Socioeconomic inequalities in early childhood malnutrition and morbidity: Modification of the household-level effects by the community SES

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1. Background

Malnutrition and infectious diseases among preschoolers feature prominently among the major public health concerns in developing countries (UNICEF, 1998; WHO, 1999; Kuate-Defo, 2001). Childhood malnutrition is widespread and is associated with increased susceptibility to disease and risk of mortality, and with poor mental development and learning ability. There is also a growing evidence of reduced work efficiency and poor reproductive outcomes among individuals who experienced persistent malnutrition during childhood (De Onis et al., 2000; UNICEF, 1998; Adair and Guilkey, 1997; Wagstaff and Watanabe, 2000). On the other hand, diarrhea and acute respiratory infections (ARI) are contributing factors to malnutrition and major causes of morbidity and mortality among preschoolers in the third world. The burden of diarrhea is highest in deprived areas where there is poor sanitation, inadequate hygiene and unsafe drinking water, and ARI often affects children with low birth weight or those whose immune systems are weakened by malnutrition or other diseases (WHO, 1999; Forste, 1998). Consequently, children living in impoverished familial or residential environments are caught in a vicious circle of poor nutrition, impaired immune function and barrier protection, and increased susceptibility to infectious diseases, leading to decreased dietary intake, immunological dysfunction and metabolic responses that further alter their nutritional status (Brown, 2003; Tomkins and Watson, 1989; Scrimshaw et al., 1968; Chandra, 1997).

The causes of malnutrition and morbidity are diverse, multi-sectoral, interrelated and entail biological, social, cultural and economic factors, and their influences operate at various levels such as child, family, household[1], community[2] and nation. The socioeconomic statuses (SES) of individuals, households and communities are basic determinants of child health, since poverty remains the root cause of the more proximate correlates such as limited access to education, health care and foods, as well as poor environment and housing, and large family

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[1] In this paper, the term "Household" is used interchangeably with "Family".

[2] The term community, area and neighborhood are used interchangeably to refer to a person's residential environment which is hypothesized to have characteristics potentially related to health.

size (Gopalan, 2000; Emch, 1999; FAO, 1997). Empirically, a large body of research has documented inverse relationship between SES and a variety of health outcomes over time and in different countries, regardless of the measure of the SES (Kuate-Defo, 2001; 1996; Adair and Guilkey, 1997; Ricci and Becker, 1996; Emch, 1999). Furthermore, researchers and policy makers increasingly recognize that although human health has improved in the past decades, the gap between rich and poor remains very wide just as it does also between the better-off and disadvantaged groups defined, for example, by place of residence, education, and job status. Addressing the problems of inequalities in child health, both between countries and within countries, remains therefore one of the greatest challenges, and is of special appeal for policies and programs targeting child's welfare and survival (Feachem, 2000).

Unfortunately, the literature on these topics is built mainly on evidence from industrialized countries (Alvarez-Dardet, 2000). For developing countries research on these issues has focused mainly on mortality, and there has been comparatively very little research regarding morbidity or malnutrition. Importantly, in the absence of standard conceptualization and measurement of SES, researchers have typically used their own socioeconomic indicators, thus making comparisons highly difficult. Moreover studies in this area are rarely based on nationally representative data within a comparative perspective, and their modelling strategies often ignore the hierarchical structure of the data.

Against this background, this study is designed in an attempt to examine variations among communities in childhood malnutrition and morbidity, and to investigate how the SES of communities and that of households affect child health regardless of their individual characteristics, and how they interact in this process (Robert, 1999; Diez-Roux, 2001; 1998; Duncan et al., 1998; 1996). More specifically, the motivation is to test the following hypotheses: (i) Childhood malnutrition and diarrhea morbidity cluster among communities, according to patterns consistent with the presence of contextual effects; (ii) Malnutrition and diarrhea morbidity occur more frequently among children from households and communities with lower SES; (iii) The household socioeconomic influences on child health are modified by the SES of communities.

The first hypothesis relates to the presence of contextual effects in explaining child health, since the variation among communities may arise from compositional effects with particular types of people, who are more likely to experience poor health due to their individual characteristics, being found more commonly in particular communities or households (Kuate-

Defo and Diallo, 2002; Pickett and Pearl, 2001; Macintyre et al., 1993). Our second hypothesis pertains to the association between health status and SES that has been so widely documented in variety of settings and contexts, with special interest in examining the independent influence of the community SES over and above the effects associated with household SES (Robert, 1999; Diez-Roux, 2001; Duncan et al., 1998), and in exploring evidence of co-occurrence between malnutrition and morbidity, since both outcomes theoretically influence each other (Brown, 2003; Tomkins and Watson, 1989; Scrimshaw et al., 1968). The third hypothesis is about potentially interactive effects whereby the socioeconomic position of families and those of their communities of residence interact to produce substantively different expression of child health outcomes (Robert, 1999; Gordon et al., 2003; Sastry, 1996).

The remainder of this paper is divided into four sections: The first sets out a conceptual framework for the analysis of household and community socioeconomic influences on child health, followed by a presentation of the data and methods used in this work. Results of the analyses are object of a third section, and the main findings are outlined and discussed in a concluding section.

2. Conceptual framework

Along the lines of Mosley and Chen's (1984) and UNICEF's (1990) frameworks, we postulate that socioeconomic factors at different levels (community, family) operate through more proximate determinants to influence child's nutritional and morbid statuses, as depicted in Figure 1. These factors include: (i) household size and composition that may be measured by both the total number of its members and especially those under five years of age as well as the gender composition of the household; (ii) access to and utilisation of health care services, especially for antenatal care, delivery and immunization of children; (iii) mother's nutritional behaviour and status proxied by breastfeeding patterns and body mass index; (iv) mother's reproductive patterns and cultural practices, encompassing age at puberty, age at sexual debut, age at maternity, birth spacing practices, religious affiliation and religiosity, and exposure to media; and (v) child's characteristics, prominent among which are biological variables such as age, sex, birth weight, gestational length, health conditions at birth, and birth order. The literature yields mounting evidence of the effects of these factors on child's health (Adair and Guilkey, 1997; Kuate-Defo, 2001; Ricci and Becker, 1996; Forste, 1998; Cebu Study Team, 1991).

2.1. Socioeconomic factors

The socioeconomic factors that influence child health include family-level variables such as education and employment, income and ownership of consumer durable goods, type of drinking water, sanitation and housing; as well as community-level covariates captured by the availability of health-related services and relevant socioeconomic infrastructures. A number of studies (Armar-Klemesu et al., 2000; Bicego and Boerma, 1993; Dargent-Molina et al., 1994; Sandiford et al., 1995) have supported the general evidence that maternal schooling is a stronger determinant of child welfare in developing countries, estimated to influence her choices and to increase her skills and behaviours related to preventive care, nutrition, hygiene, breastfeeding, among others. Empirically, educated women are more likely to take advantage of modern health care services in caring for their children, and are more aware of the nutritional problems their children may face, while in contrast, inadequate or improper education often exacerbates women's inability to generate resources for improved nutrition for their families (Mosley and Chen, 1984; UNICEF, 1990; Kuate-Defo and Diallo, 2002). The household socioeconomic factors mainly influence its member's health through the financial ability to secure goods and services that promote better health, help to maintain a more hygienic environment, and ensure adequate nutrition needs. For example, lack of ready access to water and poor environmental sanitation are important underlying causes of both malnutrition and diseases. The presence of electricity, radio, television, the availability of transportation means as well as housing – both size and quality - also feature prominently among the household-level determinants of child's health (Mosley and Chen, 1984; UNICEF, 1990; Kuate-Defo, 2001).

[Figure 1 about here]

As shown in the framework depicted in Figure 1, community socioeconomic factors may influence child health and survival by shaping the family/household-level SES, or by directly affecting the social, economic and physical environments shared by residents, which in turn operate through more proximate attributes to impact on health outcomes (Mosley and Chen, 1984; Robert, 1999). In effect, health-related services and other socioeconomic infrastructure such as schools and markets, public services such as electricity, water, sewerage, transportation and telephone networks, are likely to be quite inadequate in lower socioeconomic communities with often deleterious consequences on child's health. And even when these basic services and foods may be available in deprived areas, their access may be hampered by barriers such as inadequate or unsafe transportation systems (Mosley and Chen, 1984). An often made critique of cross-sectional studies investigating contextual effects of neighbourhood is that people may be selected into communities based on values of the outcome being investigated, especially when the outcome under study or some of its factors may influence where people can or choose to live. For instance, Sastry (1996) and Robert (1999) suggested that community-level services and infrastructure may be determined endogenously as they may be located in areas of especially high prevalence of ill-health outcomes, or individuals may choose to migrate to communities on the basis of their demand for a particular mix of community services and amenities. However, community variables are treated as exogenous in the present study because of the absence of data to apply appropriate corrections.

2.2. Effects modification: Cross-level socioeconomic interactions

Of particular importance in this study is the investigation on potentially interactive effects whereby the socioeconomic position of families and those of their communities of residence interact to produce substantively different expression of child health outcomes, or more precisely, the extent to which community factors moderate, exacerbate or mitigate the effects of the household SES on child health (Duncan et al., 1998; Robert, 1999; Gordon et al., 2003; Sastry, 1996). Assignment of community SES and household SES to what Jaccard (2001) refers to as *moderator variable* and *focal variable* respectively, may seem arbitrary in a general context since as did Sastry (1996), one may wish to examine whether household socioeconomic factors modify the effects of community characteristics. In a multilevel context however, investigating effects modification by community-level factors is probably more compelling, as many of the conceptual frameworks are driven by the assumption that higher levels constructs moderate the effects of lower levels factors (Gordon et al., 2003). Our research question also pertains to issues of community characteristics complementing or substituting for certain household attributes (Sastry, 1996), of *double jeopardy* or *relative deprivation* (Robert, 1999). More specifically, it relates to whether higher community SES lessens or even eliminates, or alternatively initiates or enlarges the effects of the household SES on child health. Gordon et al. (2003) refer to these patterns as *lessening/eliminating* model and *initiating/enlarging* model respectively.

2.3. Co-occurrence of malnutrition and morbidity

Since the publication of the World Health Organization monograph by Scrimshaw et al (1968), studies in the field of malnutrition and diarrhea have generally been carried out in one of the three major areas: (i) nutritional risk factor for diarrhea (Etiler et al., 2004; Emch, 1999); (ii) effects of diarrhea on nutritional status (Adair and Guilkey, 1997; Tharakan and Suchindran, 1999; Madise et al., 1999); and (iii) dietary management of patients with diarrhea

(Brown, 2003). With cross-sectional data, it may not be very meaningful to tease apart the independent effects of malnutrition on infection and vice-versa, since both outcomes are potentially endogenous variables. It may be more appropriate to investigate the correlates of the presence of malnutrition alone, diarrhea alone, or the two together.

3. Data and methods

3.1. Data

To achieve the objectives of this study, we use data from the Demographic and Health Surveys (DHS) of five African countries which have carried out more than one DHS in the 90s: Burkina Faso (1992/93, 1998/99); Cameroon (1991, 1998); Egypt (1992, 2000); Kenya (1993, 1998) and Zimbabwe (1994, 1999). The selected countries exhibit quite different socioeconomic and demographic profiles, with Burkina Faso being one of the least developed country and Egypt by contrast, one of the most affluent. Hence, although they are not representative of the entire African continent, their geographic location (West, Central, North, East and Southern Africa) and socioeconomic and cultural diversities constitute a good yardstick for the continent and may allow us to draw some robust inferences. Basically, the DHS retrieve detailed nutrition and health related information on women aged 15-49 years and their children born in the three or five years preceding the survey date, and on relevant child, mother, household and community characteristics. From here we refer to the first and second surveys in each country as DHS-1 and DHS-2 respectively.

Dependent variables: Nutritional and morbid statuses of children

Among various growth-monitoring indices, there are three commonly used comprehensive profiles of malnutrition in children namely stunting, wasting and underweight, measured by height-for-age, weight-for height, and weight-for-age indexes respectively. More specifically, stunting or growth retardation, or chronic protein-energy malnutrition (PEM) results in young children from recurrent episodes or prolonged periods of nutrition deficiency for calories and/or protein available to the body tissues, inadequate intake of food over a long period of time, or persistent or recurrent ill-health. Wasting or acute PEM captures the failure to receive adequate nutrition during the period immediately before the survey, resulting from recent episodes of illness and diarrhea in particular, or from acute food shortage. Underweight status is a composite of the two preceding ones, and can be due to either chronic or acute PEM (Kuate-Defo, 2001). As recommended by the World Health Organization, children whose index is more than two standard deviations below the median NCHS/CDC/WHO[3] reference population are classified as malnourished, that is stunted, wasted or underweight depending on the index used.

For children's morbid status, DHS data provide information based on mothers' reports regarding fever, diarrhea or coughing accompanied by short, rapid breathing during the two-week period preceding the survey, the latter referring to acute respiratory infections (ARI). The present paper focuses on stunting, underweight and diarrhea, as wasting[4] is generally of very low prevalence, and ARI more subject to missing values (close to 70% in Burkina Faso, Cameroon and Egypt in their DHS-1). Boerma et al. (1992) showed that the survival bias - since only children who survive are taken into account - could be ignored in studies using anthropometrics indicators. Finally, to test for the co-occurrence of malnutrition and morbidity, two variables referred to as stunting-diarrhea and underweight-diarrhea are defined as follows:

$$y = \begin{cases} 0 & \text{if the child suffers from neither malnutrition nor diarrhea} \\ 1 & \text{if the child suffers from malnutrition or (exclusive) from diarrhea} \\ 2 & \text{if the child suffers from both malnutrition and diarrhea} \end{cases}$$

Defining community

An important issue in studies dealing with area effects on health is the definition of communities or neighbourhoods or, more precisely the geographic area whose characteristics may be relevant to the health outcome under study. Of the many health-based studies in developing countries using community-level characteristics, very few have provided a concise definition of community. For research in industrialized countries, administratively defined areas have often been used as rough proxies for communities or neighbourhoods. Conceptually, the size and definition of community may vary according to the processes through which area effect is hypothesized to operate and to the health outcome studied (Diez-Roux, 2001). Nevertheless, researchers working with large national-representative samples often have no choice but to rely on administrative definitions for which standard data are available, even though these structures may have no explicit theoretical justification in terms

[3] US Center for Health Statistics/US Center for Disease Control/World Health Organization.

[4] A number of studies have shown that wasting is volatile over seasons and periods of sickness (World Bank, 2002).

of the outcome under consideration (Duncan et al., 1998). Consequently, we have defined community by grouping sampling clusters within administrative units[5].

Independent variables: Socioeconomic status

Despite the overwhelming interest and progress on SES in health-related research, there is still no consensus on its nominal definition or a widely accepted measurement tool (Lynch and Kaplan, 2000; Campbell and Parker, 1983; Cortinovis et al., 1993; Oakes and Rossi, 2003). In this context the general approach has been to use different individual-, household- or community-level indicators including maternal education, household income or possessions, land ownership, water and sanitation, flooring material, place of residence, although Cortinovis et al. (1993) and Durkin et al. (1994) have attempted to draw awareness on the need to construct overall socioeconomic indexes rather than using individual indicators, as stressed by Campbell and Parker (1983). Methodologically, when covariates are strongly collinear as are likely to be socioeconomic factors, it may be very difficult and perhaps not very meaningful to tease apart their independent effects. Other shortcomings of current approaches concern the ignorance of father's education, despite the fact that in many societies of the developing world, the husband generally makes decision regarding fertility, contraception and use of health care services, so that certain behaviours and practices which may affect child health and nutrition depend on the father and specifically on his level of education (Kuate-Defo and Diallo, 2002).

Along the lines of Gwatkin et al. (2000), Filmer and Pritchett (2001) and within the framework developed above which recognizes the distinctive feature of socioeconomic indexes measured at the household versus community levels, we have constructed three relevant and complementary socioeconomic indexes using principal component analysis: (i) Household wealth index that captures household's possessions, type of drinking water source, toilet facilities and flooring material, and thus may be used as proxy for the commonly used income or expenditures variables; (ii) Household social index, that encompasses maternal and paternal education and occupation; and (iii) Community SES, defined from the proportion of households having access to electricity, telephone and cleaned water, together with relevant community-level information retrieved from community surveys when available[6]. Besides distinguishing socioeconomic factors by level of influence, it is of special interest to examine

[5] The numbering of clusters (primary sampling units) in the DHS does reflect their proximity since before the selection process, they are ordered geographically within the hierarchy of administrative units. Our grouping of clusters was done in order to have a desirable minimum of 8 households per community and a number of communities totalling a minimum around 30 in each urban and rural samples.

[6] They were carried out only for DHS-1 (Egypt carried out no community survey).

whether socioeconomic inequalities in health are mainly attributable to factors related to poverty and material hardship, or to factors such as education, employment status and other indicators of social status that are likely to causally precede income and wealth (Rahkonen et al., 2002; Lynch and Kaplan, 2000). The two household indexes seek to further our understanding of this issue. The three socioeconomic indexes are continuously centered variables. In the descriptive analyses however, households and communities are assigned to five 20% quintile groups and classified hereinafter as poorest (bottom 20%), low (next 20%), middle (next 20%), high (next 20%) and richest[7] (top 20%).

In a previous paper (Fotso and Kuate-Defo, 2004), we showed that each of these socioeconomic indexes is internally coherent, in that it produces sharp separations across its quintile groups for each of the indicator used in its construction, indicating their high degree of summarizing information contained in the assets variables. The explanatory power of the indexes was then evaluated on various health outcomes including health care services utilization (antenatal care, immunization), malnutrition (stunting, underweight), and mortality (infant mortality, under-five mortality). The association generally exhibited remarkable socioeconomic gradients in each of the five selected countries and survey period.

Measuring inequalities in child health

There is a great deal of discussion on measures of health inequalities in the scientific literature, with two distinct approaches: defining relevant a priori groups and then examining the health differentials between them; or alternatively, measuring the distribution of health status across individuals in a population, analogous to measures of income distribution in a population. The former only looks at between-individual differences that are linked to differences in groupings, whilst the latter does disregard relevance groupings and then prevents inquiries into the causes of health inequalities (Kawachi et al., 2002; Wagstaff and Watanabe, 2000). Thus in this paper, we use the first approach and calculate concentration indexes as proxies for familial and community socioeconomic inequalities in child health. The concentration curve plots the cumulative proportions of the population (beginning with the most disadvantaged[8]) against the cumulative proportion of health. The resulting concentration index[9] varies from -1 to +1, and measures the extent to which a health outcome is unequally

[7] These labels are used for pure expository purposes, and not following a definition of poor and rich.
[8] Continuous socioeconomic indexes are used in this paper.
[9] The concentration index is similar to the Gini coefficient frequently used in the study of income inequalities. The closer is the index to zero, the less unequally distributed among socioeconomic groups is the health outcome and conversely, the further away is the index from zero, the more concentrated is the socioeconomic inequality. The sign of the index reflects the expected direction of the relationship between the SES and the health outcome (Gwatkin et al., 2000; Wagstaff et al., 1991).

distributed across groups (Wagstaff et al., 1991). Since the indices of inequalities in health are generally estimated from sample observations, it is useful to test their statistical significance. The concentration index and its variance are calculated according to the following formulae due to Kakwani et al. (1997):

$$\begin{cases} C = \dfrac{2}{n\mu}\displaystyle\sum_{i=1}^{n} y_i R_i - 1 \\ Var(C) = \dfrac{1}{n}\left[\dfrac{1}{n}\displaystyle\sum_{i=1}^{n} a_i^2 - (1+C)^2\right] \\ a_i = \dfrac{y_i}{\mu}(2R_i - 1 - C) + 2 - q_{i-1} - q_i \end{cases}$$

Where C is the concentration index; n is the sample size; y_i refers to the dummy variable of interest (stunting, underweight or diarrhea in our case); R_i is the relative rank of the individual i; μ is the mean of y; q_i is the cumulative proportion of y $\left(q_i = \frac{1}{n}\sum_{k=1}^{i} y_k\right)$

3.2. Statistical methods

DHS data typically have a hierarchical structure due mainly to randomly sampling naturally occurring groups in the population, with children nested within mothers, mothers clustered within household and household nested within communities. As a result, observations from the same group are expected to be more alike at least in part because they share a common set or characteristics or have been exposed to a common set of conditions, thus violating the standard assumption of independence of observations inherent in conventional regression models. Consequently, unless some allowance for clustering is made, standard statistical methods for analyzing such data are no longer valid, as they generally produce downwardly biased variance estimates, leading for example to infer the existence of an effect when in fact that effect estimated from the sample could be ascribed to chance (Duncan et al., 1998; Rasbash et al., 2002). Moreover, as pointed out in the framework depicted in Figure 1, to gain a more complete understanding of the influences of SES on child health, we need to consider the child, mother, household and community levels simultaneously.

Multilevel models provide a framework for analysis which is not only technically stronger but which also has a much greater capacity for generality than traditional single-level statistical methods, while circumventing *ecological* and *atomistic fallacies* (Duncan et al., 1998). Briefly, in addition to accounting for the hierarchical structure of the data and allowing efficient estimation of variation at each level, these methods are explicitly designed to enable to disentangle strictly contextual effects from compositional ones, and also to investigate through cross-level interactions how the effects of individual-level factors are modified by group-level variables. The DHS data form a hierarchical structure with four levels: children, mothers, households and communities. However, with an average of 1.5 under-five children per mother and 1.2 mothers of under-five children per household in our data, we define a family level by collapsing chid-, mother- and household-level data. Consequently, we use two-level (child and community) binary logistic regression analyses with the dichotomous outcome variables which are stunting, underweight and diarrhea, according to the following equations:

$$\begin{cases} Logit(\pi_{ij}) = \ln\left[\dfrac{\pi_{ij}}{1-\pi_{ij}}\right] = \beta_{0j} + \sum_{k=1}^{p} \beta_k x_{ij}^{(k)} + \sum_{l=1}^{q} \delta_l z_j^{(l)} + \sum_{k=1}^{r}\sum_{l=1}^{s} \lambda_{kl} x_{ij}^{(k)} z_j^{(l)} \\ \beta_{0j} = \beta_0 + u_{0j} \end{cases}$$

In these equations, i and j refer to the family and community respectively; π_{ij} is the probability that child referenced (i, j) is stunted, underweight or has had diarrhea (depending on the outcome studied); $x_{ij}^{(k)}$ and $z_j^{(l)}$ are the k^{th} family-level covariate and the l^{th} community-level covariate respectively; β_{0j} is the constant term modelled to randomly vary among communities; the β_k and the δ_l represent the regression coefficients of the familial explanatory variables and the community explanatory variables respectively; the λ_{kl} refers to the coefficients for the cross-level interaction terms[10]; and u_{0j} and e_{0ij} are the random community residuals and random familial residuals respectively, distributed as $N(0,\sigma_{u0}^2)$ and $N(0,\sigma_{e0}^2)$ respectively. Being at different levels, they are supposed independent from each other (Snijders and Bosker, 1999; Rasbash et al., 2002). Models are fitted using the MLwiN software (Rasbash et al., 2002) with Extra-binomial and Marginal Quasi Likelihood (MQL) first-order linearization procedures.

For the multi-category dependent variables (stunting-diarrhea and underweight-diarrhea), polytomous logistic regression models are used to fit two logit functions with suffering from neither malnutrition nor diarrhea as reference category. We exclude from the analyses observations with missing values on dependent variables for each relevant model. Sampling probabilities are used in all our analyses to weight information at the individual level, so that the resulting findings are generalized to the total population. In effect, DHS surveys often over-sampled certain sub-groups in order to obtain statistically meaningful sample sizes for analysis. Moreover, all continuous variables are centered around the grand mean.

[10] r is less than p, and s is less than q since we do not model all the possible cross-level interactions.

Methodologically, we achieve the goals of the study through five models. The first one is a null model (Model 1) which provides information on the extent to which communities vary in their outcomes before account is taken for any control variable, whilst Model 2 controls for all the level 1 variables in order to test the existence of contextual effects. Model 3 is about the gross socioeconomic effects on child health (it includes place of residence and the three socioeconomic measures without any control), and Model 4 expands Model 3 by adding household, mother and child covariates. We assess changes over time by comparing the coefficients between the two survey periods[11]. Finally, Model 5 includes cross-level socioeconomic interactions. From the interaction coefficients therein, we derive conditional household socioeconomic effects according to the community SES. The control variables include at the household level, the number of household members and the number of under-five children (both continuous centered variables); at the mother level, religion, exposure to media (radio or television), current age, teenage childbearing, and nutritional status; and at the child level, current age, sex, low birth weight, antenatal care, place of delivery, age-specific immunization status, breast feeding duration, birth order and birth intervals.

4. Results

For descriptive analyses, Figures 2 to 4 display the association between SES and childhood malnutrition and diarrhea morbidity in the DHS-1; Figure 5 shows the prevalence of the three outcomes, and Figures 6 to 8 illustrate the socioeconomic inequalities in child health. Results of multivariate analyses are in Table 1 (stunting), Table 2 (underweight), Table 3 (diarrhea), Table 4 (stunting-diarrhea) and Table 5 (underweight-diarrhea), whilst conditional effects are in Table 6 (household wealth status) and Table 7 (household social status). We present below the main findings emerging from these results, focusing primarily on the first survey (DHS-1) and referring to DHS-2 when evaluating changes over time.

4.1. Descriptive analyses: Socioeconomic inequalities in child health

To a large extent, Figures 2 to 4 exhibit remarkable socioeconomic gradients irrespective of the measure of SES and the country, as rates of malnutrition and diarrhea generally decline steadily with increasing SES, though relationships for diarrhea are weaker on the whole. Analogous patterns are observed in the DHS-2 as well (Figures not shown). Estimates for the prevalence (Figure 5) forcefully indicate that malnutrition and diarrhea morbidity are highly

[11] Calculation of the standard deviation of change is based on the assumption of independence of the DHS-1 and DHS-2 samples in each country. This may not be the case strictly-speaking, since some households may be selected in both samples.

prevalent in the selected countries. From the DHS-1, stunting affects between 22% (Zimbabwe) and nearly 35% (Burkina Faso and Kenya) of young children, and underweight between 10% (Egypt) and 33% (Burkina Faso), whilst diarrhea prevalence ranges from 13% (Egypt) to almost 25% in Zimbabwe. As regards change over time, the situation of child health has generally worsened in Burkina Faso and Cameroon, and in contrast, has dramatically improved in Egypt. Between these two extremes, in Kenya the situation has improved for malnutrition and deteriorated for morbidity, whilst in Zimbabwe it has worsened for stunting and improved for underweight and diarrhea.

With reference to socioeconomic inequalities measured by concentration index and illustrated in Figures 6 to 8 with values multiplied by -100 for sake of convenience, almost all the estimates are in the expected direction (negative), indicating that poor health is more concentrated in the lower socioeconomic groups. Additionally, inequalities in malnutrition are higher than those in diarrhea in virtually all countries and time periods. Figure 6 shows that, as a general rule, higher levels of socioeconomic inequalities among communities in childhood malnutrition and morbidity are in Cameroon and in Egypt. At the other extreme, Kenya and Zimbabwe experience lower extent of inequalities. Furthermore, socioeconomic inequalities have generally tended to narrow in Burkina Faso, and to a lesser degree in Cameroon, suggesting that factors responsible for the rising malnutrition and morbidity rates do not affect all socioeconomic groups in the same way. In contrast, inequalities among communities are on the rise in Egypt for stunting and diarrhea, and to a lesser extent in Kenya and Zimbabwe for underweight.

[Figures 2 to 4 about here]

[Figures 5 to 8 about here]

In Figure 7, the patterns of household wealth inequalities are virtually similar to those described above, with Cameroon witnessing the highest levels of inequalities for the three child health outcomes and the two periods, followed by Egypt, and the lowest values being recorded in Zimbabwe, Kenya and Burkina Faso, depending on the outcome. The trends over time are also similar to those depicted for inequalities among communities. Finally, household social inequalities (Figure 8) are still highest in Cameroon, whilst the four other countries have roughly similar levels.

4.2. Clustering among communities in childhood malnutrition and morbidity

The first objective of this study relates to whether childhood malnutrition and morbidity cluster among communities, and if the variation is accounted for by contextual factors over and above likely compositional effects. Estimates from Panel A in Table 1 (stunting), Table 2 (underweight) and Table 3 (diarrhea) show that community-level random variations are significantly different from zero at the level of 5% in all the countries and periods (Model 1), indicating apparent variability among communities in child health. Interestingly, family-level random variations are closer or equal to unity in all countries and periods, as expected with the hypothesis of binomial distribution of the outcome variables. Model 2 reveals that with the exception of underweight in Burkina Faso (Table 2, DHS-1), significant variations between communities remain after adjustment for familial- and child-level variables. It is therefore clear that differences among communities with regard to child malnutrition and morbidity cannot be explained simply by familial socioeconomic and demographic factors.

[Table 1 about here]

[Table 2 about here]

[Table 3 about here]

4.3. Socioeconomic influences on childhood malnutrition and morbidity

Our second hypothesis concerns the inverse relationship between SES and child health, with special interest in examining whether the SES of communities have independent contribution to child health, over and above the influences of the SES of households. Model 3 in Tables 1 to 3 shows the ″gross″ socioeconomic effects without accounting for measured covariates, whilst Model 4 adjusts for household, mother and child characteristics. Model 4 in Tables 1 and 2 indicates that urban-rural differentials in childhood malnutrition are entirely explained by the SES of communities and families in virtually all countries. Figures for diarrhea morbidity reveal that whilst unadjusted rural rates of diarrhea are indistinguishable from urban ones except in Zimbabwe (results not shown), adjusted estimates in Models 3 and 4 (Table 3) suggest that urban children tend to be more likely than their counterparts in rural areas, to suffer from diarrhea, with statistically significant estimates in Cameroon and Kenya.

With reference to the socioeconomic effects on stunting (in the DHS-1), Model 3 (Table 1) shows that the three measures of SES are statistically significant in Burkina Faso; that household wealth and social indexes both exhibit significant effects in Egypt, Kenya and Zimbabwe; and that only wealth status emerges in Cameroon. Including controls (Model 4) results in a loss of statistical significance of the social status in Zimbabwe, and surprisingly, in a substantial increase between 20% and 50% of the estimates in Burkina Faso (community SES and wealth status) and Zimbabwe (wealth status). Comparing estimates in DHS-1 and DHS-2 (Model 4 in Table 1) reveals that with few exceptions socioeconomic inequalities have generally tended to narrow, with statistically significant changes in Burkina Faso for social inequalities ($p<0.01$) and in Zimbabwe for wealth inequalities ($p<0.10$).

As concerns underweight (Table 2), Model 3 shows that the three SES indexes are statistically significant in Egypt; that household wealth and social indexes have significant effects in Burkina Faso, Kenya and Zimbabwe with larger magnitude for wealth status; and that only wealth status reaches statistical significance in Cameroon. Model 4 produces no significant change, except in Zimbabwe where social index loses statistical significance. Additionally, it reveals that socioeconomic inequalities with regard to underweight have generally tended to widen in Cameroon and Kenya for community SES and household social status, as well as in Zimbabwe for household social status, without however reaching statistical significance. By contrast, significant reduction in socioeconomic inequalities is recorded in Burkina Faso and Egypt for social index ($p<0.01$ and $p<0.10$, respectively).

Finally, Model 4 in Table 3 shows that community SES and household wealth status are significantly associated with diarrhea morbidity in Cameroon; that household wealth and social indexes emerge in Kenya; and that only the wealth status is significant in Burkina Faso. In Egypt in contrast, no measurable SES has influence on diarrhea morbidity, whilst in Zimbabwe, household social status is positively associated with diarrhea occurrence ($p<0.05$). Model 4 further reveals that without reaching statistical significance, socioeconomic inequalities in morbidity among communities have tended to diminish in Cameroon, and that inequalities among families have been on the rise in Cameroon and Egypt.

4.4. Co-occurrence of malnutrition and diarrhea morbidity

Our interest in this study includes the evaluation of the socioeconomic influences on the co-occurrence of malnutrition and diarrhea morbidity. With regard to stunting-diarrhea (Table 4), gross estimates (Model 1) in columns 1 and 2 are generally in line with expectation, as the odds of suffering from either stunting or diarrhea (Column 1), and the odds of suffering from both stunting and diarrhea (Column 2) decrease with increasing SES. Interestingly, estimates in Column 2 are generally larger than those in Column 1 especially when their difference (Column 3) reaches statistical significance, suggesting that living in poorest socioeconomic conditions (household or community) increases the odds of suffering from both stunting and diarrhea, as opposed to experiencing only one of the two outcomes. As a matter of illustration, converting[12] the coefficient for Cameroon (DHS-1) into odds ratio indicates that in the poorest 30% households, as opposed to the richest 30% ones, children are almost 2.3 times more likely to suffer from both stunting and diarrhea morbidity as opposed to suffering from only one of the two pathologies. Overall, statistically significant estimates in Column 3 are recorded for community SES in Egypt ($p<0.05$), for wealth status in Cameroon ($p<0.05$), and for social status in Kenya and Zimbabwe ($p<0.05$ and $p<0.10$ respectively).

[Table 4 about here]

[Table 5 about here]

Adding controls in Model 2 does not significantly alter these patterns, except in Zimbabwe where coefficient for wealth status is now statistical significant. It is worth noting that larger estimates in Column 3 are recorded in Cameroon and to a lesser degree in Zimbabwe. On the other hand, some changes from DHS-1 to DHS-2 in coefficients estimated in Column 3 (Model 2) can be observed in Burkina Faso where wealth status is now statistically significant; in Cameroon and Egypt where wealth status and community SES respectively have larger effects; in Kenya where community SES reaches statistical significance at the expense of the social status; and in Zimbabwe where no socioeconomic effect is significant.

For underweight-diarrhea, similar findings emerge from Table 5, as results in Model 1 (DHS-1) generally display positive estimates in Column 3 for the three socioeconomic measures. Including controls (Model 2) tends to reduce the size and the degree of significance of estimates (Column 3), in Burkina Faso, Egypt and Zimbabwe. Finally, noticeable changes from DHS-1 to DHS-2 (Model 2) are in Cameroon, with a substantial reduction of the wealth effects; and in Kenya where community SES is now statistically significant at the expense of social status.

4.5. Modification of the household socioeconomic effects by the community SES

Besides investigating socioeconomic influences on child health, it is particularly relevant to examine whether the SES of communities exacerbates or mitigates the effects of the household SES on child health. Though Model 5 in Tables 1 to 3 displays cross-level interactive effects, which allow us to have an overview of the interplay between household and community SES, it is more compelling to examine whether higher community SES *initiates/enlarges,* or *lessens/eliminates* the effects of familial SES on health. Conditional household socioeconomic effects are outlined in Tables 6 and 7 according to five community socioeconomic quintile groups.

[12] This is done using mean values of the socioeconomic indexes.

With regard to household wealth effects (Table 6), Figures for the DHS-1 are mainly consistent with *initiating/enlarging* model, as the estimates generally increase with increasing community SES, indicating that the wealth situation of families affects child health mainly in the more privileged areas. In Cameroon for example, there is a very strong wealth effects on stunting in the fourth and richest communities ($p<0.01$), though the interaction term (average effect) failed to reach statistical significance. These patterns of household wealth status having almost no impact on child health in the most deprived communities and significant effects in the most affluent ones, are also noticeable in Burkina Faso for the three health outcomes, in Zimbabwe for malnutrition and in Kenya for diarrhea morbidity. From the DHS-1 to the DHS-2, a shift from *initiating/enlarging* to *lessening/eliminating* model is recorded in Burkina Faso for malnutrition and in Cameroon for underweight and diarrhea, whilst an opposite change is recorded in Egypt for stunting.

[Table 6 about here]

[Table 7 about here]

As regards household social effects, Table 7 reveals a somewhat contrasting picture with the coexistence of *initiating/enlarging* and *lessening/eliminating* models across and within countries, though the former emerges more frequently. The latter is recorded in Kenya (for the three outcomes) and in Egypt (for underweight), as household social status is estimated to have no influence on child health among families living in relatively more privileged communities. There is an atypical pattern in Zimbabwe with positive and significant coefficients for diarrhea. On the other hand, very few changes between DHS-1 and DHS-2 in the patterns of interaction can be observed.

5. Summary and discussion

This paper has examined the clustering of, and socioeconomic inequalities in, childhood malnutrition and morbidity among communities and families in Africa. Its novelty is to define and use more standardized measures of the SES within a multilevel framework; to model the co-occurrence of malnutrition and morbidity; and to demonstrate the ways in which interaction between family and community characteristics on child health can be comprehensively considered in the case of continuous measures. In fact, although many studies have modelled interaction terms, there has been relatively little use of cross-level ones, and few papers have attempted to probe how the presence of an interaction term alters the interpretation of other coefficients, especially in the case of continuous predictors. A number of key findings emerge from this study:

First, variations in child health among communities are clearly accounted for by contextual factors over and above likely compositional effects, even though differences between communities in the risks of childhood malnutrition and morbidity are found to originate mainly from differences in familial characteristics. Such finding which is in line with most studies that have attempted to disentangle contextual from compositional effects (Madise et al., 1999; Subramanian et al., 2003; Frohlich et al., 2002), upholds a key role for community context as a strong influence on health. Thus, it supports the growing body of research suggesting that neighborhood characteristics per se exert an important influence on the resident's health (Macintyre et al., 1993; Pickett and Pearl, 2001).

Second, there is a strong patterning in child nutritional status along SES lines, with household wealth status emerging to be the most powerful predictor as its effects outweigh in virtually all countries and time periods the influences of the two other socioeconomic indexes, and community SES having in some instances a contribution independent of the effect of the SES of households. This latter finding reinforces the relevance of neighborhood characteristics in health research (Robert, 1999; Mosley and Chen, 1984; Cortinovis et al., 1993). On the other hand, unlike most other studies (Adair and Guilkey, 1997; Forste, 1998; Tharakan and Suchindran, 1999), our results clearly show that urban-rural differentials in childhood malnutrition are entirely accounted for by the SES of communities and families. This probably relates to a stronger explanatory power of our standardized socioeconomic measures. Moreover, our results provide evidence of co-occurrence between malnutrition and infection and suggest that living in poorest socioeconomic conditions (household or community) increases the odds of suffering from both malnutrition and diarrhea, as opposed to experiencing only one of the two outcomes. A number of studies have produced evidence of nutritional risk factor for diarrhea (Etiler et al., 2004; Emch, 1999), or shown the effects of diarrhea on nutritional status (Tharakan and Suchindran, 1999; Madise et al., 1999), ignoring the fact that both outcomes are potentially endogenous variables in cross-sectional design.

Third, community SES is estimated to significantly modify the association between household SES and child health, according to patterns mainly consistent with *initiating/enlarging* model. Even when interaction parameters were not statistically significant, conditional effects revealed interesting features regarding the modification of household-level effects by the community SES. For example, Stafford et al. (2001) found no statistically significant interaction between levels of deprivation in the area and individual socioeconomic position, but merely conjectured that socioeconomic gradient may be steeper in more deprived areas, and Sastry (1996) found no significant interaction between household income and community characteristics. In these two cases, investigating conditional effects may have disclosed relevant patterns of interaction. Our finding which is in line with works of Dargent-Molina et al. (1994) and that of some authors cited by Stafford et al. (2001) has important policy implications as it clearly indicates that corollary measures to improve access of mothers and children to basic community resources may be necessary preconditions for higher levels of household socioeconomic situation to contribute to improved child health (Dargent-Molina et al., 1994). It clearly provides an additional means to targeting relevant groups of population at higher risks for childhood malnutrition and morbidity. It also provides further evidence on community effects to the debate on whether we should focus on "people" or "places" in policies and interventions regarding human health in developing countries.

Spelling out in each country the underlying mechanisms of *initiating/enlarging* or *lessening/eliminating* models is an inquiry beyond the scope of this work. It is however worth mentioning in brief that, when basic socioeconomic and health services are lacking in the poorest communities, families therein can hardly take advantage of their increased means, ability and knowledge in caring for their children. In this instance, community and household SES may interact in accordance with an *initiating/enlarging* model. Alternatively, if in the most developed neighborhoods, there are enough positive social, economic and environmental factors, increased household SES may emerge to have no additional influences on health, leading to pattern of interaction in line with *lessening/eliminating* model (Gordon et al., 2003; Reed et al., 1996). On the other hand, explaining change over time in these patterns requires further investigation. Two hypotheses are however worthy of attention. The change from DHS-1 to DHS-2 may point to poorly-measured community SES in the DHS-2 and in Egypt, in relation with the absence of community surveys. It may also have to do with the fact that most African countries have undergone sound economic, social and health sector reforms during the years 1990s that may have resulted in profound changes in the patterns of SES and well-being of populations.

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