1.0 (0.5-1.7)***	**37.3 (32.6-42.4)***
Abuja	**6.3 (5.9-6.8)***	**24.4 (22.8-26.0)***	**7.8 (5.5-11.0)***	**35.4 (30.8-40.4)***
Nasarawa	**7.7 (7.0-8.4)***	**59.1 (56.4-61.7)***	**5.6 (4.6-6.9)***	**57.4 (51.6-63.1)***
Plateau	**6.4 (5.7-7.1)***	**31.8 (30.1-33.5)***	**8.0 (6.2-10.4)***	**45.0 (38.9-51.2)***
Taraba	**4.4 (4.1-4.6)***	**24.7 (23.6-25.9)***	**4.2 (3.1-5.5)***	**24.2 (20.6-28.1)***
Benue	**1.9 (1.7-2.0)***	**48.4 (47.2-49.6)***	**1.6 (1.2-2.2)***	**65.0 (59.2-70.4)***
Kogi	**2.5 (2.4-2.6)***	**55.5 (54.2-56.9)***	**2.6 (1.6-4.1)***	**53.2 (48.1-58.3)***
Kwara	**4.7 (3.9-5.4)***	**49.6 (47.2-52.0)***	**5.2 (4.0-6.6)***	**34.1 (29.9-38.5)***
Oyo	**1.6 (1.3-1.8)***	**39.0 (36.7-41.3)***	**2.1 (1.4-3.4)***	**41.7 (36.6-47.0)***
Osun	**1.1 (1.0-1.3)***	**32.7 (31.2-34.2)***	**1.7 (1.1-2.5)***	**32.4 (27.9-37.2)***
Ekiti	**7.7 (7.0-8.4)***	**31.4 (28.8-34.0)***	**12.9 (11.5-14.5)***	**26.4 (23.7-29.4)***
Ondo	**2.8 (2.5-3.1)***	**68.5 (67.2-69.7)***	**4.0 (2.6-6.1)***	**58.9 (52.8-64.7)***
Edo	**3.4 (3.1-3.7)***	**47.7 (46.3-49.1)***	**3.3 (2.1-5.1)***	**31.5 (25.2-38.5)***
Anambra	**9.0 (8.7-9.3)***	**25.0 (24.3-25.6)***	**12.2 (10.7-13.9)***	**25.4 (20.2-31.4)***
Enugu	**3.5 (3.4-3.6)***	**26.9 (25.5-28.3)***	**8.1 (6.1-10.9)***	**26.7 (23.6-30.1)***
Ebonyi	**9.0 (8.7-9.3)***	**58.3 (56.6-59.9)***	**12.9 (10.6-15.6)***	**68.0 (63.6-72.0)***
Cross River	**9.1 (8.8-9.5)***	**43.7 (39.3-48.0)***	**16.1 (13.4-19.2)***	**43.4 (38.9-48.0)***
Akwa Ibom	**8.4 (7.6-9.1)***	**48.0 (46.5-49.4)***	**13.5 (10.8-16.7)***	**36.5 (31.0-42.2)***
Abia	**2.2 (1.9-2.4)***	**32.2 (30.0-34.3)***	**3.4 (1.6-7.1)***	**23.9 (21.2-26.9)***
Imo	**8.5 (7.8-9.2)***	**45.1 (42.7-47.6)***	**14.2 (11.6-17.4)***	**29.7 (20.9-40.2)***
Rivers	**8.4 (8.0-8.9)***	**24.4 (21.9-26.9)***	**9.6 (7.6-12.1)***	**27.7 (24.7-30.9)***
Bayelsa	**4.8 (4.5-5.2)***	**32.4 (29.5-35.2)***	**8.1 (6.4-10.1)***	**32.7 (28.1-37.7)***
Delta	**3.7 (3.5-4.0)***	**29.2 (27.9-30.5)***	**5.7 (3.9-8.1)***	**36.5 (31.8-41.4)***
Lagos	**5.9 (5.4-6.3)***	**20.9 (20.2-21.6)***	**6.5 (5.0-8.3)***	**21.3 (18.1-24.8)***
Ogun	**3.8 (3.6-4.0)***	**44.2 (42.2-46.1)***	**5.1 (3.4-7.6)***	**49.3 (44.8-53.9)***
Total	**4.8 (4.5-5.1)***	**47.5 (45.6-49.3)***	**5.5 (5.0-6.0)***	**52.2 (50.2-54.2)***
CI - confidence interval, * statistical significance between the years (non-overlapping 95% CIs). ITN - Insecticide treated net				

Access to care for children under five years of age with fever in the last two weeks had a significant change at national level and also in 13 states between the years 2008 and 2018 (Table 6). Out of these 13 states, 5 states had a decrease while 8 states had an increase of care seeking. The proportion of children under 5 years who received ACT treatment (out of all who received antimalarial treatment) increased significantly from 2008 to 2018 in 24 states and also nationally. Zamfara and Narsawa were the states that had the lowest percentage in 2018 for both access to care and ACT-treatment. Zamfara 42.5% in access to care and 12.8% in ACT treatment while Narsawa with 47.4% in access to care and 0% in ACT-treatment. The

states with highest access to care were Anambra (97.4%) and Ogun (93.4%). The highest proportions of ACT-treatment were in Ebonyi (89.0%) and Kebbi (83%).

Table 6. Access to care and treatment with ACT by state.

	Access to care for children under 5 with fever the last 2 weeks % (95% CI)		ACT-treatment for children under 5 with fever the last two weeks % (95% CI-binomial)	
State	2008	2018	2008	2018
Sokoto	**39.1 (31.1-47.8)***	**73.2 (67.6-78.2)***	12.5 (3.5-29.0)	21.1 (14.3-29.4)
Zamfara	60.7 (52.1-68.6)	42.5 (33.3-52.4)	0 (0-15.4)	12.8 (4.3-27.4)
Katsina	**67.9 (64.2-71.3)***	**80.2 (75.0-84.5)***	**12.0 (5.9-21.0)***	**45.0 (38.0-52.2)***
Jigawa	78.4 (70.0-84.9)	83.4 (79.1-87.0)	**3.8 (0.1-19.6)***	**62.4 (55.3-69.1)***
Yobe	**71.2 (63.7-77.7)***	**83.8 (78.9-87.7)***	5.7 (0.7-19.2)	17.9 (12.3-24.9)
Borno	65.5 (60.3-70.3)	77.5 (68.5-84.5)	**6.2 (3.8-30.7)***	**69.6 (55.9-81.2)***
Adamawa	54.6 (41.0-67.6)	49.3 (40.3-58.2)	**13.5 (5.6-25.8)***	**68.4 (56.9-78.4)***
Gombe	**75.7 (70.8-80.0)***	**84.4 (80.2-87.8)***	18.2 (5.2-40.3)	48.6 (38.8-58.5)
Bauchi	78.1 (75.3-80.7)	71.3 (66.6-75.5)	**1.8 (0.05-9.6)***	**43.1 (35.9-50.5)***
Kano	**60.8 (56.6-64.9)***	**83.9 (80.7-86.7)***	**5.7 (1.2-15.7)***	**47.7 (41.5-53.9)***
Kaduna	58.6 (49.9-66.7)	63.3 (57.2-69.0)	0 (0-7.9)	6.7 (2.2-14.9)
Kebbi	82.9 (70.7-90.6)	72.8 (68.0-77.2)	**14.3 (5.9-27.2)***	**83.0 (78.3-87.0)***
Niger	56.8 (49.0-64.3)	50.2 (44.3-56.2)	**13.0 (4.9-26.2)***	**78.3 (70.4-84.8)***
Abuja	82.8 (71.6-90.2)	79.6 (71.7-85.7)	0 (0-21.8)	31.4 (16.9-49.3)
Nasarawa	**80.0 (65.4-89.4)***	**47.4 (33.7-61.4)***	9.7 (2.0-25.8)	0 (0-30.8)
Plateau	**74.3 (59.5-85.1)***	**49.8 (43.6-56.0)***	**9.5 (1.2-30.4)***	**56.7 (37.4-74.5)***
Taraba	**76.4 (68.6-82.8)***	**53.0 (47.3-58.6)***	**13.2 (6.7-23.5)***	**47.9 (38.8-57.2)***
Benue	**72.1 (59.7-81.8)***	**91.7 (84.6-95.8)***	**1.8 (0.04-9.7)***	**23.4 (12.3-38.0)***
Kogi	75.0 (40.4-93.0)	53.2 (39.3-66.7)	8.3 (0.2-38.5)	33.3 (14.6-57.0)
Kwara	53.3 (42.1-64.1)	53.5 (44.0-62.8)	11.8 (1.5-36.4)	50 (30.6-69.4)
Oyo	63.2 (51.8-73.4)	80.8 (60.3-92.1)	5.9 (0.1-28.7)	33.3 (13.3-59.0)
Osun	64.5 (52.5-74.9)	65.6 (53.7-75.9)	**9.7 (2.0-25.8)***	**64.3 (44.1-81.4)***
Ekiti	62.4 (53.5-70.5)	61.2 (42.5-77.1)	**0 (0-9.5)***	**47.2 (30.4-64.5)***
Ondo	65.8 (47.6-80.3)	62.2 (53.2-70.5)	**0 (0-20.6)***	**67.9 (47.7-84.1)***
Edo	85.0 (76.1-91.0)	78.7 (68.3-86.4)	**5.3 (0.6-17.7)***	**41.9 (24.5-60.9)***
Anambra	**72.4 (61.8-80.9)***	**97.4 (94.6-98.7)***	**0 (0-23.2)***	**75.0 (64.6-83.6)***
Enugu	65.7 (53.4-76.2)	81.3 (74.4-86.6)	**0 (0-45.9)***	**66.7 (51.6-79.6)***
Ebonyi	73.1 (67.7-77.9)	65.0 (59.5-70.1)	**9.5 (2.7-22.6)***	**89.0 (82.9-93.4)***
Cross River	77.1 (66.0-85.4)	86.1 (76.0-92.4)	**16.4 (7.8-28.8)***	**71.4 (47.8-88.7)***
Akwa Ibom	71.3 (65.9-76.2)	69.8 (63.7-75.2)	**6.7 (0.8-22.1)***	**70.7 (59.6-80.3)***
Abia	79.5 (76.3-82.4)	86.3 (73.3-93.5)	0 (0-15.4)	23.5 (6.8-49.9)
Imo	**81.0 (69.8-88.7)***	**51.0 (38.3-63.7)***	**0 (0-11.9)***	**63.5 (54.0-72.3)***
Rivers	**65.7 (59.6-71.4)***	**89.8 (85.5-92.9)***	**6.2 (1.7-15.0)***	**48.1 (39.2-57.0)***
Bayelsa	60.4 (51.2-68.9)	71.6 (60.6-80.5)	**8.6 (1.8-23.1)***	**43.8 (29.5-58.8)***
Delta	71.5 (63.6-78.2)	66.5 (35.9-97.5)	5.0 (0.6-16.9)	22.2 (2.8-60.0)
Lagos	59.6 (49.1-69.4)	78.4 (59.2-90.1)	19.4 (7.5-37.5)	47.1 (29.8-64.9)
Ogun	**60.2 (47.7-71.6)***	**93.4 (78.2-98.2)***	**0 (0-23.2)***	**66.7 (38.4-88.2)***
Total	**68.5 (67.0-69.9)***	**72.8 (71.2-74.3)***	**8.0 (6.6-9.6)***	**53.8 (52.0-55.5)***

CI - confidence interval, * statistical significance between the years (non-overlapping 95% CIs). ACT – artemisinin-based combination therapy

The proportions of wealth quintiles by state are shown in Table 7. Zamfara, Jigawa and Yobe are the three states that contain the highest proportion of the population from the poorest quintile in both 2008 and 2018. The states with the highest proportions of the richest quintile

in 2008 were FCT Abuja, Anambra and Lagos and in 2018 they were Abia, Ogun and again Lagos.

Table 7 Wealth index by state for 2008 and 2018, proportions of each quintile in a state.

	2008					2018				
	Poorest	Poorer	Middle	Richer	Richest	Poorest	Poorer	Middle	Richer	Richest
Sokoto	40.6	36.4	8.8	9.8	4.5	51.9	26.3	10.9	8.3	2.6
Zamfara	53.4	24.7	7.7	7.4	6.9	54.3	17.3	11.0	11.3	6.0
Katsina	31.2	40.4	17.6	8.3	2.6	21.6	39.5	21.7	13.3	4.0
Jigawa	53.6	29.7	10.2	4.9	1.7	55.3	24.9	11.6	4.3	4.0
Yobe	52.3	24.7	13.4	8.0	1.6	63.2	17.0	10.4	7.2	2.2
Borno	48.7	17.1	14.6	13.1	6.6	19.4	18.9	26.5	21.6	13.7
Adamawa	40.9	23.5	21.1	12.3	2.3	19.4	34.7	26.3	14.3	5.3
Gombe	39.8	28.9	16.2	12.7	2.4	40.5	28.2	15.1	11.2	5.0
Bauchi	52.2	25.8	13.8	6.2	1.9	45.2	26.6	17.1	8.4	2.8
Kano	25.6	29.8	16.3	15.6	12.9	29.3	24.2	17.3	14.6	14.5
Kaduna	7.8	25.1	32.0	23.3	11.8	6.2	30.2	29.7	17.1	16.7
Kebbi	35.8	29.6	20.3	9.4	5.0	36.3	36.9	17.2	8.1	1.5
Niger	21.4	24.5	25.4	16.3	12.5	17.3	30.4	23.7	16.2	12.4
Abuja	2.3	6.1	16.1	23.4	52.1	5.5	13.0	17.2	22.8	41.5
Nasarawa	9.9	31.1	32.0	20.7	6.3	3.9	17.4	27.1	33.4	18.1
Plateau	32.0	30.1	22.7	9.9	5.3	24.6	30.1	20.4	17.4	7.5
Taraba	45.9	17.8	21.4	11.4	3.5	30.4	36.1	20.8	10.2	2.5
Benue	35.4	26.6	25.2	8.6	4.2	17.5	28.0	28.3	15.6	10.6
Kogi	3.6	18.9	33.0	30.0	14.5	2.8	20.1	34.6	31.3	11.2
Kwara	20.5	14.9	18.8	19.3	26.6	20.1	11.2	23.2	27.0	18.5
Oyo	4.4	15.9	16.2	28.8	34.8	4.3	7.5	17.0	32.8	38.5
Osun	3.3	14.5	20.4	35.8	26.1	7.9	13.3	24.7	34.0	20.1
Ekiti	6.2	17.1	25.4	32.9	18.4	12.4	13.0	24.3	29.6	20.7
Ondo	6.6	22.9	26.4	23.6	20.6	5.1	16.0	27.9	27.6	23.5
Edo	5.0	9.6	15.6	33.8	36.0	4.3	9.9	31.1	27.5	27.2
Anambra	0.7	2.8	15.8	36.5	44.3	0.2	6.3	19.5	35.6	38.3
Enugu	5.6	18.0	40.7	22.2	13.5	3.2	14.2	35.2	25.0	22.5
Ebonyi	23.8	27.6	22.9	17.6	8.1	20.1	26.5	29.8	19.4	4.1
Cross river	12.4	25.1	31.7	20.0	11.0	6.7	21.5	25.6	26.2	19.9
Akwa Ibom	8.1	10.5	26.8	33.8	20.8	3.9	15.1	29.7	26.9	24.5
Abia	0.1	4.5	21.9	38.7	34.9	0.0	1.5	13.1	37.8	47.6
Imo	0.7	4.8	38.9	36.7	18.9	0.3	1.6	22.8	42.8	32.5
Rivers	6.8	11.3	19.2	28.9	33.8	1.8	6.4	13.8	30.9	47.2
Bayelsa	6.6	22.5	29.8	28.4	12.8	1.7	12.2	31.6	30.4	24.2
Delta	2.7	13.9	21.1	32.2	30.2	0.8	4.3	23.3	36.9	34.8
Lagos	1.4	1.6	3.7	12.9	80.4	0.0	0.7	2.6	21.7	75.1
Ogun	8.0	13.4	21.8	29.4	27.4	1.0	6.9	16.0	26.7	49.4
Total	19.9	19.9	20.1	20.0	20.0	20.0	20.0	20.0	20.1	20.0

As shown in Table 8, the outcomes access and use of ITN and treatment with ACT had a statistically significant increase from 2008 to 2018 for all independent variables and for the wealth index. However, access to care was not statistically significant in all the different independent variables. Access to ITN had no statistical difference between urban and rural dwellers in 2008, but rural dwellers had significantly higher access (non-overlapping CI) in

2018. In 2008, low education of the mother or the household head correlated with low access to ITN. However, in 2018, those (the mother or household head) with no education had higher access to ITNs than those with the higher education. Having fewer children under 5 years correlated with higher access to ITNs in both years. Having different numbers of bedrooms was not associated with a significant difference in access to ITNs (nor was it associated with any other of the outcomes either). ITN use was significantly higher among urban dwellers in 2008 but was significantly higher among rural residents in 2018. In 2008, higher education of the mother or the head of the household would increase the proportion of ITN use. On the contrary, in 2018, use of ITNs was highest among those whose mothers had no education. Meanwhile, there was no significant difference between those who had household heads with higher education and those with no education regarding the use of ITNs in 2018. Less children correlated with higher use of ITNs among children under 5 years in 2008, but there was no significant difference in 2008. Moreover, access to care was higher among urban dwellers in both years. Lower education of the mother or head household correlated with lower access to care in both years, except for mother's education in 2008, where there was no statistical significance between those with higher education and those without education. In 2008 and 2018, there was no correlation between having fewer children under 5 years in the household and access to care. Access to ACT treatment was significantly higher for urban residents in 2018, but not in 2008. Higher maternal education correlated with higher access to ACT treatment in 2018 compared with mothers without education. Education of the household head in both years and mother education in 2008 showed statistically non-significant results regarding ACT treatment. In 2018, there was a correlation between having

fewer children under 5 years in the household with access to ACT treatment, but in 2008, the results were not statistically significant.

Table 8 shows that in 2008 a higher wealth index (higher socioeconomic status) correlated with higher access and use of ITN and a higher rate of seeking care for children with fever. Among the poorest, the access to ITNs was 2.2% and among the richest 7.3%, and use of ITNs among children under five years was 2.5% among the poorest and 8.0% among the richest. In contrast, in 2018, the people with low socioeconomic status, the poorest, had higher access to ITNs (54.5%) than the richest (37.9%). The same change was found in the use of ITNs among children under 5 years with 59.9% ITN use among the poorest and 39.6% among the richest. In 2018, care-seeking was still higher among children in the richer wealth quintiles. In 2018, those in the richer socioeconomic groups were more likely to receive ACT treatment. Nevertheless, there was no statistical significance regarding ACT treatment in 2008.

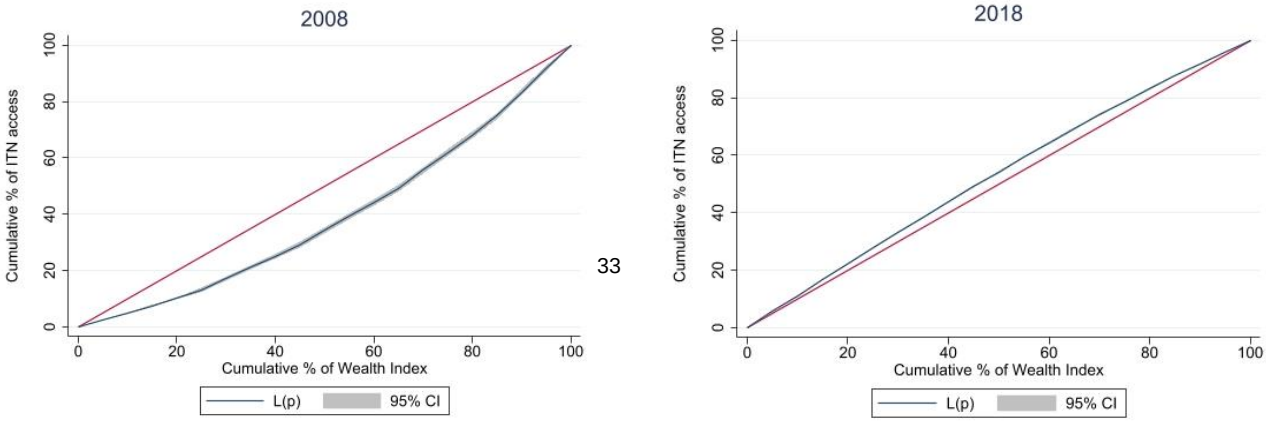
Table 8. National level: outcomes in proportions by independent variables and wealth index for 2008 and 2018.

Year		ITN access % (95% CI)	ITN use % (95% CI)	Access to care % (95% CI)	Access to ACT % (95% CI-binomial)	Number households (% in category) (mother education N is not by household)
2008	Urban	**5.3 (4.9-5.6)***	**6.5 (5.8-7.3)***	73.2 (69.9-76.1)	**11.1 (8.1-14.7)***	10,724 (31.5)
	Rural	**4.5 (4.2-4.9)***	**5.0 (4.4-5.6)***	66.9 (65.2-68.6)	**6.7 (5.2-8.6)***	23,346 (68.5)
	Household head education					
	No education,	**2.7 (2.4-2.9)***	**2.8 (2.4-3.2)***	63.5 (61.1-65.8)	**7.6 (5.3-10.5)***	13,085 (39.1)
	Primary	**4.6 (4.2-4.9)***	**5.7 (5.0-6.4)***	**68.2 (64.9-71.3)***	**7.7 (4.9-11.3)***	7,643 (22.8)
	Secondary	**5.9 (5.4-6.3)***	**6.7 (5.9-7.6)***	75.0 (72.0-77.8)	**6.2 (3.9-9.1)***	8,541 (25.5)
	Higher	**10.4 (9.8-11.0)***	**11.6 (10.2-13.2)***	**73.2 (67.8-77.9)***	**13.5 (8.8-19.4)***	4,234 (12.6)
	Education of the mother					
	No education	**3.1 (2.7-3.6)***	**3.1 (2.7-3.6)***	64.1 (61.8-66.3)	**8.3 (6.1-11.0)***	12,621 (49.8)
	Primary	**5.0 (4.4-5.5)***	**5.5 (4.8-6.3)***	68.4 (64.9-71.7)	**6.6 (4.0-10.2)***	5,791 (22.8)
	Secondary	**8.3 (7.4-9.3)***	**8.8 (7.7-10.0)***	75.5 (72.1-78.5)	**6.7 (4.5-9.6)***	5,681 (22.4)
	Higher	**14.3 (12.5-16.1)***	**12.9 (11.3-14.7)***	72.8 (65.3-79.2)	**16.3 (9.4-25.5)***	1,264 (5,0)
	Number of children below 5 years					0 children = 17,010 (49.9)
	1-2,	**5.4 (5.0-5.7)***	**5.9 (5.3-6.5)***	69.5 (67.5-71.3)	**7.7 (6.0-9.6)***	13,790 (40.5)
	3-4,	**4.3 (4.0-4.6)***	**5.0 (4.4-5.6)***	**65.9 (63.1-68.6)***	**7.9 (5.3-11.2)***	2,943 (8.6)
	>_5	**3.1 (2.8-3.3)***	**2.8 (2.1-3.7)***	68.7 (61.7-74.9)	**14.3 (6.4-26.2)***	327 (1.0)
	Number of rooms used to sleep in					
	1-2.	**4.6 (4.3-5.0)***	**5.9 (5.3-6.6)***	**68.0 (66.0-70.0)***	**7.1 (5.4-9.1)***	23,513 (69.2)
	>_3	**5.0 (4.7-5.2)***	**4.8 (4.3-5.3)***	69.1 (66.7-71.4)	**9.3 (6.9-12.2)***	10,467 (30.8)
	Wealth index					
	Poorest	**2.2 (1.8-2.6)***	**2.5 (2.0-3.2)***	**61.1 (57.9-64.2)***	**6.6 (3.8-10.6)***	7,261 (21.3)
	Poorer	**3.7 (3.2-4.1)***	**4.3 (3.7-5.0)***	65.1 (61.8-68.3)	**6.1 (3.5-9.8)***	6,735 (19.8)
	Middle	**4.9 (4.5-5.3)***	**6.3 (5.5-7.3)***	69.6 (66.2-72.7)	**8.1 (5.2-11.9)***	7,214 (21.2)

	Richer	**5.8 (5.3-6.3)***	**7.1 (6.2-8.2)***	77.5 (73.6-81.1)	**7.5 (4.7-11.4)***	6,800 (20.0)
	Richest	**7.3 (6.7-7.9)***	**8.0 (6.9-9.3)***	**74.6 (69.6-79.0)***	**11.7 (8.0-16.4)***	6,060 (17.8)
	Total	**4.8 (4.5-5.1)***	**5.5 (5.0-6.0)***	**68.5 (67.0-69.9)***	**8.0 (6.6-9.6)***	34,070
2018	Urban	**41.3 (38.8-43.8)***	**44.8 (41.9-47.8)***	78.7 (75.7-81.3)	**59.1 (56.1-62.1)***	16.780 (41.5)
	Rural	**52.2 (50.1-54.3)***	**57.0 (54.7-59.3)***	70.2 (68.3-71.9)	**51.1 (48.9-53.3)***	23,647 (58.5)
	Household head education					
	No education,	**52.4 (50.5-54.3)***	**57.3 (55.0-59.6)***	66.1 (63.6-68.4)	**51.8 (48.8-54.9)***	12,431 (30.8)
	Primary	**46.9 (45.0-48.8)***	**51.0 (48.5-53.5)***	**74.8 (72.3-77.1)***	**51.8 (47.9-55.6)***	8,582 (21.2)
	Secondary	**41.7 (39.7-43.8)***	**47.2 (44.6-49.7)***	77.0 (74.6-79.3)	**55.6 (52.3-58.8)***	12,790 (31.6)
	Higher	**48.0 (45.6-50.3)***	**53.0 (49.8-56.2)***	**82.7 (79.3-85.6)***	**57.6 (52.8-62.3)***	6,600 (16.3)
	Do not know	**36.7 (31.6-41.7)***	**14.6 (5.2-34.6)***	32.7 (8.1-72.6)	**100 (2.5-100)!***	24 (0.1)
	Education of the mother					
	No education	**53.9 (51.7-56.0)***	**59.8 (57.3-62.2)***	66.2 (63.1-69.1)	**49.4 (45.0-53.8)***	4,613 (38.5)
	Primary	**45.4 (43.1-47.8)***	**50.0 (47.2-52.8)***	73.8 (69.1-78.0)	**54.2 (47.7-60.7)***	2,005 (16.7)
	Secondary	**41.2 (39.3-43.2)***	**43.4 (40.8-46.0)***	77.7 (74.1-80.8)	**59.1 (54.4-63.7)***	4,264 (35.6)
	Higher	**44.4 (40.6-48.2)***	**43.7 (39.2-48.2)***	85.8 (78.7-90.8)	**65.7 (55.6-74.8)***	1,094 (9.1)
	Number of children below 5 years					0 children = 19,550 (48.4)
	1-2,	**48.1 (46.3-50.0)***	**52.7 (50.1-55.1)***	73.3 (71.3-75.1)	**55.7 (53.5-57.8)***	17,119 (42.4)
	3 - 4,	**47.0 (45.5-48.4)***	**52.2 (50.1-54.4)***	**71.9 (69.4-74.3)***	**51.2 (47.8-54.8)***	3,335 (8.3)
	≥5	**42.0 (40.8-43.2)***	**49.5 (46.6-52.4)***	71.5 (67.3-75.3)	**43.9 (37.0-51.0)***	423 (1.1)
	Number of rooms used to sleep in					
	1-2,	**46.1 (43.7-48.5)***	**52.7 (50.1-55.3)***	**73.6 (71.5-75.6)***	**54.0 (51.7-56.3)***	27,929 (69.1)
	≥3	**49.2 (47.8-50.5)***	**51.4 (49.5-53.3)***	71.6 (69.6-73.6)	**53.5 (50.7-56.3)***	12,498 (30.9)
	Wealth index					
	Poorest	**54.5 (52.1-57.0)***	**59.9 (57.1-62.7)***	**67.8 (65.0-70.4)***	**46.8 (43.2-50.4)***	7,290 (18.0)
	Poorer	**52.7 (50.5-54.8)***	**59.1 (56.5-61.6)***	70.1 (67.1-73.0)	**54.3 (50.6-57.9)***	7,823 (19.4)
	Middle	**48.9 (47.4-50.4)***	**53.7 (51.4-53.7)***	72.2 (69.7-74.6)	**55.8 (52.1-59.6)***	8,920 (22.1)
	Richer	**43.3 (41.6-45.0)***	**45.0 (42.8-47.2)***	78.9 (75.8-81.7)	**66.0 (51.7-60.1)***	8,676 (21,5)
	Richest	**37.9 (35.2-40.7)***	**39.6 (36.3-43.0)***	**85.6 (81.6-88.9)***	**60.6 (55.3-65.7)***	7,718 (19.1)
	Total	**47.5 (45.6-49.3)***	**52.2 (50.2-54.2)***	**72.8 (71.2-74.3)***	**53.8 (52.0-55.5)***	40,427

*CI- confidence interval, *Statistical significance between the years (non-overlapping 95% CIs)*
ITN – insecticide treated nets, ACT-artemisinin-based combination therapy

Figure 2 shows concentration curves at the national level for the 4 outcomes. The curves show that ITN access in 2008 was significantly higher for the richer population than for the poorer in 2008 (pro-rich). In 2018, ITN access has approached equality, although the use was higher among the poorer population. A similar result was seen for ITN use among children under 5 years, with higher rate among the richer population in 2008 and has become higher among poorer population in 2018, although it was closer to the equality line. In contrast, access to care for children under 5 years with fever in the last two weeks was higher among those with higher socio-economic status in both 2008 and 2018. However, there were no significant results in this group regarding ACT-treatment in 2008. In 2018 ACT treatment was significantly higher among the richer people.



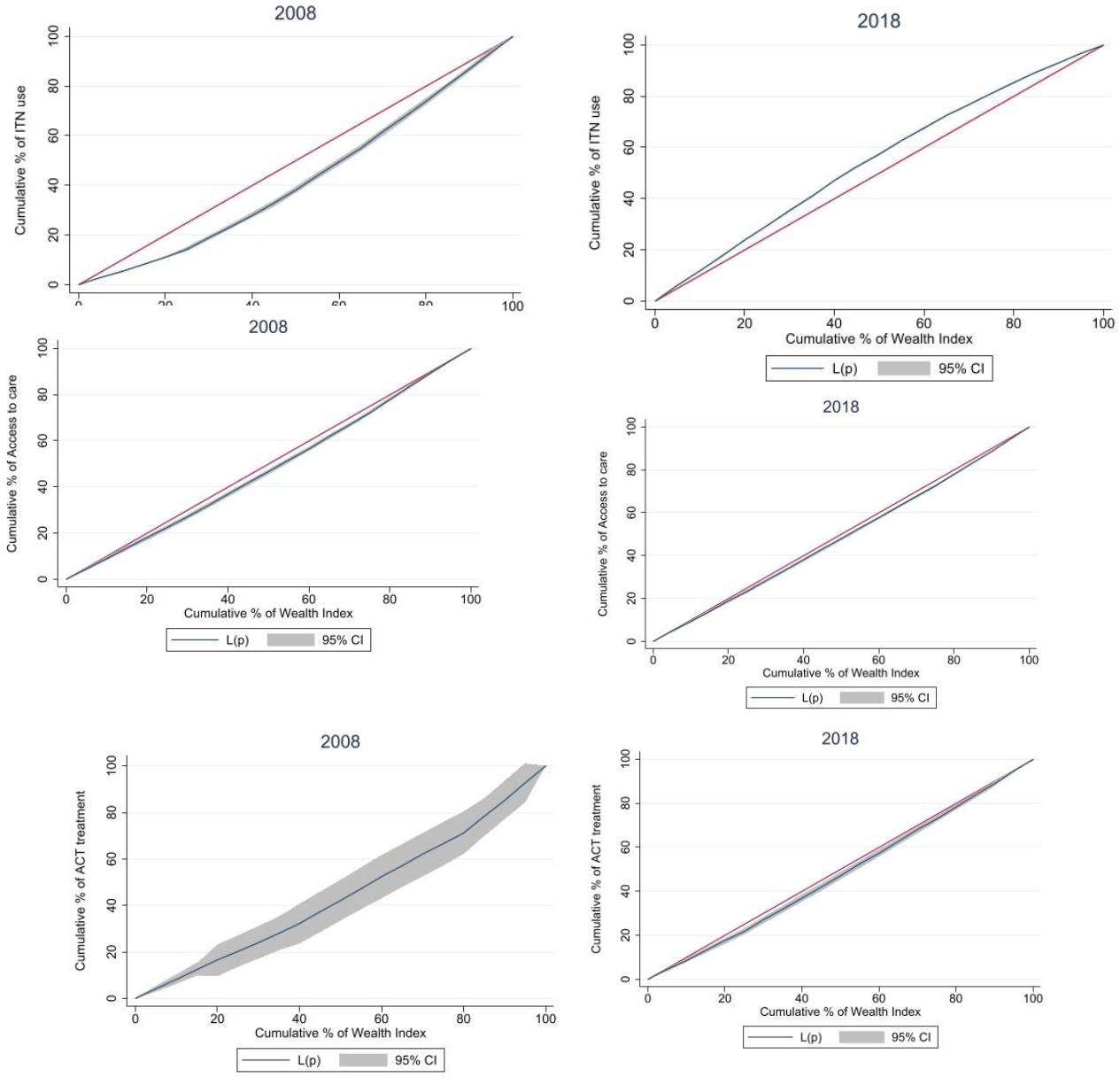


Figure 2 Concentration curves for all the four outcomes nationally, in 2008 and 2018. The red 45degree line indicates total equality in use or access. A concentration curve above the red line will indicate that the outcome is concentrated in the poorer households while a concentration curve below the red line indicated that the outcome is more concentrated among the richer households. ITN – insecticide treated nets, ACT-artemisinin-based combination therapy.

As presented in Table 9, the only state that was significantly pro-poor in ITN use in both 2008 and 2018 was Delta. Although not statistically significant, ITN access in Bayelsa and Ogun was pro-poor in both years, as was ITN use in Bayelsa, Lagos, and Ogun. ACT treatment was pro-poor in Yobe and Ebonyi in both years. Further, the states that were pro-rich in 2008 but pro-poor in 2018 with statistical significance in ITN access was Borno, in ITN use in Borno,

Narsawa, Kwara and Ondo and in ACT treatment in Adamawa. Although not statistically significant, ITN access changed from pro-rich in 2008 to pro-poor in 2018 in Katsina, Jigawa, Gombe, Narsawa, Ondo, Akwa Ibom, Abia while ITN use changed in Katsina, Jigawa, Gombe, Bauchi, Kano, Kaduna, Kebbi, Ekiti, Cross River and Akwa Ibom. Access to care changed similarly in Sokoto, Plateau, Benue, Ondo, Akwa Ibom and ACT treatment in Jigawa, Borno, Adamawa, Gombe, Niger, Benue, Edo. There was no state where prevention and treatment outcomes were more concentrated among the poor in 2008 but among the richest households at statistically significant levels in 2018. Pro-poor in 2008 but pro-rich in 2018, though not statistically significant, was ITN access in Edo, Anambra and Lagos; ITN use in Kogi, Oyo, Edo and Enugu, access to care in Kaduna and Lagos and ACT treatment in Sokoto, Kano, Kaduna, Plateau, Taraba, Kwara and Oyo. Moreover, the states that were pro-rich statistically significant levels in both years were: ITN access in Taraba, Benue, Kwara, Ebonyi, Imo and Rivers; ITN use in Yobe and Taraba; access to care in Zamfara, Jigawa, Bauchi, Kebbi and Kwara. Concentration indices with confidence intervals are to be found in appendix 1 and 2.

Table 9 Concentration index for each outcome by state.

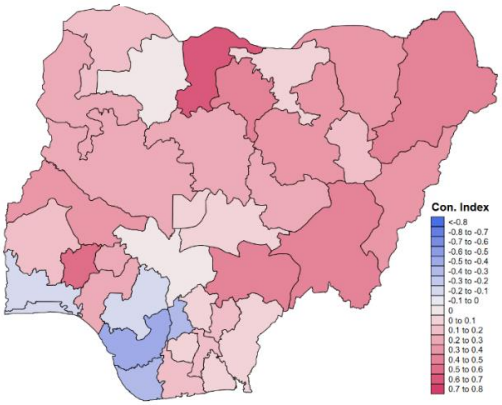
C-index	ITN access	ITN access	ITN use	ITN use	Access to	Access to	ACT	ACT
State	2008	2018	2008	2018	2008	2018	2008	2018
Sokoto	0.265	0.008	0.085	0.003	**0.238***	**-0.008***	-0.227	0.145
Zamfara	0.068	0.033	**0.484***	**0.049***	0.088	0.179		0.207
Katsina	0.736	-0.011	**0.718***	**-0.020***	0.055	0.04	0.158	0.032
Jigawa	**0.181***	**-0.008***	0.108	-0.016	0.035	0.029	0.144	-0.021
Yobe	0.413	0.045	**0.474***	**0.062***	0.017	0.026	-0.156	-0.002
Borno	**0.537***	**-0.058***	**0.556***	**-0.084***	0.073	0.12	**0.740***	**-0.227***
Adamawa	**0.492***	**0.055***	**0.440***	**0.028***	0.039	0.167	**0.459***	**-0.105***
Gombe	0.24	-0.014	0.167	-0.009	0.027	0.023	0.153	-0.042
Bauchi	**0.490***	**0.013***	**0.436***	**-0.003***	0.034	0.068	-0.006	0.063
Kano	**0.554***	**-0.005***	**0.509***	**-0.014***	0.09	0.028	-0.017	0.119
Kaduna	0.348	0.01	**0.343***	**-0.029***	**-0.075***	**0.063***		0.308
Kebbi	**0.326***	**0.015***	**0.323***	**-0.001***	0.053	0.051	0.373	0.004
Niger	0.368	0.057	0.186	0.02	0.065	0.09	0.445	-0.011
Abuja	0.164	0.045	0.181	0.031	0.057	0.032		0.322
Nasarawa	0.163	-0.014	**0.156***	**-0.067***	**0.0190***	**0.232***	0.18	
Plateau	**0.339***	**0.070***	**0.396***	**0.069***	0.029	-0.11	-0.411	0.124
Taraba	0.504	0.126	0.475	0.108	0.05	0.048	-0.207	0.134
Benue	0.587	0.055	0.423	0.036	0.066	-0.01	0.447	-0.223
Kogi	0.066	0.076	-0.119	0.036	0.107	0.014	0.25	0.049

Kwara	**0.481***	**0.060***	**0.411***	**-0.076***	0.271	0.167	-0.169	0.135
Oyo	0.294	0.05	-0.041	0.041	0.02	0.104	-0.885	0.001
Osun	0.618	0.087	**0.479***	**0.024***	0.091	0.163	0.675	0.105
Ekiti	**0.356***	**0.018***	0.266	-0.075	0.025	0.007		0.266
Ondo	**0.382***	**-0.003***	**0.277***	**-0.070***	0.074	-0.048		0.016
Edo	-0.046	0.008	-0.16	0.02	0.016	0.033	0.292	-0.044
Anambra	-0.213	0.014	-0.025	-0.01	0.006	0.018		-0.051
Enugu	0.135	0.003	-0.082	0.005	0.083	0.041		0.068
Ebonyi	0.2	0.043	0.14	0.014	0.056	0.047	-0.145	-0.019
Cross River	0.152	0.009	0.111	-0.018	0.025	0.016	0.248	0.169
Akwa Ibom	0.119	-0.108	0.01	-0.146	0.04	-0.015	0.546	0.164
Abia	0.259	-0.013	0.207	0.069	0.06	0.018		-0.195
Imo	0.142	0.083	0.108	0.207	0.024	0.061		0.103
Rivers	0.276	0.146	0.062	0.113	0.071	0.013	**0.582***	**0.083***
Bayelsa	-0.228	-0.033	-0.21	-0.097	0.015	-0.05	0.333	0.16
Delta	-0.361	-0.046	-0.427	-0.09	0.11	0.021	0.4	0.41
Lagos	-0.013	0.029	-0.171	-0.011	-0.012	0.026	0.095	-0.131
Ogun	-0.021	-0.027	-0.048	-0.053	0.092	0.021		0.138
Total	**0.217***	**-0.074***	**0.139***	**-0.115***	0.047	0.04	0.167	0.042

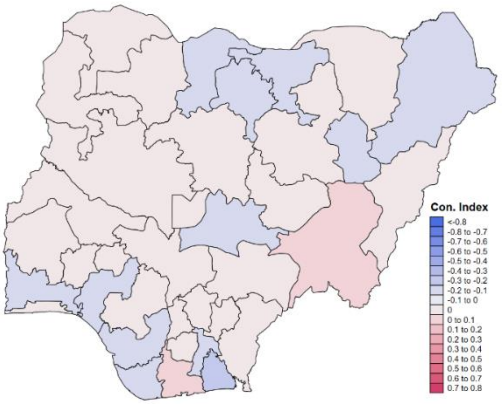
*A number >0 indicates that the outcome is more concentrated among the richer, <0 the outcome is more concentrated among the poorer, 0 indicates equality. Green indicates a significant positive number (pro-rich) (95% confidence interval). Yellow indicates all confidence intervals that includes zero. Red signifies a significant negative number (pro-poor). *significant difference between 2008 and 2018 (not overlapped Cis). Empty cells - no data to calculate concentration index. ITN – insecticide treated nets, ACT-artemisinin-based combination therapy.*

As shown in Figure 3, the colours change from pro-rich (red) to pro-poor (blue) by state for the years 2008 and 2018. The maps show that some states in the south or southwest of Nigeria were already pro poor in 2008, unlike the other states, but seem to have reached closer to equality in 2018. These results should be interpreted with the summaries in Table 8 as some may not be statistically significant.

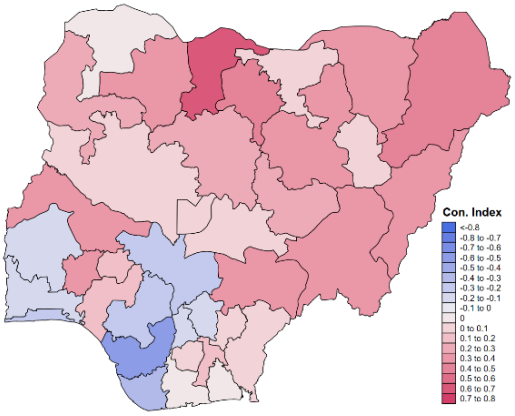
Access to ITN 2008



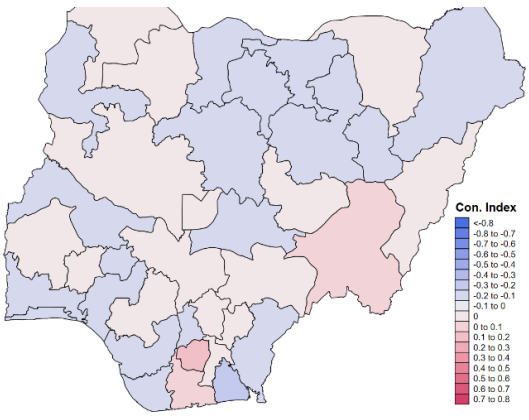
Access to ITN 2018



Use of ITN 2008



Use of ITN 2018



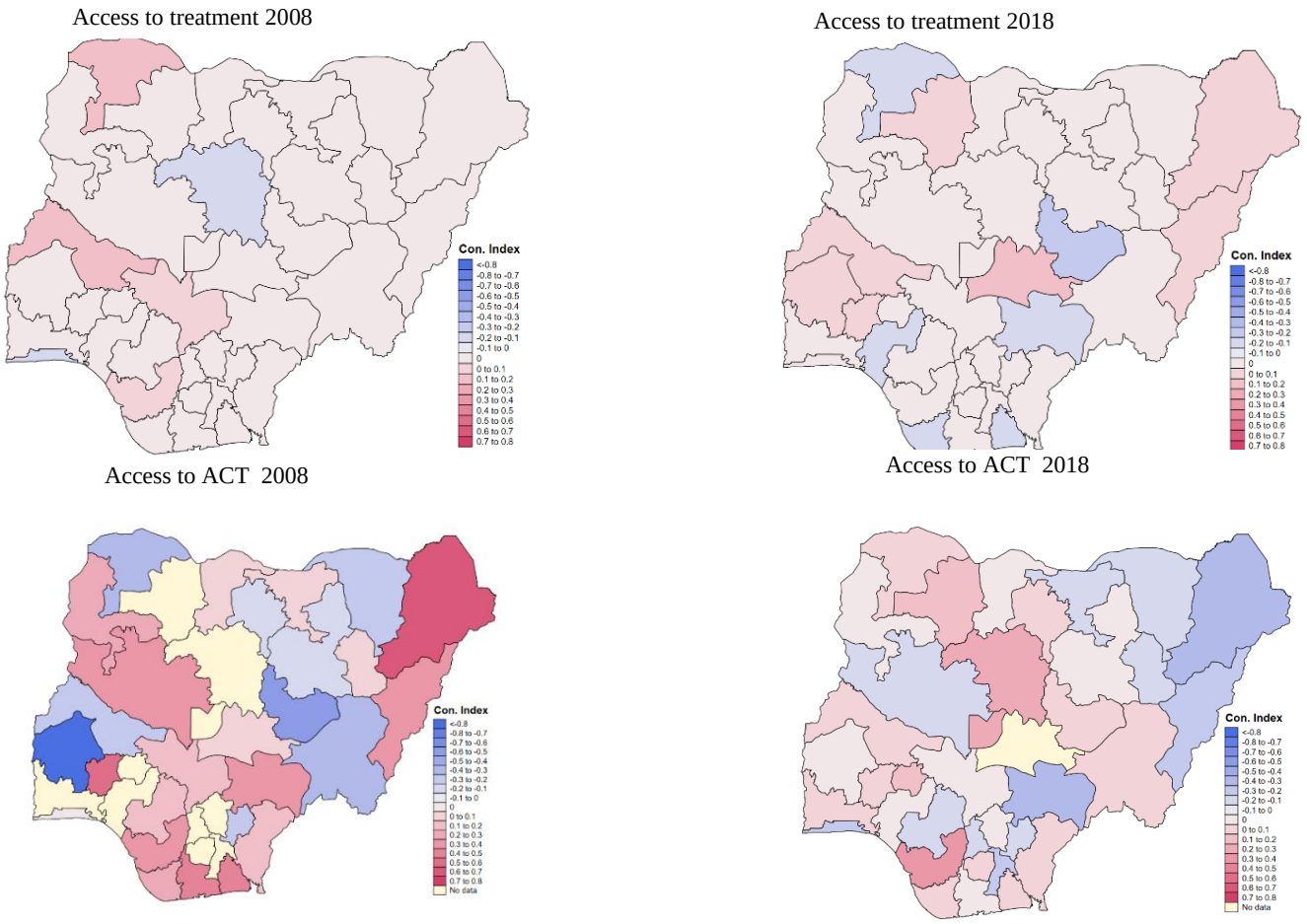


Figure 3. Maps over Nigeria's 37 states. Red colour illustrate that the outcome is more concentrated in the rich population while blue colour illustrate that the outcome is concentrated in the poor population. ITN – insecticide treated nets, ACT-artemisinin-based combination therapy.

Discussion

This study presents overall findings that suggest there is still inequality and inequity in access and use of malaria preventions and treatment, although there have been improvements. ITN access and use among children under 5 years shifted from being more concentrated among richer socioeconomic groups in 2008 to being more concentrated among poorer groups in 2018. This suggests improved equity since equity means that those who suffer the most should get more help. Since the results show that poor in Nigeria have the highest malaria burden and should therefore have higher access to ITNs, to get the same opportunity to stay healthy as the rich have. In contrast, access to care and treatment with ACT, which should be equal by socio-economic status to achieve equity, as every febrile child needs to access care,

continued to be more concentrated in the rich groups and did not have any significant change between 2008 and 2018. Socio-economic equality and equity varied by state in both time periods.

Nationwide ITN access and use approached equity (pro-poor) after the free mass distributions to communities. Similar results following free net distribution campaigns were shown in an earlier study in Nigeria and several other sub-Saharan African countries (52). Taylor *et al*., using data from DHS (DHS 2008 and DHS 2013) and Malaria Indicator Survey (MIS) 2010, suggested that the cumulative percentage of ITNs in Nigeria already had shifted in favor of the poor and become more equitable in 2013. However, the concentration index was analyzed on households that owned at least one ITN (52), which does not provide enough information compared to the access and use of ITNs that have been analyzed here. In addition, another study conducted after the 2009 free mass campaign in Kano found that ITN distribution had already succeeded in creating equality in ownership and use of ITN, but suggested that further efforts were needed to maintain the improvements (53). In the current analysis, access and use of ITNs in Kano remain equal (although not in equity) in 2018.

Although equity in access and use of ITNs improved nationally in 2018, the pattern varied by state. Only 10 states had a significant change towards equity in ITN access, however Borno and Akwa Ibom were the only states that became pro-poor at statistically significant levels (which indicate equity) in 2018. In contrast, 8 states (Taraba, Benue, Kogi, Kwara, Osun, Ebonyi, Imo and Rivers) remained statistically significantly pro-rich in ITN access. Regarding ITN use, 14 states had significant change towards equity and there were 8 states that were significantly pro-poor (which would indicate equity) in 2018. In Yobe, Taraba, Imo

and Rivers ITN use was more pro-rich in 2018 at statistically significant levels. It is unclear why inequity in access and use of ITNs persisted in certain states (which are pro-poor or equal in distribution). Further research would be needed to improve their status. One important consideration is to implement a larger scale up of ITNs.

Although access to and use of ITNs has become more equitable (pro-poor), there are still significant inequities, across the country in 2018, and the burden of malaria remains significantly higher for children in the poorest socioeconomic group (56.9%) compared to the richest socioeconomic group (10.8%); rural dwellers had higher malaria prevalence than urban dwellers. However, given the difference in malaria prevalence between the richest and poorest populations, further efforts are needed to ensure greater coverage of prevention and treatment interventions among the poorest households and those living in rural areas. In contrast, another study conducted in Anambra in 2009, suggested that the most vulnerable population have been left out of targeted efforts to reach the poor (42). The self-reported results showed that malaria was more prevalent among people with high socio-economic status and urban dwellers. The authors suggested that ITNs should be distributed without taking account for either socio-economic status or geographic location. The authors reached this conclusion, although they wrote that self-reported malaria may be biased because people of higher socio-economic status are more likely to acknowledge and seek care for their illness than poorer people (42). Comparing self-reported malaria across wealth quintiles will not give reliable results, and studies have shown that self-reported malaria has a low correlation with parasite prevalence (54). A meta-analysis with surveys from 1980-2011 using parasite prevalence found that children 0-15 years with lower socio economic status were more likely (adjusted odds ratio 2.06 ($p<0.001$)) to have malaria (55).

Malaria prevalence varied across the states, being highest in Kebbi at 76.8% and lowest in Lagos at 3.4%. This report showed that the states with the highest parasite prevalence in 2018 were Kebbi, Katsina, Osun and Sokoto. These states, except for Osun, contained mostly of rural dwellers and people with low socio-economic status. They are located in the Northwest region of Nigeria, with the exception of Osun which is located in the Southwest (44). In addition to the high levels of inequity in malaria prevention and treatment, environmental factors may also have an impact since three of the states are in the same area and malaria has previously been found to be environmentally driven (37). Earlier studies have shown that low education, poor housing and low socio economic status increase the risk of contracting malaria (31). In contrast to results in this study, an earlier study in 2007 suggested that malaria prevalence was highest in the Niger Delta region (and some other isolated parts) (37), presumably because the Niger Delta region (in the south) has a lot of flooding during rainy season due to the delta area and has a more humid climate than the northern Nigeria (34). According to MIS 2010, Southwest Nigeria had the highest malaria prevalence at 60.5% and Northwest 56.0% with an overall parasite prevalence 51.5% that year (56). However in MIS 2015, Northwest Nigeria showed the highest parasite prevalence at 58.3% and the Southwest had a vast decrease to 32.1% from 2010 and nationally the parasite prevalence was 45.1% (34). This shows that overall malaria prevalence has decreased (in 2018 it was 36.2%) and whether this is due to environmental fluctuations throughout Nigeria between years or due to malaria prevention and treatment efforts is impossible to say. However, there is still vast differences depending on residence and socio-economic status. The proportion of children having self-reported fever was higher in 2018 than 2008, and the highest increase has been in the lower socioeconomic groups. This may be due to that the malaria prevalence increased in

2018. Another reason perhaps may be that Nigeria have participated educational campaigns about malaria and the importance of acknowledging fever symptoms (41). No methodological changes have been found that could cause the increase.

The results show that between 2008 and 2018, there was no significant change in equality in access to care among children under 5 years at the national level and was still in inequity (pro-rich). At national level, there was a small increase in overall access to care between the years. However, at state level, there was a significant change from equity in access to care to become more concentrated among the rich in Kaduna and Narsawa, while Sokoto was the only state that showed significant change towards equity. There were 15 states that were pro-rich (in inequity) at statistically significant level in 2018 (Zamfara, Katsina, Jigawa, Yobe, Borno, Adamawa, Bauchi, Kaduna, Kebbi, Niger, Narsawa, Kwara, Oyo, Osun), 1 was statistically significantly pro-poor, in inequity (Plateau) and the other 21 states statistically indicate that there was equity in care seeking. Zamfara and Narsawa had the lowest levels of access to care while Imo, Taraba, Plateau and Narsawa recorded significant decline in access to care between 2008 and 2018. Further efforts are needed especially in states where inequity is prevalent and access is low. Equity in access to health care has many dimensions and Evans *et al.* (2013) defined it as physically accessible, affordable and acceptable (patient's own inclination to seek care) (57). This report shows results that higher levels of education of household heads and urban living correlated with higher proportions of access to care (however, no regression analysis was performed – risk for confounding bias). Other studies also concluded that place of residence (urban or rural living) was an important determinant of health care access, as people living in rural areas with lower socioeconomic status tended to live far from health facilities (58). A survey conducted in 2011 in Southeast Nigeria showed

that the main reasons why people did not seek treatment after the onset of fever was either because they believed their condition was not severe enough to seek care or they did not have enough money to pay for the care (59). This may be related to community awareness, which in turn correlates with education level.

Nationwide and in 24 states, there was a vast increase in the use of ACT from 2008 to 2018. This could be partly due to the fact that ACT first became a first-line treatment in Nigeria in 2005. Due to the high cost of ACT and lack of adherence to guidelines in the private sector, Affordable Medicine Facility-malaria was started in 2009, which helped to reduce the price of ACT in the private sector in Nigeria (60). The concentration index shows that the use of ACT treatment is concentrated among the rich nationwide in both 2008 and 2018. Although the concentration curve from 2008 indicates that there was no statistical significance, most likely due to the small sample size. Also, due to the small sample size for this indicator, the state analysis of concentration indices in 2008 also had wide confidence intervals, making it difficult to draw important conclusions. Nevertheless, the results showed a significant change towards equity in Rivers. Borno and Adamawa had a statistically significant change towards inequity and became pro-poor. However, eight other states (Kano, Niger, Plateau, Ekiti, Cross River, Akwa Ibom, Imo and Bayelsa) showed significant pro-rich results while the others (27 states) indicated equity in 2018 (though with very wide CIs). The reasons for the differences between states may be due to various factors. In this report, children in 2018 who live in rural areas or have mothers with high education were more likely to receive ACT treatment when they were sick, although we cannot say what is independently associated with this as no regression analysis was conducted. Other studies conducted in Nigeria have shown that people of low socioeconomic status and rural dwellers are more likely to lack access to

adequate health care to the same extent as wealthier people and mostly seek care from patent medicine dealers, which are more accessible but of lower quality (59, 61). In contrast, wealthy people are more likely seek care at private or public hospitals where higher quality care is provided (59). Studies in Nigeria have shown that patent medicine dealers more often do not dispense drugs according to guidelines and do not test for malaria before dispensing antimalarials (61). A study participated in Northcentral Nigeria in 2014 showed that patent medicine dealers preferred ACT the least, to treat malaria, among health workers (only 19.8% compared to physicians 67.6% preferred ACT treatment). The results showed that malaria case management training and good knowledge about malaria increased the preference for ACT treatment. Nevertheless, training alone did not always increase preference for ACT, and the authors suggested that training should be evaluated to ensure that knowledge according to the guidelines is taught (62). A qualitative study showed that the patent medicine dealers would mix and dispense drugs depending on what the patient can pay (ACT is more expensive than older antimalarials), the drugs came without blisters and there was no way for the patients to know if the medicine was expired or even correct (63). In addition, poor people more often have to use a larger proportion of their assets to get treatment (61). Overall, it can be concluded that there is an inequity in malaria treatment as the poorest do not receive the same quality (ACT) due to lack of money, lack of knowledge and lack of availability.

The analysis shows that access to and use of ITNs increased significantly in every state from 2008 to 2018, thanks to free mass distributions. While this is positive, the levels remain low. States remain far from the 2013 NMEP goal of 80% ITN use in the highest risk groups (children under 5 and pregnant women) (64). In 2018, there was only a 52.2% usage among children under 5 years nationally, and Jigawa and Kebbi were the only two states to meet the

goal. NMEP had a goal that 80% of malaria treatment should be appropriate according to the guidelines in 2013 (64). Only 53.8 % of children with fever in 2018 received ACT out of all who received any antimalarial. Ebonyi was the only state significantly over 80%. Similar goals were set in the most recent NMEP 2014-2020 similar goals was set (41), and future research is needed to tell whether these targets were met.

The results and analyses from this degree work are altogether identifying gaps in equity and coverage of prevention and access to care in Nigeria and could potentially be helpful to authorities in Nigeria in determining where further targeted interventions and preventions are needed. However, further research is needed to determine what factors are responsible for the inequity.

Strengths and weaknesses

The DHS household survey data have important strengths and weaknesses. Some advantages are that the surveys contain large samples and that they are representative both at the national level and by state. The sampling methods are also consistent over time and the data are available at different levels of analysis (state, household and individual). The data are weighted, which improves the reliability of the results. Some weaknesses of household surveys are that if the prevalence of a particular indicator in the population is very low, sampling errors can lead to biased results. Appropriate stratification and weighting can reduce these problems, but they still require attention. The DHS surveys are cross-sectional, and some factors such as climate variability, conflict and other emergencies may change the results, but these surveys do not take such factors in account. In quantifying socioeconomic status, the DHS survey uses asset index in PCA to generate a wealth index to divide the

population into different socio-economic groups. Such an index may have low sensitivity because some social/economic value is assigned to assets that may not generate income for households (32). It is important to be aware that the assets chosen will affect the results in either way (65). For these reasons, some economists would prefer consumption data, but these are more difficult to collect and suffer from more measurement errors compared to household assets (32). In addition, previous studies show that assets index and consumption have a low correlation (54) but when comparing health equality with socioeconomic status it makes no significant difference for either (66) and is a good way to look at malaria prevalence over socioeconomic status (54). Although, comparing wealth index and consumption coming to populations in rural and urban areas, differences between those populations are larger using wealth index (65) since wealth index will overestimate the socioeconomic status in urban and more developed areas. Lastly, even though many reports did not find significant difference between using wealth index and consumption index (66) other studies have gotten to opposite conclusions (67) which is important to be aware of. Nonetheless these different alternatives measure different aspects on socioeconomic status (65) and if taking all aspects in mind it is possible to eliminate confounding factors.

There are also strengths and weaknesses related to the outcomes and other variables used in this report. First, there is a risk of confounding bias because the analysis in this report only compared different means without performing a regression analysis to see what is independently associated with the different outcomes (including socioeconomic status). Access to ITNs does not consider the physical and chemical integrity of the ITNs. The use of ITNs among children under 5 years may also be biased depending on whether or not the survey was conducted during the malaria season. The 2018 DHS was conducted (August to

December) during Nigeria's malaria season (44) whereas the DHS 2008 was conducted from June to October and thus the first half occurred before the malaria season. In addition, access to care and treatment with ACT has limitations because people may have different perceptions about how to tell if a child has a fever or not. Moreover, fever has several causes other than malaria, and because there is no information about whether the child had a malaria test before being treated with ACT, it is not possible to say whether it was the right treatment for a particular child, even though ACT is the recommended treatment when someone is infected with *P. falciparum*. Although distinctions are made between which children had access to care and which did not, the quality of care varied widely depending on which facility was used, although traditional practitioners were excluded. Comparing children under 5 years with fever who received ACT treatment with those who received any antimalarial by state yielded in small samples and showed insignificant results in many states, especially in 2008. The parasite prevalence may fluctuate vastly throughout the year and is therefore often used to examine trends over years (68). Finally, parasite prevalence was measured by RDT rather than microscopy, which is more accurate (if the microscopist is trained) (10).

Conclusions and Implications

Socioeconomic equity in health means that those who suffer the most from the burden of a specific disease, also receive the most help in preventing the disease. However, when people are sick and need treatment, there is an expectation that access to treatment is equal, but this requires financing so that the poorest are protected from the risk of financial disaster. Therefore, elements of equality and equity do matter. These findings suggest that the efforts are insufficient for the poorer and more vulnerable people. Even though ITN use and access have reached closer to equity and have become higher among the poorer people nationally in

2018 probably due to the mass distribution of ITNs, there are still inequities in certain states. There is also a higher malaria burden among the poorer people compared to the richer and the states in Northwest of Nigeria are the most exposed to malaria. The rich still have better access to care for children under 5, and they are more likely to receive the right treatment (ACT). There is especially inequity in access to care in 11 of the states that are still significantly pro-rich. Regarding ACT treatment, there are 8 states that are significantly pro-rich. This may be due to the long distances to care for rural dwellers, low quality of care, high costs to receive proper treatment, and not inadequate education for both patients and caregivers. Those states that are in inequity have been mapped and are the ones where the greatest efforts must be made to achieve equity and eventually defeat malaria. To conquer malaria and reach equity proposedly more subsidized medicines and care for the poor and better quality-care that is more accessible for people living in rural areas and validated educational campaigns so that caregivers know what medicine to give and people know when to seek care. This may contribute to reduce the malaria burden which is still higher in poor populations and also achieve equity in malaria prevalence. Since the prevention goals have not been met, as a suggestion, continuation of free distribution of ITNs is one way to reach the goal. Further measures are needed to improve equity so that poor people can have the opportunity to emerge from poverty. Further analyses are needed to understand the factors that lead to changing inequities in malaria prevention and treatment in Nigeria.

Populärvetenskaplig sammanfattning på svenska

Examensarbete

Läkarprogrammet

Titel: Socioekonomisk jämlikhet och rättvisa i tillgång till malariaprevention och behandling i Nigeria: skillnader över tid och geografi

Författare och år: Josefine Nilsson, 2021, Göteborgs Universitet

Handledare: Marian Warsame, Abdisalan Noor

Malaria är en infektionssjukdom som sprids med myggor och som år 2019 drabbade 229 miljoner människor och orsakade 409 000 dödsfall. Av dödsfallen var 2/3 barn under 5 år och Nigeria står för 27% av världens alla malariafall. Världshälsoorganisationen (WHO) jobbar aktivt med att försöka minska spridningen av sjukdomen samt minska dödligheten. Detta kan göras genom att människor i utsatta områden sover under impregnerade myggnät, får tillgång till vård och får fungerande och rätt medicinering mot malaria. Det är ingen självklarhet att alla har tillgång till ovanstående och det har tidigare visats att malaria är en sjukdom som främst drabbar de med låg socioekonomisk status.

Denna studie har undersökt hur socioekonomi påverkar tillgång till och användandet av impregnerade myggnät, vård och hur det skiljer sig mellan de olika staterna i Nigeria under 2008 och 2018 för att se om detta är jämlikt/rättvist fördelat. Informationen som användes var insamlad genom frågeformulär utförda hemma hos slumpade hushåll, av organisationen Demographic and Health Surveys.

Resultat från undersökningen visade att tillgången och användandet nationellt av impregnerade myggnät för barn under 5 år var ojämlik med fördel till de med högst

socioekonomisk status 2008. Resultaten var mer jämlika nationellt 2018, men var till fördel för de med lägre socioekonomisk status (vilket är mer rättvist på grund av den höga malariabördan bland de fattiga). Men vissa enskilda stater var fortfarande väldigt ojämlika med högre användande och tillgång hos de rika. Användandet av impregnerade myggnät ökade nationellt från 5.5% 2008 till 52.5% 2018. Detta möjligen på grund av kampanjer med utdelning av gratis myggnät som riktades till de fattiga. Trots detta så visar resultaten på att malariabördan var ojämlik, fler barn från fattiga hushåll hade malaria vid provtagningen. Vidare visade resultaten att tillgång till vård och till rätt medicin för barn under 5 år, när de har feber, fortfarande var högre bland de som hade högre socioekonomisk status i 2018. Det var stor skillnad mellan staterna och vissa av dessa hade stor ojämlikhet medan andra hade nått jämlikhet. Resultaten visade även att lägre utbildning hos förmyndare och att bo på landsbygden kan hänga ihop med att barnen hade lägre tillgång till vård och rätt medicinering, dock krävs ytterligare undersökningar för att kunna fastställa det mer korrekt.

Sammanfattningsvis finns det trots viss förbättring fortfarande stora ojämlikheter och orättvisor gällande preventiva åtgärder och behandling av malaria mellan fattiga och rika samtidigt som malariasjukdom är högst bland de fattiga. Därför behövs fler och fortsatta åtgärder speciellt riktade mot de fattiga. Förslagsvis utökning av kvalificerade vårdgivare för att tillgängliggöra bra vård för alla och subventionering av vård och medicinering för de fattiga. Denna forskning kan användas av vårdorganisationer för att se vilka stater som är i störst behov av hjälp för att uppnå jämlikhet samt för att höja användandet och tillgången av malariaprevention och behandling, för att slutligen kunna bekämpa malaria.

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Appendices

Appendix 1. Concentration index by state for each outcome in 2008 with confidence intervals.

Concentration index 2008	ITN access			ITN use			Access to care			ACT treatment		
State	Value	Lower 95% CI	Upper 95% CI	Value	Lower 95% CI	Upper 95% CI	Value	Lower 95% CI	Upper 95% CI	Value	Lower 95% CI	Upper 95% CI
Sokoto	0.265	-0.038	0.568	0.085	-0.176	0.347	**0.238***	0.088	0.388	-0.227	-0.786	0.333
Zamfara	0.068	-0.219	0.354	**0.484***	0.306	0.663	0.088	0.019	0.157			
Katsina	0.736	-0.004	1.477	**0.718***	0.111	1.324	0.055	-0.001	0.111	0.158	-0.180	0.495
Jigawa	**0.181***	0.063	0.299	0.108	-0.025	0.241	0.035	0.004	0.065	0.144	-0.271	0.558
Yobe	0.413	0.077	0.750	**0.474***	0.147	0.802	0.017	-0.041	0.075	-0.156	-1.168	0.856
Borno	**0.537***	0.314	0.760	**0.556***	0.286	0.827	0.073	-0.001	0.148	**0.740***	-0.004	1.485
Adamawa	**0.492***	0.124	0.859	**0.440***	0.053	0.828	0.039	-0.120	0.199	**0.459***	0.101	0.817
Gombe	0.240	0.035	0.444	0.167	-0.016	0.350	0.027	-0.026	0.079	0.153	-0.396	0.702
Bauchi	**0.490***	0.210	0.770	**0.436***	0.083	0.789	0.034	0.002	0.066	-0.006	-0.204	0.192
Kano	**0.554***	0.291	0.817	**0.509***	0.311	0.708	0.09	0.038	0.143	-0.017	-0.768	0.733
Kaduna	0.348	0.028	0.668	**0.343***	0.046	0.639	**-0.075***	-0.159	0.010			
Kebbi	**0.326***	0.092	0.560	**0.323***	0.047	0.599	0.053	0.004	0.103	0.373	-0.122	0.869
Niger	0.368	0.099	0.636	0.186	-0.071	0.442	0.065	-0.029	0.160	0.445	-0.157	1.048
Abuja	0.164	-0.016	0.345	0.181	-0.003	0.365	0.057	-0.020	0.134			
Nasarawa	0.163	0.006	0.319	**0.156***	0.010	0.302	**0.0190***	-0.052	0.090	0.18	-0.062	0.422
Plateau	**0.339***	0.236	0.442	**0.396***	0.246	0.546	0.029	-0.054	0.111	-0.411	-1.086	0.265
Taraba	0.504	0.102	0.907	0.475	0.119	0.830	0.05	0.005	0.096	-0.207	-0.500	0.086
Benue	0.587	0.103	1.072	0.423	0.015	0.832	0.066	0.005	0.127	0.447	-0.466	1.359
Kogi	0.066	-0.224	0.357	-0.119	-0.469	0.230	0.107	-0.051	0.265	0.25	-0.567	1.067
Kwara	**0.481***	0.178	0.785	**0.411***	0.182	0.639	0.271	0.156	0.386	-0.169	-1.030	0.693
Oyo	0.294	-0.134	0.723	-0.041	-0.349	0.268	0.02	-0.132	0.171	-0.885	-2.516	0.745
Osun	0.618	-0.090	1.326	**0.479***	0.198	0.759	0.091	-0.027	0.209	0.675	0.149	1.200
Ekiti	**0.356***	0.206	0.507	0.266	0.149	0.383	0.025	-0.106	0.156			
Ondo	**0.382***	0.124	0.640	**0.277***	0.015	0.539	0.074	-0.077	0.225			

Edo	-0.046	-0.237	0.145	-0.116	-0.477	0.246	0.016	-0.057	0.088	0.292	-0.153	0.738
Anambra	-0.213	-0.543	0.116	-0.025	-0.293	0.243	0.006	-0.066	0.078			
Enugu	0.135	-0.127	0.398	-0.082	-0.446	0.281	0.083	-0.019	0.185			
Ebonyi	0.200	0.033	0.368	0.140	-0.017	0.297	0.056	-0.032	0.143	-0.145	-0.601	0.312
Cross River	0.152	-0.029	0.332	0.111	-0.053	0.274	0.025	-0.044	0.094	0.248	-0.262	0.757
Akwa Ibom	0.119	-0.119	0.357	0.010	-0.281	0.301	0.04	-0.041	0.122	0.546	-0.074	1.166
Abia	0.259	0.037	0.482	0.207	-0.099	0.514	0.06	-0.023	0.144			
Imo	0.142	0.009	0.274	0.108	-0.070	0.286	0.024	-0.044	0.092			
Rivers	0.276	0.106	0.447	0.062	-0.137	0.261	0.071	0.001	0.141	**0.582***	0.207	0.957
Bayelsa	-0.228	-0.496	0.040	-0.210	-0.464	0.044	0.015	-0.091	0.121	0.333	-0.236	0.902
Delta	-0.361	-0.806	0.083	-0.427	-0.773	-0.080	0.11	0.031	0.190	0.4	-0.235	1.036
Lagos	-0.013	-0.114	0.088	-0.171	-0.343	0.002	-0.012	-0.089	0.064	0.095	0.017	0.173
Ogun	-0.021	-0.251	0.208	-0.048	-0.312	0.216	0.092	-0.107	0.291			
Total	**0.217***	0.169	0.266	**0.139***	0.089	0.189	0.047	0.032	0.062	0.167	0.032	0.302
CI -confidence intervals. *Significant change between the years (no overlapped CIs)												

Appendix 2. Concentration index by state for each outcome in 2008 with confidence intervals. Significant change between the years is marked with bold and "".*

Concentration index 2018	ITN access			ITN use			Access to care			ACT treatment		
State	Value	Lower 95% CI	Upper 95% CI	Value	Lower 95% CI	Upper 95% CI	Value	Lower 95% CI	Upper 95% CI	Value	Lower 95% CI	Upper 95% CI
Sokoto	0.008	-0.023	0.038	**0.003**	-0.027	0.032	**-0.008***	-0.056	0.040	0.145	-0.070	0.361
Zamfara	0.033	-0.038	0.104	**0.049***	-0.013	0.111	0.179	0.019	0.339	0.207	-0.415	0.828
Katsina	-0.011	-0.040	0.018	**-0.020***	-0.053	0.013	0.04	0.006	0.074	0.032	-0.093	0.157
Jigawa	**-0.008***	-0.019	0.003	-0.016	-0.029	-0.002	0.029	0.002	0.057	-0.021	-0.107	0.066
Yobe	0.045	-0.002	0.091	**0.062***	0.009	0.114	0.026	0.002	0.049	-0.002	-0.292	0.288
Borno	**-0.058***	-0.113	-0.003	**-0.084***	-0.144	-0.024	0.12	0.061	0.179	**-0.227***	-0.329	-0.126
Adamawa	**0.055***	-0.004	0.114	**0.028***	-0.040	0.096	0.167	0.062	0.273	**-0.105***	-0.195	-0.014
Gombe	-0.014	-0.075	0.047	**-0.009**	-0.063	0.045	0.023	-0.005	0.052	-0.042	-0.164	0.080
Bauchi	**0.013***	-0.051	0.077	**-0.003***	-0.053	0.048	0.068	0.027	0.109	0.063	-0.061	0.186
Kano	**-0.005***	-0.032	0.022	**-0.014***	-0.040	0.012	0.028	-0.003	0.060	0.119	0.019	0.218
Kaduna	0.01	-0.049	0.070	**-0.029***	-0.077	0.018	**0.063***	0.013	0.112	0.308	-0.187	0.803
Kebbi	**0.015***	-0.001	0.031	**-0.001***	-0.012	0.011	0.051	0.017	0.086	0.004	-0.025	0.034
Niger	0.057	-0.018	0.133	0.02	-0.051	0.092	0.09	0.015	0.165	-0.011	-0.057	0.035
Abuja	0.045	-0.044	0.135	0.031	-0.050	0.112	0.032	-0.019	0.083	0.322	0.077	0.567
Nasarawa	-0.014	-0.061	0.034	**-0.067***	-0.119	-0.016	**0.232***	0.117	0.347			
Plateau	**0.070***	-0.017	0.157	**0.069***	-0.010	0.148	-0.11	-0.214	-0.007	0.124	-0.085	0.334
Taraba	0.126	0.033	0.218	0.108	0.007	0.208	0.048	-0.028	0.123	0.134	0.032	0.235
Benue	0.055	0.003	0.107	0.036	-0.014	0.086	-0.01	-0.036	0.017	-0.223	-0.472	0.026
Kogi	0.076	0.027	0.126	0.036	-0.011	0.083	0.014	-0.113	0.140	0.049	-0.242	0.339
Kwara	**0.060***	0.002	0.117	**-0.076***	-0.147	-0.005	0.167	0.026	0.307	0.135	-0.088	0.358
Oyo	0.05	0.000	0.099	0.041	-0.002	0.084	0.104	0.054	0.154	0.001	-0.422	0.423
Osun	0.087	0.019	0.154	**0.024***	-0.045	0.094	0.163	0.084	0.242	0.105	-0.083	0.293
Ekiti	**0.018***	-0.046	0.082	-0.075	-0.171	0.020	0.007	-0.084	0.098	0.266	0.001	0.530
Ondo	**-0.003***	-0.031	0.025	**-0.070***	-0.120	-0.019	-0.048	-0.183	0.087	0.016	-0.152	0.184
Edo	0.008	-0.067	0.082	0.02	-0.101	0.140	0.033	-0.040	0.106	-0.044	-0.324	0.237
Anambra	0.014	-0.054	0.083	-0.01	-0.090	0.070	0.018	-0.008	0.043	-0.051	-0.114	0.011
Enugu	0.003	-0.065	0.071	0.005	-0.079	0.089	0.041	0.008	0.075	0.068	-0.031	0.168
Ebonyi	0.043	0.013	0.074	0.014	-0.029	0.057	0.047	-0.008	0.102	-0.019	-0.052	0.013
Cross River	0.009	-0.059	0.077	-0.018	-0.093	0.057	0.016	-0.040	0.071	0.169	0.039	0.299
Akwa Ibom	-0.108	-0.174	-0.042	-0.146	-0.218	-0.073	-0.015	-0.076	0.047	0.164	0.104	0.225
Abia	-0.013	-0.080	0.054	0.069	-0.015	0.153	0.018	-0.047	0.083	-0.195	-0.591	0.201
Imo	0.083	0.022	0.144	0.207	0.042	0.372	0.061	-0.046	0.168	0.103	0.038	0.167
Rivers	0.146	0.069	0.222	0.113	0.035	0.191	0.013	-0.016	0.043	**0.083***	-0.015	0.181
Bayelsa	-0.033	-0.098	0.033	-0.097	-0.167	-0.028	-0.05	-0.147	0.048	0.16	0.004	0.315
Delta	-0.046	-0.103	0.012	-0.09	-0.145	-0.034	0.021	-0.283	0.325	0.41	-0.255	1.076
Lagos	0.029	-0.014	0.072	-0.011	-0.068	0.046	0.026	-0.041	0.094	-0.131	-0.280	0.018
Ogun	-0.027	-0.087	0.033	-0.053	-0.127	0.020	0.021	-0.042	0.084	0.138	-0.016	0.292
Total	-0.074*	-0.089	-0.060	-0.115*	-0.131	-0.099	0.04	0.027	0.052	0.042	0.014	0.069
CI -confidence intervals. *Significant change between the years (no overlapped CIs)												