Inequalities in Under-five Mortality in Nigeria: A Population-based Analysis of Individual- and Community-level Determinants

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Abstract

Background

Regions with geographically diverse ecology and socio-economic circumstances may have different disease exposure and child health outcomes. This study assessed variations in the risks of under-five deaths across regions of Nigeria and determined characteristics at the individual and community levels that explain possible variations between regions.

Methods

Multilevel Cox proportional hazards analysis was performed using a nationally-representative sample of 6029 children from 2735 mothers aged 15-49 years and nested within 365 communities from the 2003 Nigeria Demographic and Health Survey. Odds ratios with 95% confidence intervals were used to express measures of association between the characteristics. Variance partition coefficients and Wald statistic were used to express measures of variation.

Results

Patterns of under-five mortality cluster within families and communities. The risks of under-five deaths were significantly higher for children of mothers resident in the South South (Niger Delta) region (HR = 1.25, 95% CI = 1.01 - 1.57) and children of mothers resident in communities with low proportion of mothers attending prenatal care by doctor (HR = 1.47, 95% CI 1.26 - 1.85). In addition, the cross-level interaction between mothers’ education and community prenatal care by doctor was associated with more than two-fold higher risks of dying (HR = 2.32, 95% CI 1.25 – 4.32).

Conclusion

Findings suggest the need to differentially focus on community-level interventions aimed at increasing maternal and child health care utilization, and improving maternal socio-economic position especially in disadvantaged regions, such as the South South (Niger Delta) region. Findings call for further studies on community-levels determinants of under-five mortality.
Introduction

The reduction of regional and socio-economic inequalities in mortality within countries is a major objective of national governments and international organisations [1-3]. To achieve this goal, determinants of high mortality among disadvantaged people, communities and regions need to be identified. The physical and ecological structure, political, and impoverished socio-economic milieu in several countries in sub-Saharan Africa account for geographic variations in childhood mortality [4-6]. One such environment is the regional environment. Poor or polluted environments tend to expose children to disease-causing agents, predisposing them to high mortality risks [7]. In Nigeria, marked regional disparities in under-five mortality have been reported, with higher rates observed in the Northern regions than in the Southern regions [8-10]; however these were survey reports rather than empirical studies, and the role of explanatory factors were not investigated. Regional disparities in health-seeking behaviour have been reported regarding child immunization [11], maternal and child healthcare utilization [12], differences in the socio-economic composition [13], and communicable diseases [13], childhood nutrition and malnutrition [14]. Other studies have reported higher proportions of home delivery and complications during childbirth [15], younger age of first marriage, younger age at birth of first child, ideal family size, lower knowledge and use of contraception in the Northern regions compared to the Southern regions [16].

Regional disparities in these parameters are associated with factors at the community level that distinguish these regions from each other. The availability of services and social amenities in communities or the lack thereof may positively or negatively influence the health of the residents of communities. Some of these factors include differences in community-level development, population density, prevalence of poverty, and availability of maternal and child healthcare services. These are often interrelated aspects of the regional environment that are important for child health and well-being, and may also be relevant in exacerbating or
mitigating inequities in resources and population health outcomes across regions [7]. Regions may either exert fair independence and autonomy within nations (in which case they become even more salient for child health), or may exhibit greater centralization (in which case regional factors may not be as significant) [7]. A classic example of attempts to attain the former is the South South (Niger Delta) region in Nigeria [17]. Understanding the links between child survival and geographic location is crucial for exhibiting that, within nations, socio-political conditions (and associated factors) may not be homogeneous, and often lead to regional child health inequities. The aims of this study are two-fold: i) to determine whether there is significant variation in the risks of under-five deaths across regions of Nigeria; and ii) to determine the individual- and community-level factors that explain disparities in the risks of under-five deaths between regions.

Data and Methods

Cross-sectional data from the 2003 Nigeria DHS was used in this study. This is a nationally representative sample collected by face-to-face interviews from 3725 women aged 15 to 49 years with a stratified two-stage cluster sampling procedure. An extensive report of the survey could be found elsewhere [18]. Birth history data, such as month and year of birth, survivorship status, and current age or age at death if the child had died were collected for each birth. This sample contained a total of 6029 live born, which was limited to births in the last 5 years before the survey so as to ensure that the household variables investigated provided a close enough or accurate picture of the current living conditions of the children within period they were exposed to increased risks of death.

Ethical considerations

This study is based on analysis of secondary DHS data with all respondent identifiers removed. The survey was approved by the National Ethics Committee in the Federal Ministry...
Measurements

Outcome variable: The outcome variable was the risk of under-5 death (0 – 59 months), defined as a child dying between birth and the fifth birthday. Under-five mortality was estimated for the 5 years preceding the survey. All children between 0 and 59 months of age were included in the estimation and exposure time and cases were observed during this time frame, with all living children 59 months or younger being considered as exposures, that is contributing person-time, and all deaths among children 59 months or younger regarded as cases. Children born during the time frame (at birth) or before the time frame (at any age until 59 months) could enter this time frame. Children that stayed alive after 59 months of age within this time frame were censored after 59 months of age.

Exposure variables: Region of residence of the mother was the main exposure variable, categorized as five sets of dummy variables: a) North Central, b) North East, c) North West, d) South East, and e) South South. The regions comprised of the following states: North Central region (Benue, Kogi, Kwara, Nasarawa, Niger, Plateau states, and Federal Capital Territory, Abuja), North East region (Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe states), North West region (Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto, and Zamfara states), South East region (Abia, Anambra, Ebonyi, Enugu, and Imo states), South South region (Akwa Ibom, Bayelsa, Cross River, Delta, Edo and Rivers states), and South West region (Ekiti, Lagos, Ogun, Ondo, Osun, and Oyo states).

Explanatory factors: Eight additional individual-level factors of interest were examined: i) birth order, consisting two dummy variables a) first births, and b) 5th or higher birth order; ii) sex of the child, female; iii) mother’s age, consisting two dummy variables a) 15 – 23 years;
and b) 34 years or older; iv) mother’s age at birth of first child, 18 years or younger; v) marital status, consisting two dummy variables a) single; and b) divorced; vi) mother’s education, consisting two dummy variables a) no education; and b) primary education; and vii) wealth index, consisting of two dummy variables a) poorer wealth quintile, and b) richer wealth quintile. Wealth index was applied in this analysis as a composite index and an indicator of the socio-economic status of households since the DHS does not generally collect information on household income or wealth. It is consistent with expenditure and income measures in low- and middle-income countries. It assigns weights or factor scores generated by principal component analysis to information on household assets collected from censuses and surveys. These indicators include those relating to household ownership of durable assets and household environmental conditions. Principal components analysis allows each asset owned to be given a score, and the factor loading scores used to create linear composites of each household socio-economic status variable. The scores were then summed up and divided into quintiles (poor, middle, and rich) to represent different levels of wealth.

Cross-level interactions between individual- and community-level measures of socio-economic position provide the opportunity to explore whether community-level effects are different for children of mothers in low socio-economic position. Interaction effects were assessed as a) cross-level interaction between mother’s age at birth of first child and community prenatal care by doctor; and b) cross-level interaction between mother’s education and community prenatal care by doctor.

Three community-level factors were assessed: i) community mother’s education, defined as the percentage of mothers with secondary or higher education in the PSU, consists of two subsets of dummy variables: a) low, and b) high. This variable was selected because higher levels of maternal education are associated with better child health outcomes like childhood mortality and child immunization rates [19, 20], thus the proportion of mothers with
secondary of higher education is a predictor of child survival. ii) community hospital delivery, defined as the percentage of mothers who delivered their child in the hospital in the PSU, consists of two subsets of dummy variables: a) low, and b) high; and iii) community prenatal care by doctor, defined as the percentage of mothers who had prenatal care provided by a doctor, consisting of the dummy variable low. Prenatal care directly increases the chances that mothers would access subsequent health care services for their child, such as delivery in a health institution as well as mother and child immunization [21, 22]. Hospital delivery is also one of the most important preventive measures against maternal and child health outcomes and an important determinant of full immunization [23, 24]. Hence the proportion of mothers that received prenatal care and that delivered in a hospital setting are both salient predictors of child survival, hence their inclusion in the analysis.

The contextual variables were at the level of the PSU (n = 365). Primary sampling units are small administratively defined areas designed to be fairly homogenous units in relation to population socio-demographic characteristics, economic status and living conditions. They are used as proxies for “neighbourhoods” or “communities” [25, 26] and contain one or more enumeration areas, which are the smallest geographic units for which census data are available in Nigeria. Each cluster consisted of a minimum of 50 households, with a contiguous enumeration areas added when a cluster had less than 50 households [18].

**Statistical analysis**

The distribution of the individual- and community-level characteristics in the sample was assessed separately by region of residence in order to assess the unadjusted effect of these individual- and community-level characteristics on region of residence. Data were analysed using multilevel Cox proportional hazards analysis [27], which models censored time-until-event data as a dependent variable where one can assume that the covariates have a
multiplying effect on hazard rates and warrants recoding characteristics in dummy variables.
The association between under-five mortality and individual- and community-level characteristics were assessed separately (in order to show how regional variation is built up from variation on various levels) as well as successively. Measures of association (fixed effects) are expressed as hazard ratios (HR), 95% confidence intervals (95% CIs) and \( p \)-value. Measures of variation (random effects) are expressed as intraclass correlation (ICC), which is a measure of the relatedness of clustered data. Generalized linear and latent mixed models (gllamm) were used to perform the three-level multilevel analysis using Stata version 10.0 [28].

Four models were fitted in the analysis containing individual- and community-level characteristics. Model 0 (empty model) contained no explanatory variable since its role was to decompose the total variance into its individual- and community-level components, and to identify a possible contextual phenomenon that can be quantified by clustering of under-five mortality within neighbourhoods [29]. Model 1 contained region of residence as the only explanatory variable to assess the gross effects of region of residence before netting out the effects of other variables, and Model 2 added sex of the child and birth order. Model 3 included the mother-level variables (mother’s age, mother’s age at birth of first child, marital status, mother’s education, wealth index, and cross-level interactions between community prenatal care by doctor and mother’s age at birth of first child as well as mother’s education). Finally, Model 4 added community-level variables (community mother’s education, community hospital delivery, and community prenatal care by doctor). The simultaneous inclusion of both individual- and neighbourhood-level predictors in the multilevel logistic regression model permits: \( i \) the examination of neighbourhood or area effects after individual-level confounders have been controlled for; \( ii \) the examination of individual-level characteristics as modifiers of the area effect (and vice versa); and \( iii \) the simultaneous
examination of within- and between neighbourhood variability in outcomes, and of the extent to which between-neighbourhood variation is “explained” by individual- and neighbourhood-level characteristics [30, 31].

Results

*Characteristics of children and women by region of residence*

Examination of individual-level characteristics across regions of residence shows that children in the Northern regions constituted most of the study sample. Mothers who had secondary of higher education were most likely from the Southern regions, while mothers from the Northern regions were mostly in the middle and poor wealth quintiles, and were 18 years or younger at the birth of their first child (Table 1). An assessment of community-level characteristics across regions of residence in the study sample indicated that children in the Northern regions constituted most of the study sample. Most of the mothers in the North East and North West regions lived in communities with low proportion of mothers who attended prenatal care by doctor, while most of the mothers in the North Central and North East regions lived in communities with the proportion of mothers who had hospital delivery, as well as in communities with the proportion of mothers with secondary or higher education at the median level for the community. In contrast, most of the mothers in the Southern regions lived in communities with high proportion of mothers who attended prenatal care by doctor, and within the South East and South West regions in communities with a high proportion of mother who had hospital delivery. Mothers in the North Central and North East regions who lived in communities with the proportion of secondary or higher education at the median level for the community made up most in the sample (Table 2).
Risk factors of under-five mortality

The risk factors for under-five mortality by region of residence were controlled separately for individual-level factors, and finding showed that the risks of under-five deaths were almost two-fold higher for children of mothers residing in the North East (HR = 1.70, 95% CI = 1.14 - 2.53), North West (HR = 1.68, 95% CI = 1.14 - 2.53), and South South (HR = 1.90, 95% CI = 1.22 - 2.97) regions compared with children of mothers in the South west region. The risks of dying were higher for children of ≥ 5 birth order (HR = 1.57, 95% CI = 1.22 - 2.02), children of mothers with no education (HR = 1.68, 95% CI = 1.26 - 2.24), primary education (HR = 1.62, 95% CI = 1.23 - 2.15) and in the poor wealth quintile (HR = 1.30, 95% CI = 1.04 - 1.62). In contrast, the risks of dying were lower for children of mothers in the middle wealth quintile (HR = 0.71, 95% CI = 0.54 - 0.92) (Table 3).

The risk factors for under-five mortality by region of residence were controlled separately for community-level factors. Children or mothers resident in the South South region had 15% higher risk of under-five death (HR = 1.15, 95% CI = 1.06 - 1.90) compared with children of mothers in the South West region. In addition, the risks of dying were higher for children resident in communities with low proportion of mothers who attended prenatal care by doctor (HR = 1.68, 95% CI = 1.46 - 1.98) and who had hospital delivery (HR = 1.34, 95% CI = 1.04 - 1.72), while the risks of dying were lower for children resident in communities with high proportion of hospital delivery (HR = 0.66, 95% CI = 0.44 - 0.98) (Table 4).

The risk factors for under-five mortality by region of residence were controlled simultaneously for individual- and community-level factors. Region of residence was included as the only explanatory variable in Model 1 to assess the independent influence of region of residence on the risks of under-five deaths, and was significantly associated with the risks of under-five deaths, with about two-fold higher risks for children of mothers resident in the North East (HR = 2.41, 95% CI = 1.63 - 3.57), North West (HR = 2.28, 95% CI = 1.56 -
3.34) and South South (HR = 1.85, 95% CI = 1.17 - 2.91) compared with children of mothers resident in the South West region. The risks of under-five deaths were attenuated with the inclusion of child, mother and community characteristics. In the final model (Model 4), children of mothers resident in the South South region had 25% higher risks of dying (HR = 1.25, 95% CI = 1.01 - 1.57) compared with children of mothers resident in the South West region (Table 5).

Furthermore, children of ≥ 5 birth order and of divorced mother had 64% (HR = 1.24, 95% CI 1.24 - 2.18) and 76% (HR = 1.76, 95% CI 1.09 - 2.84) higher risks of under-five deaths compared with children of 2nd – 4th birth order and married mothers, respectively. The risks were more than two-fold higher for children of mothers with no education (HR = 2.24, 95% CI 1.51 – 3.34), primary education (HR = 1.93, 95% CI 1.35 - 2.77) compared with children of mothers with secondary or higher education. The cross-level interaction between mothers’ education and community prenatal care by doctor was associated with more than two-fold higher risks of dying (HR = 2.32, 95% CI 1.25 – 4.32). Low proportion of mothers attending prenatal care by doctor in the community was associated with 47% (HR = 1.47, 95% CI 1.26 - 1.85) higher risks of under-five deaths compared with high proportions.

**Discussion**

This study showed that under-five mortality was significantly associated with region of residence, with higher risks of under-five deaths for children of mothers resident in the South South region after adjusting only for individual-level risk factors, only for community-level risk factors, as well as after simultaneously adjusting for individual- and community-level risk factors. Findings indicate that demographic factors such as birth order, socio-economic factors such as marital status, mothers’ education, and community-level factors such as living in communities with low proportion of mothers that received prenatal care by doctor are the
main predictors of regional under-five mortality in this study. These may be associated with spatial inequality in social development in the community within regions, which may also be associated with population density, differential levels of regional development, political and ethno-religious situations, as well as varying economic resources [32]. These factors reflect the situation in the South South region of Nigeria, which is reported to suffer from deficient social infrastructure and services (schools, roads, electricity and health services), high unemployment, social deprivation and endemic conflict, in spite of the region accounting for over 90% of Nigeria’s proven gas and oil reserves and the nation's wealth [33, 34]. Geographically, the region is characterized by extensive mangrove forests, extensive networks of lagoons and swamps affected by environmental degradation from crude oil spillage and pollution. These conditions may be related with the increased risks of under-five deaths for children in this region.

In addition, cross-level interaction between mother’s education and community prenatal care by doctor (i.e. mothers who had no education and lived in communities with low community prenatal care by doctor) was associated with more than two-fold increase in risks of under-five deaths. Although the specific mechanisms underlying the increased mortality are unknown, plausible explanations may include the fact that mothers with little or no education residing in communities deprived of prenatal care by doctor are more vulnerable because they are generally poor and lack the economic means for essential goods and services (healthcare, medications, and transportation) than mothers with higher education and access to prenatal care.

The risks of under-five deaths were higher for $\geq 5$ birth order. The influence of birth order on various types of child outcomes is largely dependent on the social and cultural context and may be associated with social disadvantages within families, and communities [35], given that large sibships may be a marker for low socio-economic status [36], and erosion of nutritional
resources [37, 38]. This study also found that lower socio-economic position (divorce, no
education, and primary education) was associated with increased risks of under-five deaths,
which is in agreement with findings from previous studies indicating that higher socio-
economic position of individuals and populations strongly influences health-seeking
behaviour, and is associated with better health [39, 40].
Furthermore, living in communities with low percentage of mothers that received prenatal
care by doctor was associated with higher risks of under-five deaths. This could be explained
by lower access to prenatal care directly increasing the chances that mothers in the
community would not utilize health care services, such as institutional delivery and
immunization for their child [41, 42]. Timely access to prenatal care by doctor is an important
preventive measure against maternal and child health outcomes such difficult or obstructed
labour, postnatal bleeding, and child deaths [43, 44]. Community prenatal care by doctor is
also an indication of the quality of care received by the mother and infant during child birth.
This association at the community level is also a reflection of socio-economic position at the
individual level, since individual socio-economic position strongly influences health-seeking
behaviour by enhancing mothers’ perception of disease aetiology and treatment patterns,
which result in improved health and welfare of their child. Higher socio-economic position
empowers mothers and enhances their decision-making power. Community-level variation
remained significant after controlling for individual- and community-level variables,
indicating that differences among communities still remain unexplained and a need for further
exploration of community-levels determinants of under-five mortality. This finding is also
validated by the result of the cross-level interaction.
The intraclass correlation across communities in all the models and across mothers in **Models**
1 was significantly different from zero, implying that there are significant differences in the
risks of under-five deaths between communities in all the models and between mothers in Models 1 (with region of residence as the only explanatory variable).

The geo-political regions of low- and middle-income countries such as Nigeria are an important sphere of influence on child survival. As such, findings show the relevance of adopting a more spatially disaggregated, community-level approach to regional policies, given that regions are usually made up of peoples and communities sharing similar geographical, political, socio-economic and cultural characteristics that either promote or inhibit health-seeking behaviour and access to healthcare facilities.

Several limitations need to be considered when interpreting findings in this study. First, administratively defined boundaries were used as a proxy for neighbourhoods or communities in this study. There is an inherent risk of non-differentially misclassifying individuals into inappropriate administrative boundaries, which may generate information biases and reduce the validity of the analysis. Second, data on household income or expenditure, which are the indicators commonly used to measure wealth are not routinely collected in DHS surveys. The assets-based wealth index used in this study is only a proxy indicator for individual/household economic status and may not always produce results similar to those obtained from direct assessments of income and expenditure where such data are available or can be reliably collected [45, 46]. The strengths of this study are also worth mentioning and include: i) DHS surveys are nationally-representative and enable the generalization of the results across the country; ii) the DHS variables are defined similarly across countries and results are therefore comparable across countries [47, 48]; and iii) using administrative boundaries permits the comparability of any set of DHS data on the same geographical frame, or of presenting complex data in a simple way, provided there is a good conceptual framework of the studied territory.
Conflict of interests

None to declare

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