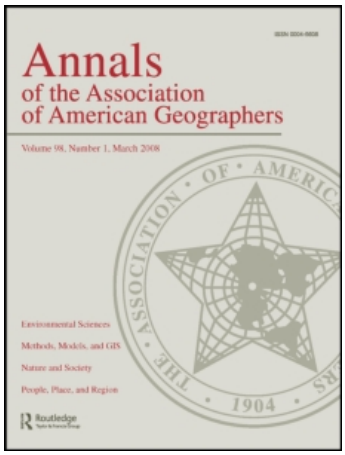

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Neighborhoods and Fertility in Accra, Ghana: An AMOEBA-Based Approach

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Fertility levels remain high in most of sub-Saharan Africa, despite recent declines, and even in a large capital city such as Accra, Ghana, women are having children at a pace that is well above replacement level and this will contribute to significant levels of future population growth in the city. Our purpose in this article is to evaluate the way in which neighborhood context might shape reproductive behavior in Accra. In the process, we introduce several important innovations to the understanding of intraurban fertility levels in a sub-Saharan African city: (1) Despite the near explosion of work on neighborhoods as a spatial unit of analysis, very little of this research has been conducted outside of the richer countries; (2) we characterize neighborhoods on the basis of local knowledge of what we call *vernacular neighborhoods*; (3) we then define what we call *organic neighborhoods* using a new clustering tool—the AMOEBA algorithm—to create these neighborhoods; and (4) we then we evaluate and explain which of the neighborhood concepts has the largest measurable contextual effect on an individual woman's reproductive behavior. Multilevel regression analysis suggests that vernacular neighborhoods are more influential on a woman's decision to delay marriage, whereas the organic neighborhoods based on socioeconomic status better capture the factors that shape fertility decisions after marriage. *Key Words: Accra, AMOEBA, fertility, multilevel analysis, neighborhoods.*

撒哈拉以南非洲的生育水平仍然很高，尽管近期有所下降，即使是在大都市，例如加纳的阿克拉，妇女生育孩子的步伐远远高于人口更替水平，这将有助于持续城市未来人口的显著增长。本文的目的是评估阿克拉市社区背景对生育行为的影响。在这个过程中，我们推出了几项重要的创新，对了解撒哈拉以南非洲城市的城间生育水平有所帮助：（1）作为分析中的一个空间单位，尽管在居民区附近进行了大量的工作，这项研究对富裕国家以外的地区鲜有涉及；（2）我们对社区的划分是基于我们称之为“白话社区”的当地认知基础上的；（3）我们然后利用了一个新的聚类工具：AMOEBA 阿米巴算法，来创立我们所定义的另一种社区，我们称之为“有机社区”；（4）此后，我们评价和解释了不同的社区邻里概念对单个妇女的生育行为可衡量的背景影响。多层次回归分析表明，对于一个女人推迟结婚的决定，白话社区具有更多的影响，而基于社会经济地位的有机社区，对于妇女婚后生育的影响因素更多地相关联。*关键词：阿克拉，阿米巴算法，生育率，多层次的分析，邻里。*

A pesar de una reciente declinación, los niveles de fertilidad siguen siendo altos en la mayor parte del África subsahariana, e incluso en una ciudad capital tan grande como Accra, Ghana, las mujeres están teniendo hijos a un ritmo que está bien por encima del nivel de remplazo, lo cual contribuirá significativamente en el futuro crecimiento de la población de la ciudad. Nuestro propósito en este artículo es evaluar la manera como el contexto del vecindario podría configurar el comportamiento reproductivo de Accra. En el proceso, introdujimos varias innovaciones importantes para entender los niveles de fertilidad intraurbanos en una ciudad africana subsahariana: (1) A pesar de lo casi explosivo del número de trabajos que toman al vecindario como unidad de análisis espacial, muy poco es lo que se ha hecho en este tipo de investigación por fuera de los países más ricos; (2) caracterizamos los vecindarios con base en el conocimiento local de lo que llamamos *vecindarios vernáculos*; (3) luego definimos lo que llamamos *vecindarios orgánicos* utilizando una nueva herramienta de agrupamiento—el algoritmo AMOEBA—para crear estos vecindarios; y (4) después evaluamos y explicamos cuál de los conceptos de vecindario tiene el más grande efecto contextual medible sobre el comportamiento reproductivo individual de una mujer. El análisis de regresión multinivel sugiere que los vecindarios vernáculos son más influyentes en lo concerniente a la decisión de una mujer de aplazar el matrimonio, en tanto que los vecindarios orgánicos basados en estatus socioeconómico capturan mejor los factores que configuran las decisiones de fertilidad después del matrimonio. *Palabras clave: Accra, AMOEBA, fertilidad, análisis de multinivel, vecindarios.*

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The achievement of low fertility in the richer nations and the widespread, albeit uneven, declines experienced by less rich nations have taken attention away from fertility levels as a topic of interest among geographers and other social scientists in richer countries. Now, however, there is a huge demographic divide in the world created by the different timings of the various components of the demographic transition—the health and mortality transition, the fertility transition, the age transition, the migration and urban transitions, and the family and household transitions that make up the overall demographic transition (Weeks 2008). Sub-Saharan Africa, in particular, continues to have much higher mortality, higher fertility, a younger age structure, a more robust pattern of rural-to-urban migration, and a more traditional pattern of family and household structure than do the richer countries. It is one of the few areas of the world where the United Nations Population Division (2009) does not predict fertility to drop to replacement level by the middle of this century.

At the end of World War II, fertility averaged about six children in sub-Saharan Africa and has declined since then through a combination of increasing use of contraception (and abortion) and later age at marriage, which have had to counteract the increasing levels of fecundity (biological ability to reproduce) brought about by improved reproductive health in the region (Garenne 2008). Despite this decline, in Ghana, as in virtually all of West Africa, fertility is still well above replacement level and even stalled at more than four children per woman during the late 1990s, based on data from the last five rounds of the Ghana Demographic and Health Surveys (DHS; 1988, 1993, 1998, 2003, and 2008) as shown in Table 1. In particular, the stall has continued in urban areas, although the most recent data show a drop in the capital city of Accra, where women are now having 2.5 children each (Ghana Statistical Service, Ghana Health Service, and ICF Macro 2009). At its current pace of population growth, Ghana will be dealing with twice as many people by midcentury as there are today, and the United Nations Population Division (2008) projects that Accra will grow from its current population of 2.1 million to 3.4 million by 2025, fueled by its own high rate of natural increase and by a steady flow of in-migrants from rural areas. By midcentury the city could potentially have three times its current population, unless fertility drops rather dramatically throughout the country in the very near future.

Since the world's population, including that in sub-Saharan Africa, is increasingly urban (United Nations Population Division 2008), we would expect that the impact of higher levels of urbanization would be to push fertility levels ever lower. However, urbanization in much of sub-Saharan Africa is associated with a growing slum population, which might place people in environments that are similar in many respects to the social and economic conditions that prevail in poor rural villages (UN Habitat 2006). For this reason, urban "amenities" such as ready access to schooling and the general availability of well-paid jobs that often operate to encourage smaller family size might be substantially diminished in their impact. We cannot assume that the conditions are automatically and ubiquitously present in urban areas to dramatically limit fertility. In particular, fertility-dampening conditions can vary considerably from one part of the city to the next, so it is important to understand the intraurban spatial variability in fertility levels and in the determinants of those fertility levels in light of the role that neighborhoods often play as action sites for the provision of health and social services.

Table 1. Change in total fertility rates by urban and rural populations in Ghana, 1988–2008

Year	Ghana	Rural	Urban	Greater Accra
1988	6.4	7.0	5.3	4.7
1993	5.2	6.0	3.7	3.4
1998	4.4	5.3	3.0	2.7
2003	4.4	5.6	3.1	2.9
2008	4.0	4.9	3.1	2.5

Note: Total fertility rate is based on women fifteen to forty-nine years old.
Source: 1988 through 2003 data adapted from Ghana Demographic and Health Surveys (http://www.measuredhs.com). 2008 data are from Ghana Statistical Service, Ghana Health Service, and ICF Macro (2009).

Fertility levels are generally considered to be influenced by the ideational changes that occur in a person's life associated with characteristics such as education and income. These changes in a person's perspective on life do not occur in a vacuum, however, so the diffusion of ideas within and between groups is also known to have a potentially very important influence beyond the original agents of change (Hägerstrand 1967; Casterline 2001). These ideational factors affect fertility by motivating a woman to delay marriage and childbearing and then, within a sexual union, by motivating her and her partner to implement one or more means of preventing a live birth. Education, for example, is a powerful predictor of fertility levels among women all over the world. Women who delay marriage are more likely to stay in school and then, after receiving more education than other women, will likely find employment and other opportunities that compete with family

building, thus leading to lower fertility than among less educated women. Indeed, one possible source of the stall in fertility has been identified as the reversal in some places within sub-Saharan Africa of the gains in education among young women. Given the influence of education on fertility, a slowdown in educational attainment, especially among girls, could have the effect of slowing down the decline in fertility (Derose and Kravdal 2007). However, the 2000 census data for Ghana do not provide any evidence of educational reversals among women in Accra—younger cohorts of adult women are consistently better educated than each successively older cohort—so this seems unlikely to be a contributing factor, at least in Accra.

Furthermore, despite the potential power of education to reduce fertility, that reduction is relative to place. For example, data from the DHS show that women with a secondary education in sub-Saharan Africa will have considerably higher levels of fertility than will similarly educated women in South Asia, who in turn have higher levels of fertility than similarly educated women in South America (a good example of spatial heterogeneity). Put another way, it is the differentiation among women by education, along with the interaction of education and culture, that seems to influence fertility, rather than there being a specific educational level that triggers a specific reproductive response among women. Education shapes behavior but does not determine it.

Although *place* in the survey data refers to regions and nations, the same variability (spatial heterogeneity) in the relationship between education and fertility can be observed within countries. Data from the 2003 and 2008 Ghana DHS and from the 2000 Census of Ghana (made available to the Minnesota Population Center, www.ipums.org, by Ghana Statistical Service [GSS]) confirm that women with a secondary level of education will have considerably fewer children if they live in the Accra region than if they live, for example, in the adjacent central region. We believe that the relevance of place in such relationships also operates at the intraurban spatial scale of the neighborhood context, which could play a potentially strong, even if indirect, role in the reproductive behavior of women.

Some microstudies conducted in Accra in the early 1990s also show the potential effects of spatial variability in fertility outcomes. In the elite suburb of Airport Residential Area of Accra, parents were concerned about the quality of their children and the quality of their proposed spouses. As a result, their actual and preferred family size has converged at around three children, with successful family limitation achieved by easily accessible contraception. In contrast, urban poor women start childbearing early, either inside or outside of marriage, but thereafter practice birth control (Agyei-Mensah, Aase, and Awusabo-Asare 2003). Other interesting findings on contextual effects of fertility can be seen in an edited volume on reproductive change in sub-Saharan Africa, which covers countries such as Ghana, Kenya, Malawi, Sudan, Zambia, Mali, and Ethiopia (Agyei-Mensah and Casterline 2003). The novelty of these studies is their localized nature, which makes it possible to probe certain topics more intensively than is feasible in studies with broader geographic coverage, such as DHS.

In this article we test the hypothesis that fertility levels in Accra, Ghana, are shaped and influenced by the neighborhood contexts in which women live, even when controlling for the individual characteristics of women. In the process, we introduce several important innovations to the understanding of intraurban fertility levels in a sub-Saharan African city: (1) Despite the near explosion of work on neighborhoods as a spatial unit of analysis, very little of this research has been conducted outside of the richer countries; (2) we characterize neighborhoods on the basis of local knowledge of what we call *vernacular neighborhoods;* (3) we then define what we call *organic neighborhoods* as contiguous agglomerations of census-based enumeration areas that are similar to one another with respect to contextual characteristics, using a new clustering tool—the AMOEBA algorithm—to create these neighborhoods; and (4) then we evaluate and explain which of the neighborhood concepts has the largest measurable contextual effect on an individual woman's reproductive behavior.

Neighborhood Context as a Factor in Fertility Levels

If we are to understand inequality in human society, we must understand that "[t]he answer to the question of who ends up where is that people's social environments largely influence what rung of the ladder they end up on. . . . Context matters tremendously" (Fischer et al. 1996, 8). Within a city the social context will vary from place to place, in a pattern of intraurban ecology (see, for example, Diez Roux 2001; MacIntyre, Ellaway, and Cummins 2002; MacIntyre and Ellaway 2003; Sampson 2003; Oakes 2004; Weeks et al. 2004). Applying this concept to an analysis of human reproduction suggests that if we are to understand fertility levels we must understand not only the

characteristics of the people who are having children and creating families but also the characteristics of their environment, in particular those environments that might either promote higher fertility than would otherwise be expected in an urban environment or at least prevent fertility from dropping to the low levels that are typically expected in urban areas. Yet, no matter how much agreement there might be that context matters—that neighborhoods are powerful factors in the social world—there is remarkably little agreement about what constitutes a neighborhood, and this might help explain why the research to date has shown only modest neighborhood effects in relationship to demographic phenomena, even when we expect fairly large effects (Entwisle 2007), as we discuss later.

Martin (2003) emphasized the contingent nature of the concept of neighborhood: Neighborhoods are spatially and socially constituted, but their salience to human behavior depends importantly on the way in which people, both within and outside of the neighborhood, imagine or mentally conceptualize the place. The idea of a neighborhood will differ, she argued, depending on what is being examined. Furthermore, researchers might have very different ideas about neighborhood identification and definition than do the people who live there. If we accept the idea that neighborhood definitions depend on the context in which we wish to understand them, we are left with the prospect that researchers might never agree on a single definition of a neighborhood, and so the task of researchers becomes to define and defend the neighborhoods that are created for any particular analysis.

Our focus in this analysis is on the role that neighborhoods might play in the level of childbearing activity that takes place among its inhabitants. Conceptually, we must understand that the physical environment is imbued with social meaning—the physical and social are constitutively entangled (Fayard and Weeks 2007). For example, the type of housing and its infrastructure, the level of crowding and cleanliness, the quality of roads, and the accessibility of shops and other amenities will not necessarily have the same impact on the behavior of all people. The environment (like education, as noted earlier) shapes behavior but does not determine it. We can assess the material aspect of the environment with relative ease (although we can only guess at the way in which humans interact with the built environment in most instances), but the social aspect tends to be latent and thus more difficult to measure.

The built environment is usually defined in terms of neighborhoods, which are typically based on preexisting administrative boundaries such as ZIP codes, census tracts, or census block groups. These boundaries are used largely because data tend to be aggregated at these geographic levels and researchers would need a compelling rationale to collect large amounts of data for areas defined differently than these. Furthermore, despite the potential variability in a neighborhood's definition, if it is to be a useful concept in helping us to better understand how the world works, the neighborhood boundaries must be clearly geo-referenced and based on clearly recognizable landmarks (Hipp 2007). Thus, existing boundaries are very useful as proxies for neighborhood boundaries because they do not require reinvention or redelineation by the researcher, and other researchers can validate the claims made by accessing similar data. In the United States, census tracts are probably the most often used proxies for neighborhoods, made famous by the clustering techniques of Claritas, which put a name to each census tract in the United States on the premise that "you are where you live" (Weiss 2001, 42). These names include categories such as "God's Country," characterized as exurban areas populated by upper income baby boomers; or the "Bohemian Mix" described as an area with a collection of young, mobile urbanites; or "Back Country Folks," which are poor, remote farming villages. Emerging techniques of spatial analysis have allowed Claritas to expand its categorization of neighborhoods from census tracts to the geographically smaller block group level and to the geographically more general ZIP code areas, recognizing that different users of their information might have different ideas of what constitutes the neighborhood of interest (Claritas [Nielsen] 2009).

Characterizing neighborhoods in this way works well for countries that are data-rich—which tend to be those countries that are rich in a variety of ways. Geodemographics companies have accomplished these tasks for the United States, Canada, and much of Western Europe (Harris, Sleight, and Webber 2005). The situation is more complex for developing nations, where a weak data collection infrastructure is layered onto a built environment that might also have a weak infrastructure. Urban informality has become the norm throughout cities of developing nations, as people are forced to create and negotiate neighborhoods without much oversight or assistance from official government resources (Roy and Alsayyad 2004). Informality might express itself most overtly through inadequate water supplies, poor sewerage, haphazard construction of dwellings, and crowding. These are the general features of slums, which form the predominant type of neighborhood in cities

of sub-Saharan Africa. The UN Habitat (2006) estimates that nearly three out of four urban dwellers in sub-Saharan Africa are living in slums. Thus, slums are the norm, rather than the exception, in most cities, but this also means that "when slums constitute the largest proportion of a city, differentials between, even within, slums also become apparent" (UN Habitat 2006, 21).

Informal settlements or slums provide residents with a context that is distinctly different from a more elite neighborhood with paved streets; piped water and sewerage; and large, well-constructed houses. Such differences in the built environment are obvious even to the casual observer, but in what ways might these different contexts help to shape reproductive behavior? Following Coale (1973) we note that there are three important elements to a woman's level of fertility: (1) the belief that reproduction is under a woman's own control, (2) the motivation to limit fertility if a woman believes that she is in control of this aspect of her life, and (3) availability of the means to delay or limit fertility once the motivation exists to do so. What aspect of a neighborhood might influence one or more of these preconditions for a fertility decline? We know from research in Egypt (Entwisle, Casterline, and Sayed 1989), Kenya (Kohler, Behrmen, and Watkins 2001), and elsewhere that the interaction among women in an area can influence attitudes toward family size norms as well as the means used (or not used) to deliberately control reproduction. We can hypothesize that low-rise, high-density neighborhoods characterized by pedestrian traffic will increase the likelihood of intimate contact with other people in the neighborhood and thus increase the chance that the behaviors and attitudes of others will be influential. These are also the same physical and social interaction settings in which traditional behaviors are apt to be reinforced. We know from the well-established literature on the "strength of weak ties" (Granovetter 1973, 1983, 2005) and "structural holes" (Burt 1992) that innovative behavior—the kind that is apt to lead to decisions to delay marriage and delay children within marriage—is more likely when people are in contact with others who are outside their intimate group.

We can also expect that places that afford greater opportunities for women are neighborhoods that will promote the kinds of decisions that will lead to lower fertility. This can be thought of as a latent social variable—status and opportunity available to neighborhood residents that ultimately increase the motivation to limit fertility as a means for achieving a higher standard of living—which is routinely indexed by the material condition of the neighborhood. The expectation is that an informal, low-status neighborhood will have fewer opportunities for women than will a higher status neighborhood characterized; for example, by an improved level of infrastructure.

As noted earlier, despite the seemingly strong conceptual basis for expecting neighborhoods to have an influence on fertility, the evidence of neighborhood effects on a range of demographic behaviors remains relatively weak (Entwisle 2007). Part of the explanation could be that most research takes for granted that neighborhood influences are exogenous to the individual residents:

> Most research conceptualizes people as affected and constrained by features of local environments: the "trickle down." With respect to neighborhood effects, residents are passive rather than active agents, corresponding to the cross-sectional character of much of the data that are analyzed and with the hierarchical statistical approaches that are often taken. At a moment in time, people *are* affected and constrained by their environments. Over time, however, they may change them in a variety of ways by moving between neighborhoods and/or doing something to change the neighborhood in which they live. A theory of neighborhoods and health thus needs to incorporate agency on the part of individuals. Agency may take different forms, four of which seem particularly relevant to an understanding of health and context. First, people make choices about the neighborhoods in which they live. Second, as a consequence of residential mobility, neighborhoods of origin and destination may be changed in both composition and structure. Third, people may operate directly to change neighborhood conditions. Fourth, people may be selective in relating to a local sociospatial context. (Entwisle 2007, 694)

Thus, we must be open to the possibility that neighborhoods are endogenous to behavior—being partly determined by human agency—rather than simply exogenous contexts in which life is played out. Furthermore, even the exogenous influence might differ from person to person. In particular, Entwisle summarized research suggesting that neighborhood effects might be stronger in childhood and adolescence than later in life (e.g., Angeles, Guilkey, and Mroz 2005). Thus, we can anticipate that neighborhoods will be more predictive of the age at marriage (an event influenced by adolescence) than by the number of children born once married.

Another important issue surrounding the importance of context is that the characteristics of an area might be more important in defining context than will be the specific neighborhood itself. Despite the importance of personal social networks in human society, the reality is

that most people are unlikely to interact with more than a small fraction of people in any given neighborhood. What matters is not that they know everyone but that they assume that others in the neighborhood are similar to them. Thus, behavior is shaped by the impersonal other as well as by intimate friends and family members. If the concept of interest is context, then we must recognize that the use of specific neighborhood boundaries represents a proxy measure of that context, rather than being inherently important in and of itself. If a person is embedded physically in a setting in which the built and social environments are similar in every direction, then conformity to local behavioral norms might be more natural than for a person embedded in a setting that is more diverse. To evaluate contextual effects on fertility (or vice versa), we must have a reasonable definition of context, and that typically begins with (but does not necessarily end with) a definition of something called a neighborhood. In this research, we distinguish between two different ways of defining neighborhoods that we call vernacular and organic. Each definition has potentially different consequences for our understanding of context.

Data and Methods

For our analysis we draw largely on microlevel data from the 2000 Ghana Census of Population and Housing, made available to us by GSS. Data are georeferenced to the enumeration area (EA), of which there are 1,731 in the Accra metropolitan area (AMA). The AMA is the largest district within the Greater Accra Region, which is one of ten regions that make up the entire country. The EAs represent the basic geographic building blocks for our analysis, and EAs are roughly comparable to census tracts in the United States or enumeration areas in the United Kingdom. As part of our research, we have created the first digital boundary file of those EAs, working from paper maps that are not to scale, along with high-spatial-resolution satellite imagery to do so.

Vernacular Neighborhoods

Vernacular neighborhoods refers to neighborhood boundaries that are broadly recognized and agreed to by residents of a given city—in this case Accra, Ghana—even if they might have no premeditated and formal definition. These are the place names, for example, that would be provided to a taxi driver, especially because there is no comprehensive street address system in Accra. In Accra, eighty-eight of these neighborhood boundaries have been created by GSS by grouping together contiguous EAs, shown in Figure 1.

A few of the neighborhoods are special-purpose areas, such as the presidential palace (Flagstaff House), the juvenile facility (Borstal Institute), the Police Training Depot, the Military Hospital, the International Trade Fair Center, and the University of Ghana, Legon. Most, however, are residential or mixed commercial, retail, and residential and they average twenty EAs per neighborhood, with a minimum of one and a maximum of eighty-five. The first neighborhoods in Accra were the largely autonomous Ga settlements of Nleshi (James Town—English Accra), Kinka (Ussher Town—Dutch Accra, originally Fort Crèvecoeur), and Osu (site of Christiansborg Castle—Danish Accra). These places date back to the seventeeth century and were still the essence of Accra in 1875 (Parker 2000). During the first quarter of the twentieth century, Accra grew. "As elsewhere in the colonial world, advances in Western medicine interacted with imperial ideologies to create a new emphasis on sanitation, order, and racial segregation, which conditioned the reformulation of urban space and of social relations in the growing city" (Parker 2000, 195–96). It was during this time, for example, that the "Cantonments" neighborhood was planned, financed, and acquired by the colonial government for expatriate civil servants (Acquah 1958; Agyei-Mensah and Owusu 2009). It is located to the northeast of central Accra and is still one of the more elite areas of the city; it is also home to many foreign embassies, including that of the United States. "Characteristic of the rigid social structure of the colonial period were the sharp boundaries between these elite preserves and the bordering slums and squatter settlements. Administrative divisions created highly visible ecological barriers in Accra" (Brand 1972, 297). At the same time, however, a more middle-class neighborhood, Adabraka, was established in the 1920s as a new residential and commercial area to the northwest of the older parts of the city (Pellow 1977).

The original villages that eventually formed the city were scattered along the coastline because the Ga were, and still are, active in the fishing trade. Newer neighborhoods have generally been created inland. In the 1880s a "zongo" (quarter) was built north of Ussher Town. This was by Salaga market (the first and largest market in the city) and the area was settled by Hausa (Muslim) settlers from northern Nigeria (Parker 2000). Another predominantly Muslim quarter, Sabon Zongo, was settled in 1907 to relieve some of the congestion in

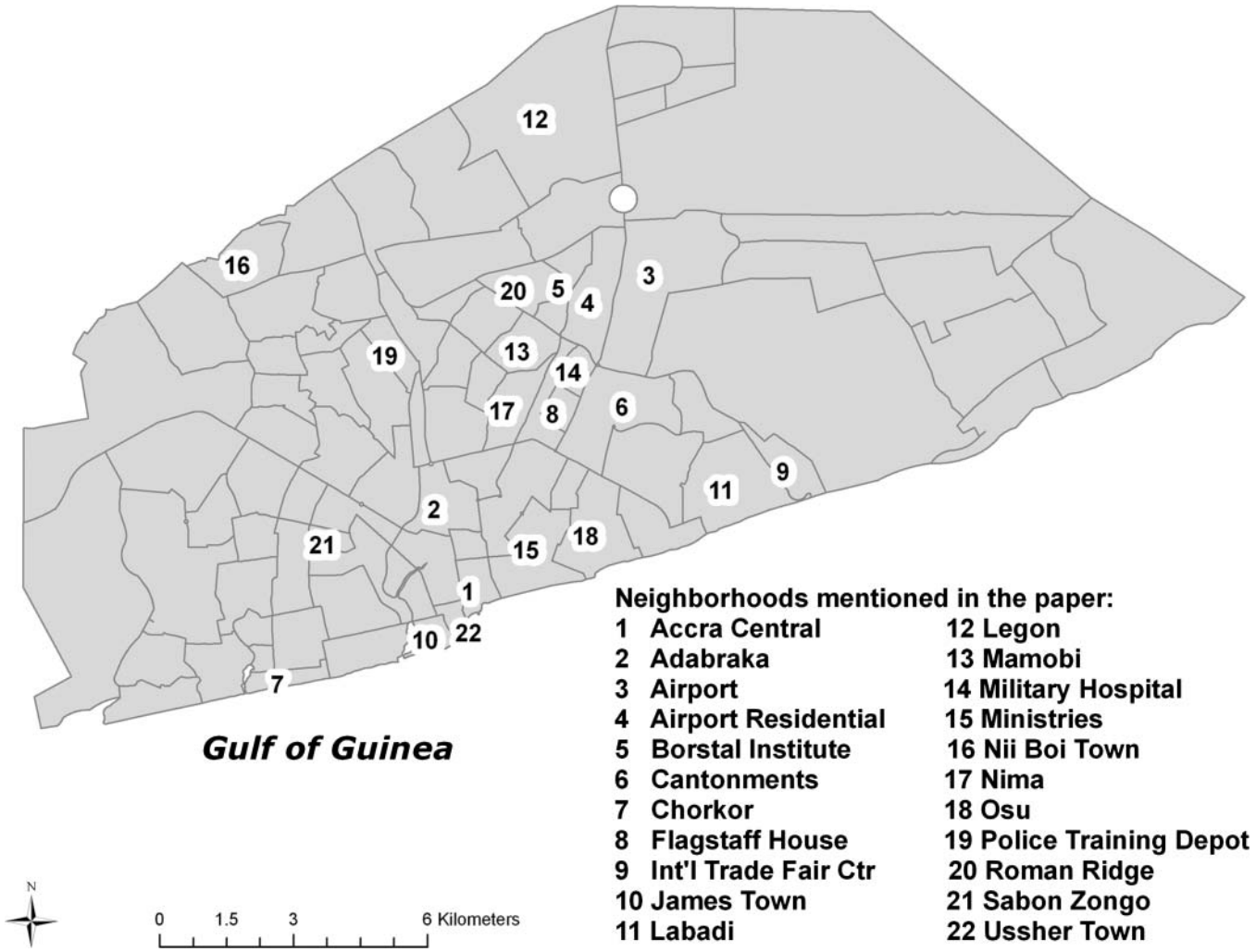

Figure 1. Vernacular neighborhoods of Accra, Ghana. *Source:* Shapefile created by authors from data provided by Ghana Statistical Service.

the older quarter (Pellow 2002). The village of Nima was built outside of the city boundaries after World War II for returning Hausa soldiers (Acquah 1958). It became part of the municipality in 1953, and by 1958 it was officially designated as a slum needing remediation (Harvey and Brand 1974).

The post–World War II era saw the building of the airport to the northeast of Nima and the University in Legon to the north of the airport. These have been relatively elite areas since their inception. After independence in 1957 the city expanded considerably, and many of the vernacular neighborhoods shown in Figure 1 have grown up in the postindependence period, a time that has also been associated with an increase of the Akan population in the city.

Another set of vernacular neighborhoods for Accra is associated with a map created by the Center for Remote Sensing and Geographic Information Systems (CERSGIS) at the University of Ghana and used by Songsore et al. (2005) and by Agyei-Mensah and Owusu (2009). The disadvantage of the CERSGIS map, however, is that the boundaries are not linked directly to the census EAs, and so it is difficult to relate the census data to that map. However, we have been able to reproject the CERSGIS map and after overlaying it with the GSS vernacular neighborhoods, we found a high degree of consistency in neighborhood definitions. In other words, there is a high degree of reliability in these neighborhood definitions among people in Accra.

Organic Neighborhoods

Organic neighborhoods refers to agglomerations of EAs that are similar to one another in terms of underlying structural characteristics and, at the same time, are contiguous to one another. They represent contexts,

rather than specifically named neighborhoods. In this approach to creating contextual boundaries, the problem of aggregation of spatial data is conceptualized as a special case of clustering in which the geographical contiguity between the elements to be grouped should be considered. This particular case of clustering methods is usually known as contiguity-constrained clustering or simply the regionalization problem (Duque, Ramos, and Surinach 2007). Each EA is compared to its neighbors to see if the neighbors are more like the "kernel" EA than would be expected by chance alone. If so, the neighbor is attached to the kernel EA, and then this new agglomerated EA is compared with neighbors. The process is iterative, working toward a stable solution in which all agglomerations (the organic neighborhoods) represent the maximum homogeneity within neighborhoods and the maximum heterogeneity between neighborhoods. Previous approaches include Openshaw's Automated Zoning Procedure (AZP; Openshaw and Rao 1995), the SAGE system developed by Haining and his associates (Wise, Haining, and Ma 2001), and the Max-P-Region algorithm (Duque, Anselin, and Rey 2007).

In this research we accomplish the task of creating organic neighborhoods through an innovative application of the AMOEBA algorithm developed by Aldstadt and Getis (2006). In its original form AMOEBA was designed to identify "hot spots" in regions in which there might be found statistically significant spatial clusters of a variable of interest for which a simple distance or contiguity spatial weights matrix did not adequately describe the pattern of clustering. AMOEBA stands for a multidirectional optimal ecotope-based algorithm. For this work on identifying Accra neighborhoods, the algorithm was expanded to exhaustively classify all subareas (EAs) into clusters regardless of statistical significance. In this way, areas of homogeneity of a variable can be delimited across the entire city without the restriction that the areas must be hot or cold spots. Briefly, for a variable, the technique requires that each EA be evaluated for the strength of its association with contiguous EAs. The association is measured using any one of the local spatial autocorrelation statistics such as local Moran's I, local Geary's C, or the Getis-Ord Gi* statistic (which was employed in this analysis). The EAs are then ordered from highest to lowest association with their neighbors. The highest contiguous association is selected as the seed to begin a process in which through a sequential operation the contiguous neighbors of the highest EA are included in a cluster if those contiguous neighbors raise the level of association by their inclusion in a cluster. The sequential operation continues by selecting the contiguous neighbors of the previously selected contiguous neighbors that increase the association of the EAs already selected. When the level of association is reduced by the addition of a contiguous neighbor, the process comes to an end and the boundary of the group of associated neighbors is identified. This first region of homogeneity is ineligible for the selection of the next possible high association between an EA and its contiguous neighbors, and so on. In this way the algorithm continues to find associated neighbors until all EAs are included within clusters. There is no restriction on the shape or size of the delimited neighborhoods (Aldstadt and Getis 2006).

The first step in creating organic neighborhoods was to characterize each of the 1,731 EAs that served as the building blocks. We employed principal components analysis (PCA) as a way of reducing sets of variables into coherent components that could be used as composite indexes of an EA's characteristics. Note that we used PCA instead of cluster analysis (as might be done in a typical geodemographic analysis) because our goal was to create a single variable that characterized an EA, rather than create neighborhood classifications.

We initially organized the variables available to us into two categories: (1) built environment and (2) sociodemographic composition. The variables are summarized in Table 2. Built environment variables were drawn from questions on the census about the type of building in which the household lives; infrastructure related to water, liquid and solid waste, and bathing and toilet facilities; cooking facilities and fuel; and the proportionate abundance of vegetation and impervious surface in the EA, as derived from the classification of remotely sensed imagery. With respect to housing, a compound is the urban embodiment of a typical West African rural housing arrangement in which several rooms face an open, inner courtyard, with the entire structure surrounded by a high wall and typically having one entrance. On average, 49 percent of buildings in an EA were compounds, with some EAs having no compounds and other EAs having only compounds. The other variables are more self-evident. The sociodemographic variables were drawn from census questions related to ethnicity, religion, place of birth, educational attainment, labor force participation, employment sector if in the labor force, occupation if employed, family structure, crowding in the household, and whether or not the family rents or owns their residence.

PCA was done separately for the built environment variables and the sociodemographic variables, but the

Table 2. Variables used in the principal components analysis for characterizing enumeration areas, Accra, Ghana

Variable	Mean	Standard Deviation
Built environment		
Percent compound[a]	49.41	26.22
Percent separate house	12.33	15.43
Percent semidetached house	15.40	15.47
Percent flat/apartment	8.99	12.73
Percent huts	2.58	4.95
Percent kiosks	3.78	4.67
Percent of surface covered by vegetation[a]	0.18	0.12
Percent of surface covered by impervious surface	0.59	0.12
Percent with inside piped water	46.34	25.03
Percent with outside piped water	44.67	24.35
Percent with own toilet[a]	26.08	25.83
Percent using public toilet	33.30	28.65
Percent with own bath	27.57	26.07
Percent with solid waste collected from house	23.23	30.73
Percent taking solid waste to public dump[a]	62.08	35.78
Percent connected to a sewer[a]	14.74	22.32
Percent putting liquid waste in gutter or street	70.59	28.63
Percent cooking with charcoal[a]	60.47	19.32
Percent with separate cooking room[a]	28.19	22.68
Percent cooking on veranda or open space[a]	55.02	24.98
Average number of rooms	2.17	0.83
Average number of sleeping rooms	1.66	0.67
Sociodemographic variables		
Percent of households with a female spouse	34.32	10.96
Percent of households with 2+ wives	0.42	0.69
Percent with household members who are not close relatives	25.19	7.59
Average number of household members	4.57	1.17
Percent of households headed by a female	36.33	9.87
Percent owned by resident	38.28	22.09
Percent rented by resident	39.34	18.24
Percent 18+ born outside of Accra	48.61	17.11
Percent 18+ Catholic	10.17	5.98
Percent 18+ Protestant	29.11	10.67
Percent 18+ Pentecostal	34.77	10.80
Percent 18+ Muslim	11.57	14.91
Percent 18+ Akan	40.38	15.02
Percent 18+ Ga-Dangme	31.61	21.52
Percent 18+ Ewe	14.32	10.02
Percent males 18+ in labor force	66.39	9.91
Percent males 18+ with professional, admininistrative, or clerical occupations[a]	31.71	10.38
Percent males 18+ working in private informal sector[a]	55.04	17.59
Percent males 18+ who are regular employees[a]	25.24	11.46
Percent males 18+ with no schooling	17.87	11.19
Percent males 18+ with primary education	37.86	10.61
Percent males 18+ with secondary education	29.54	9.22
Percent males 18+ with postsecondary education[a]	14.73	8.94
Percent females 18+ in labor force	62.04	10.28
Percent females 18+ with professional, administrative, or clerical occupations*	18.05	10.22
Percent females 18+ working in private informal sector[a]	70.54	17.36
Percent females 18+ who are regular employees[a]	12.85	7.60
Percent females 18+ with no schooling	27.51	12.92
Percent females 18+ with primary education	39.59	9.62
Percent females 18+ with secondary education[a]	22.37	8.74
Percent females 18+ with postsecondary education[a]	10.53	7.81

[a]Included in final principal component of STATUS.

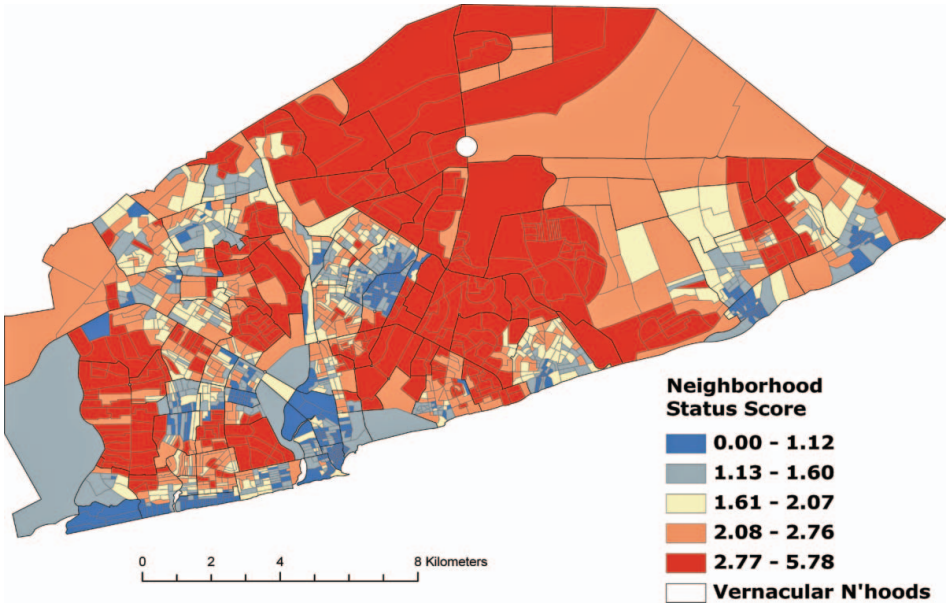

Figure 2. Accra enumeration areas according to the principal components analysis derived status score, overlaid by the boundaries of the vernacular neighborhoods. *Source:* Shapefile created by authors from data provided by Ghana Statistical Service.

correlation coefficient between the two separate components (.694) suggested to us that the entire set of variables was too interrelated to be treated separately. Thus, the analysis was done on the entire set of variables shown in Table 2. We worked iteratively to eliminate variables that lacked a reasonable level (.500) of communality and to eliminate those that cross-loaded significantly (.500 or higher) on two or more components. Four components emerged with eigenvalues greater than one, accounting for a total of 71 percent of the variance in the set of variables. However, only one of those components, with an eigenvalue of 11.1, was clearly above one, and it alone accounted for 51 percent of the total variance. The unrotated component matrix had the best structure and the highest loadings, so it was used. The variables that loaded significantly (.500 or higher) without cross-loading are flagged in Table 2. Those with the highest loadings include, in order of importance, the existence of a separate cooking room, the type of fuel used for cooking, having one's own toilet, females being regular employees in the formal sector of the economy, the proportion of an EA's surface area that was classified as vegetation, females employed in higher occupational statuses, males employed in higher occupational statuses, women with an education beyond high school, and being connected to a sewer. We call this factor STATUS, in which high values represent higher status, and lower values represent lower status. We added two to each score, so that all scores would be positive. The spatial distribution of all EAs according to their STATUS score is shown in Figure 2, with an overlay of the vernacular neighborhoods.

Figure 2 shows that the original Ga villages and the predominantly Muslim zongos identified among the vernacular neighborhoods (see Figure 1 for neighborhood names) tend to have the lower status scores, whereas the areas that were originally established for the expatriate community still tend to be among those areas with the highest status scores. There are clear clusters of high and low status, although the clusters are quite irregular in size and shape. Figure 2 also shows that some of the vernacular neighborhoods appear to be quite consistently of one status or another, but others appear to have a mix of statuses. This suggests that the identification of a person as living in one or another vernacular neighborhood might not appropriately identify the context within which such a person lives.

The organic neighborhood concept attempts to control for the variability in context by creating areas that have similar characteristics and are contiguous to one another. We implemented the AMOEBA partitioning algorithm with the Getis-Ord Gi* statistic as the indicator of spatial association because of its compatibility with an additive approach to clustering; that is, nearby areas are added to one another and evaluated for the degree of spatial autocorrelation. We used a first-order rook contiguity spatial weights matrix, and we required a minimum of four EAs to create a neighborhood. In theory, this could have produced as many as 432 neighborhoods, but in fact the algorithm generated just seventy-two different organic neighborhoods, and

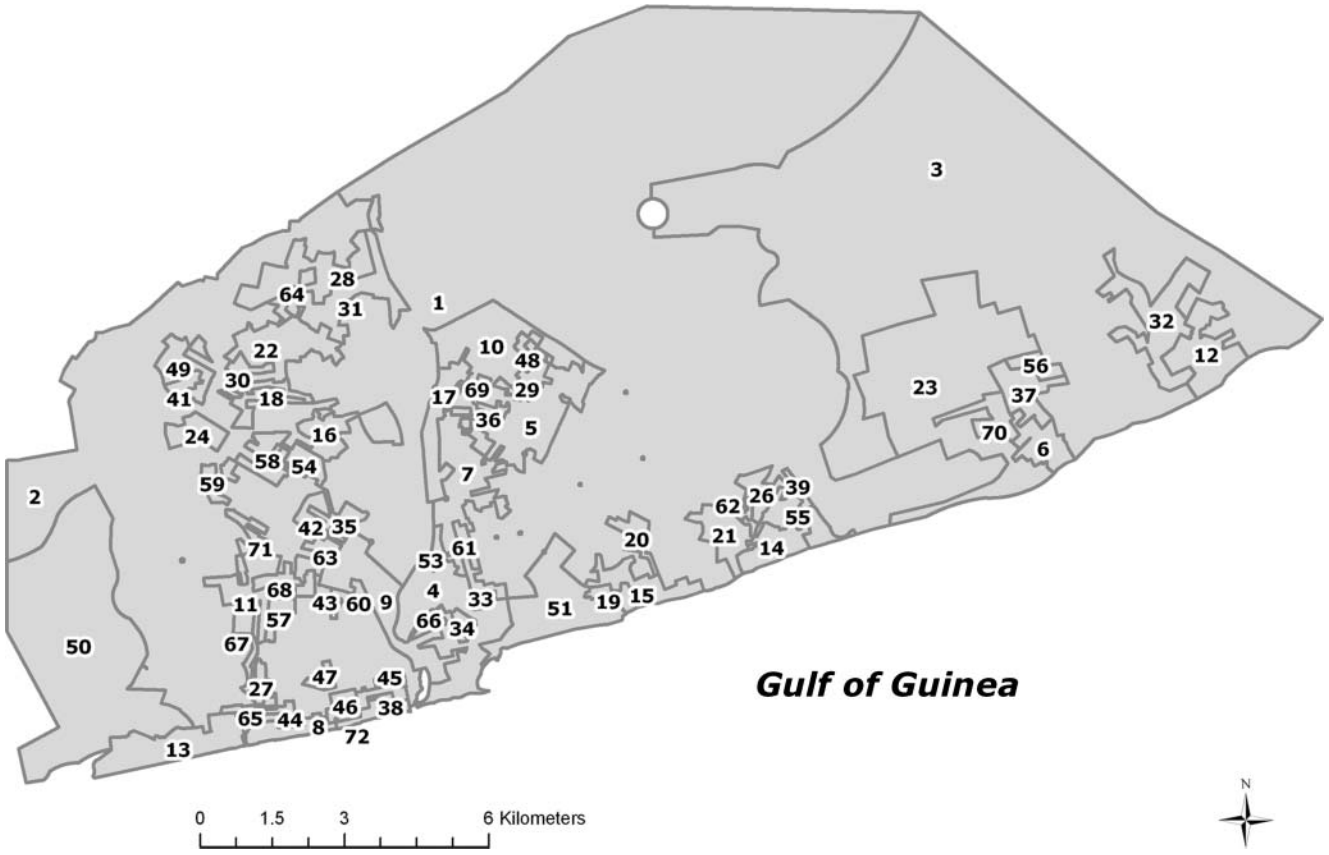

Figure 3. AMOEBA-based organic neighborhoods of Accra, Ghana. *Note:* Digitized traffic circles appear as dots on the map. *Source:* Shapefile created by authors from data provided by Ghana Statistical Service.

they are shown in Figure 3. Almost certainly by chance alone, there are seventy-two vernacular neighborhoods with four or more constituent EAs. We calculated the average variability in the STATUS score among the constituent EAs in both the vernacular and the organic neighborhoods. We found that the intraneighborhood variability in STATUS was twice as high in the vernacular neighborhoods as it was in the organic neighborhoods. This is consistent with our expectation that the organic neighborhoods generate a better approximation of context than do the vernacular neighborhoods.

Fertility Levels by Neighborhood Context

Having established two different ways of conceptualizing neighborhood context, we turn now to the measures of fertility that we hypothesize will be related to the context within which people live. We divided the analysis into two separate, albeit intimately related parts: (1) age at marriage, and (2) children born within marriage. In societies such as Ghana, where out-of-wedlock births appear to be relatively rare, a delay in marriage will have an important impact on the overall birth rate, and this effect has been noted for other sub-Saharan African nations (Garenne 2008). A rise in the age at marriage will have the effect of delaying childbearing (a tempo effect, as described by Bongaarts and Feeney 1998), but a delay in marriage also foreshadows a smaller number of children born to a woman once she does marry (the quantum effect). Because the decision to marry might be made in a very different context than the decision to have children once married, we have separated them in the analysis.

Delayed Marriage

Despite the substantial number of women in Accra with large families (there were twenty-four women enumerated in the census who reported having given birth to eighteen children, and there were 3,533 women with ten or more children), young women in Accra have been delaying marriage and childbearing. This is a national trend that has been noticed in the DHS (Ghana Statistical Service, Noguchi Memorial Institute for Medical Research, and ORC Macro 2004),

and it is especially obvious in Accra. The 2000 census data indicate that 87 percent of women aged fifteen to nineteen had never married, and 95 percent of those single women were childless. At ages twenty to twenty-four, 66 percent were still single, and 88 percent of those single women were childless. At ages twenty-five to twenty-nine, 38 percent reported never having married, and 75 percent of those women were childless. Even at ages thirty to thirty-four, 17 percent of women reported being still single, and 60 percent of them were childless. This is occurring within the context of a country in which marriage patterns are described as follows:

> Voluntary childlessness is uncommon and currently married women with no live births are likely to be those who are unable to bear children. The level of childlessness among married women at the end of their reproductive lives can be used as an indicator of the level of primary sterility. In Ghana, primary sterility among older currently married women is less than 2 percent. (Ghana Statistical Service, Noguchi Memorial Institute for Medical Research, and ORC Macro 2004, 59)

Delaying marriage only affects fertility levels, of course, if it is associated with a very low level of out-of-wedlock births, as appears to be the case in Accra. There are three principal ways to accomplish this: abstinence, contraception, and abortion. There is evidence that in Accra young women who adhere to charismatic Protestant religious groups are especially likely to be involved in activities designed to encourage abstinence, at least partly to reduce the risk of HIV (Beal 2005), and this activity might also encourage the postponing of marriage. Data from the Ghana DHS suggest that contraception utilization among young people is fairly limited, but this might be counterbalanced by the hidden use of abortion, which is not legal in most circumstances (Blanc and Gray 2000; Oliveras et al. 2008). In all events, we know from the DHS that the proportion of females aged fifteen to nineteen who have never married has been steadily increasing in Ghana (even as the fertility decline stalled), and we also know that most unmarried women at the younger ages are childless.

We use the percentage of women aged fifteen to twenty-four who are still single, according to the 2000 census, as the neighborhood-level measure of delayed marriage. Does this vary by neighborhood? Figure 4A shows that there is a clear spatial pattern among the vernacular neighborhoods, with delayed marriage being more common in the elite neighborhoods and less common especially in the older Ga villages along the coast. The lowest value (57 percent never married) is found in Chorkor, a predominantly lower status Ga area, whereas the highest value (93 percent) is in Legon—the University of Ghana. The predominantly Muslim area of Nima also has a fairly high percentage of those who never married (81 percent). Moran's I for this pattern is .27 ($z = 4.36$), indicating a statistically significant level of spatial autocorrelation. Figure 4B shows that there is also a spatial pattern among the organic neighborhoods, which is not unlike that shown by the vernacular neighborhoods. Moran's I for this pattern is .24 ($z = 3.72$), again confirming the spatial autocorrelation in the pattern of delayed marriage.

What are the neighborhood characteristics that are most associated with delayed marriage? The candidate variables are those listed in Table 2, from which we derived our STATUS variable, which incorporates more than a dozen of those variables. Higher status neighborhoods can be expected to provide opportunities and motivations for women to delay marriage, although we can also appreciate the endogeneity built into this relationship, as over time delayed marriage among women is likely to increase their status and thus the status of their neighborhood. We can also anticipate that cultural and religious attributes of neighborhoods might play a role in shaping attitudes toward delayed marriage.

Among the vernacular neighborhoods, the combination of STATUS, percentage Protestant, percentage Muslim, percentage Ga, and percentage Akan accounted for 65 percent of the variability from neighborhood to neighborhood in the percentage of women fifteen to twenty-four who were never married. The residuals were spatially autocorrelated and a spatial error model implemented in Geoda improved the R^2 to .68. The highest beta coefficient was found for the percentage Ga, which drove down the percentage never married; followed by the percentage Protestant, which drove it up; STATUS, which drove it up; and then the percentage Muslim, which also drove up the percentage never married. The percentage Akan was not a significant factor.

Among the organic neighborhoods, which were of course built on the basis of the STATUS variable, that variable turned out to have the greatest influence on the percentage never married, followed by the percentage Ga, percentage Protestant, and percentage Muslim. Again, the percentage Akan was not significant. These variables explained 49 percent of the organic neighborhood variability in percentage of young women who had never married. Once again, the residuals were spatially autocorrelated, and a spatial error model increased the R^2 to .55.

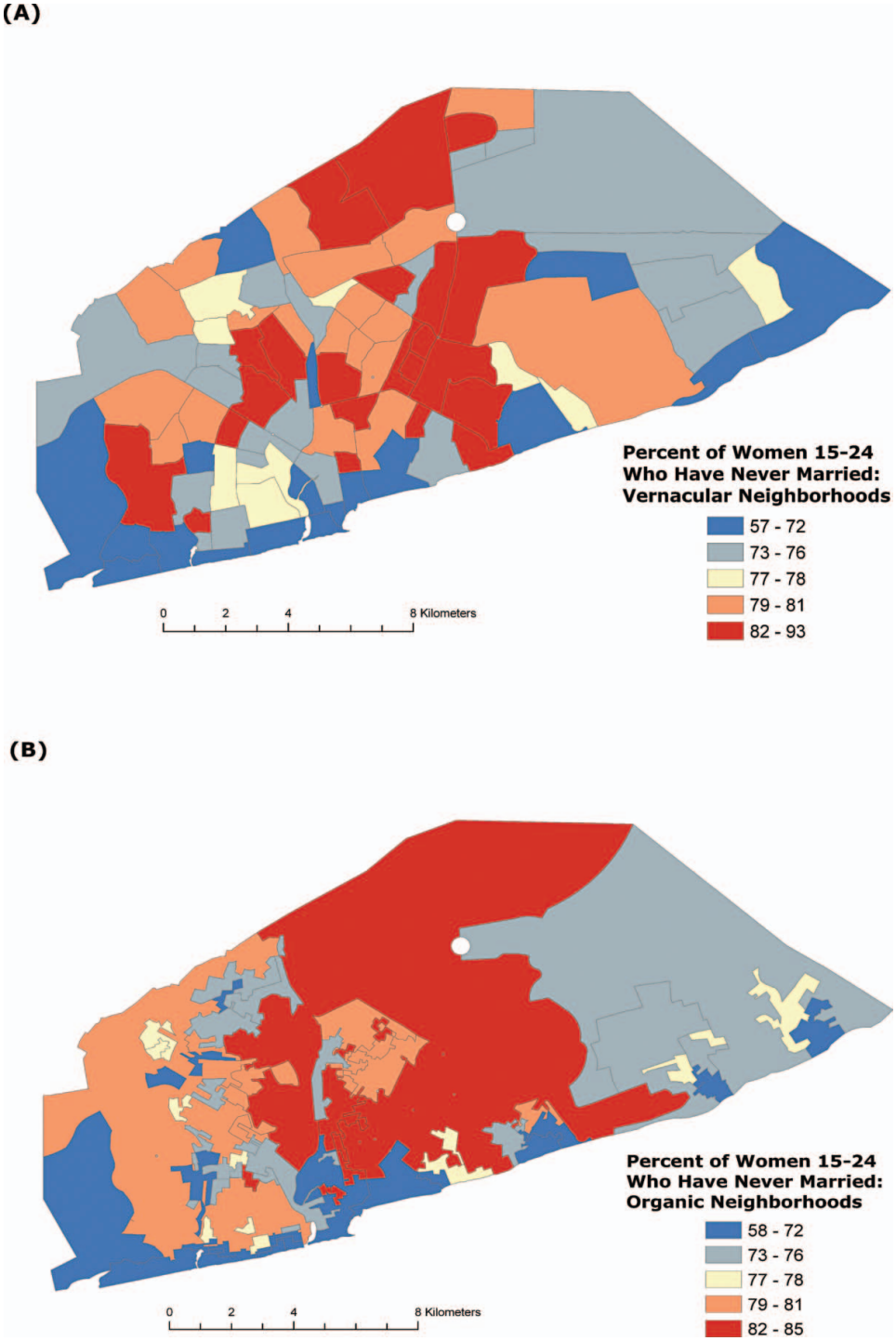

Figure 4. Percentage never married among women fifteen to twenty-four years old: Vernacular and organic neighborhoods. *Source:* Shapefile created by authors from data provided by Ghana Statistical Service.

Do these same variables explain delayed marriage at the individual level? We first explored the answer to that question with a multilevel binary logistic regression model, implemented in MLwiN software, using Markov chain Monte Carlo (MCMC) procedures (Browne 2009). The dependent variable was whether or not a woman aged fifteen to twenty-four was single (never married). The set of fixed factors at the individual level included the cultural factors of ethnicity and religion, the sociodemographic factors of education, having been born outside of Accra, and living in a home where the cooking is done with charcoal (one of the variables that loaded highest on the STATUS component at the neighborhood level), along with a

Table 3. Multilevel model: Individual and neighborhood factors associated with delayed marriage in Accra, Ghana, 2000

	Model 2 two-level with random intercept											
	Model 1 single-level fixed effects				Vernacular neighborhoods				Organic neighborhoods			
	Beta	*SE*	*t*	Exp(B)	Beta	*SE*	*t*	Exp(B)	Beta	*SE*	*t*	Exp(B)
Fixed individual effects												
Akan												
Ga-Dangme	−0.329	0.049	−6.714	0.720	−0.174	0.049	−3.551	0.840	−0.183	0.051	−3.588	0.833
Ewe	0.120	0.060	2.000	1.127	0.072	0.058	1.241	1.075	0.091	0.057	1.596	1.095
Other ethnic group	−0.068	0.059	−1.153	0.934	−0.114	0.059	−1.932	0.892	−0.088	0.059	−1.492	0.916
Catholic												
Protestant	0.154	0.069	2.232	1.166	0.182	0.073	2.493	1.200	0.204	0.067	3.045	1.226
Pentecostal	−0.070	0.065	−1.077	0.932	−0.034	0.068	−0.500	0.967	−0.007	0.063	−0.111	0.993
Other Christian	−0.202	0.085	−2.376	0.817	−0.133	0.082	−1.622	0.875	−0.110	0.084	−1.310	0.896
Islam	0.135	0.086	1.570	1.145	0.041	0.085	0.482	1.042	0.077	0.083	0.928	1.080
Traditional	−0.803	0.214	−3.752	0.448	−0.799	0.222	−3.599	0.450	−0.751	0.215	−3.493	0.472
No religion	−0.879	0.114	−7.711	0.415	−0.775	0.113	−6.858	0.461	−0.744	0.110	−6.764	0.475
Other religion	−0.413	0.189	−2.185	0.662	−0.392	0.193	−2.031	0.676	−0.387	0.195	−1.985	0.679
No education												
Primary education	0.512	0.046	11.130	1.669	0.482	0.046	10.478	1.619	0.486	0.048	10.125	1.626
Secondary education	1.091	0.052	20.981	2.977	1.046	0.053	19.736	2.846	1.045	0.054	19.352	2.843
Postsecondary education	1.216	0.085	14.306	3.374	1.118	0.086	13.000	3.059	1.118	0.090	12.422	3.059
Not born in Accra	−0.108	0.039	−2.769	0.898	−0.124	0.039	−3.179	0.883	−0.122	0.041	−2.976	0.885
Cooks with charcoal	−0.323	0.040	−8.075	0.724	−0.285	0.040	−7.125	0.752	−0.268	0.041	−6.537	0.765
Age squared	−0.006	0.000	−60.000	0.994	−0.006	0.000	−60.000	0.994	−0.006	0.000	−60.000	0.994
Neighborhood effects												
Percent Ga					−0.015	0.004	−3.750	0.985	−0.012	0.003	−4.000	0.988
Percent Protestant					0.013	0.010	1.300	1.013	0.017	0.007	2.429	1.017
STATUS of neighborhood					0.014	0.064	0.219	1.014	0.021	0.059	0.356	1.021
Random neighborhood intercept					3.445				3.176			
Variance (U0j)					0.056				0.079			
Deviance information criterion	19,121.52				18,892.51				18,907.17			

control for age within the ten-year cohort of women we are investigating. We acknowledge the possibility for endogeneity with respect to education—a delay in marriage almost certainly facilitates the acquisition of more education—but we assume that most of the effect is in the opposite direction—that women with more education have more opportunities in their life than marriage and family building and so they will delay marriage to take advantage of those opportunities. Model 1 in Table 3 shows the relationship among these variables and marital status for young women.

The results at the individual level are generally consistent with the neighborhood-level analysis. Being of Ga ethnicity lowers the odds of being never married, compared to the Akan, whereas the Ewe are slightly more likely to delay marriage. Being Protestant increases the chances of delaying marriage relative to being Catholic. Although people who practice traditional religions, no religion, or some other religion have significantly lower chances of delaying marriage, there are relatively few of them in Accra (fewer than 5 percent of women aged fifteen to twenty-four in Accra in 2000 indicated a religious preference that was not Christianity or Islam). Education was clearly the most important predictor of delayed marriage. Young women with a secondary or postsecondary level of education are more than three times as likely to be still single as women with no schooling and about twice as likely as those with only a primary education. Note that education was incorporated into the STATUS component at the neighborhood level and so was not entered separately into the neighborhood-level models. Having been born outside of Accra (probably in a rural area) lowered the odds of delaying a marriage, and living in a household that uses charcoal for fuel also significantly lowered the odds of delaying marriage.

The Nagelkerke R^2 (a pseudo-R^2 value calculated in SPSS 2008) for Model 1 was .18, indicating the presence of considerable residual variance. Is that variance accounted for by variability at the neighborhood level? Models 2 and 3 in Table 3 help to answer that question. Model 2 introduces variability at the vernacular

neighborhood level, whereas Model 3 uses the variability among organic neighborhoods. In both models, key neighborhood-level variables are introduced as fixed effects, and the neighborhood variance component is captured by the random intercept. It can be seen that the introduction of the neighborhood-level variability does not significantly alter any of the individual-level coefficients. Furthermore, the only fixed neighborhood effect that is statistically significant among vernacular neighborhoods is the percentage Ga, whereas that and the percentage Protestant are statistically significant among the organic neighborhoods. The deviance information criterion (DIC) is improved for both of the two-level models compared to the single-level model, so we can conclude that there is some measureable neighborhood effect. Following Rasbash et al. (2009), we estimate the size of that effect by calculating $\sigma^2_{u0}/(\sigma^2_{u0} + 3.29)$. For the vernacular neighborhoods, this produces a value of just less than 2 percent, and for the organic neighborhoods the value is just above 2 percent. If we add this to the 18 percent explained at the individual level, we can infer that we have explained about 20 percent of the variability in the propensity of a young woman to delay marriage and about 10 percent of that explained variance (2/20) is accounted for by the neighborhood context. Furthermore, these estimates suggest that it does not make much difference whether the context is defined in terms of the vernacular or the organic neighborhoods. We return to a further discussion of these results later in the article. We now turn, however, to the second aspect of fertility rates in Accra, relating to the number of children born among women who have begun family building.

Children Born to Women

Data from the census provide information only on the number of children ever born, not on the age at which they were born, so we are unable to measure the tempo of childbearing (the spacing of children), but we can measure the number of children born up to the current age. Our focus here is on women who have put themselves in the path of building a family through marriage or an equivalent acknowledged relationship. To maintain the same metrics (e.g., logistic regression at the individual level) that we used in the analysis of delayed marriage, the dependent variable is measured as a binary response in terms of whether an ever-married woman aged fifteen to forty-nine had given birth to fewer than three children.

The average ever-married woman of reproductive age in Accra had given birth to 2.64 children as of 2000, and 55 percent had given birth to fewer than three. The pattern by vernacular and organic neighborhoods is shown in Figure 5. Of considerable interest is the fact that the spatial pattern of this variable is not statistically significantly clustered spatially among the vernacular neighborhoods, and there is no correlation from neighborhood to neighborhood between the proportion of women who are never married and the proportion of ever-married women who have fewer than three children. To be sure, there is a higher percentage of low-fertility women in the Cantonments than in Nima, but the overall pattern is not consistent with the pattern of delayed marriage. On the other hand, there is a clearly visible spatial pattern among the organic neighborhoods (Moran's I of 0.14, with a z score of 3.77), although once again it is not the same pattern observed with respect to delayed marriage.

Using the same variables that were employed in the neighborhood-level analysis of delayed marriage, we ran ordinary least squares regression models for both the vernacular and organic neighborhoods, with the addition of a control for the average age of ever-married women, and we also included the percentage never married, even though there was no zero-order correlation. For the vernacular neighborhoods, the adjusted R^2 was zero, and there was no evidence of spatial autocorrelation in the residuals. With respect to fertility among ever-married women, there seems to be no explanatory power inherent in the vernacular neighborhoods. However, among the organic neighborhoods, this combination of variables explained 17 percent of the neighborhood variability in the percentage of women with fewer than three children, and all of that explanation came from one statistically significant variable—the STATUS score of the neighborhood. The higher the STATUS, the more likely it was that women would have fewer than three children. There was evidence of spatial autocorrelation in the residuals and the diagnostics suggested a lag spatial model. This model improved the R^2 to .33, with the spatial weight coefficient being the most important predictor, followed by the STATUS score of the neighborhood, and also by the percentage never married. Thus, when spatial relations are taken into account, a higher percentage of never-married women was, in fact, related to a lower percentage of women with fewer than three children, as expected.

We used the same individual-level variables as potential predictors of whether ever-married women had

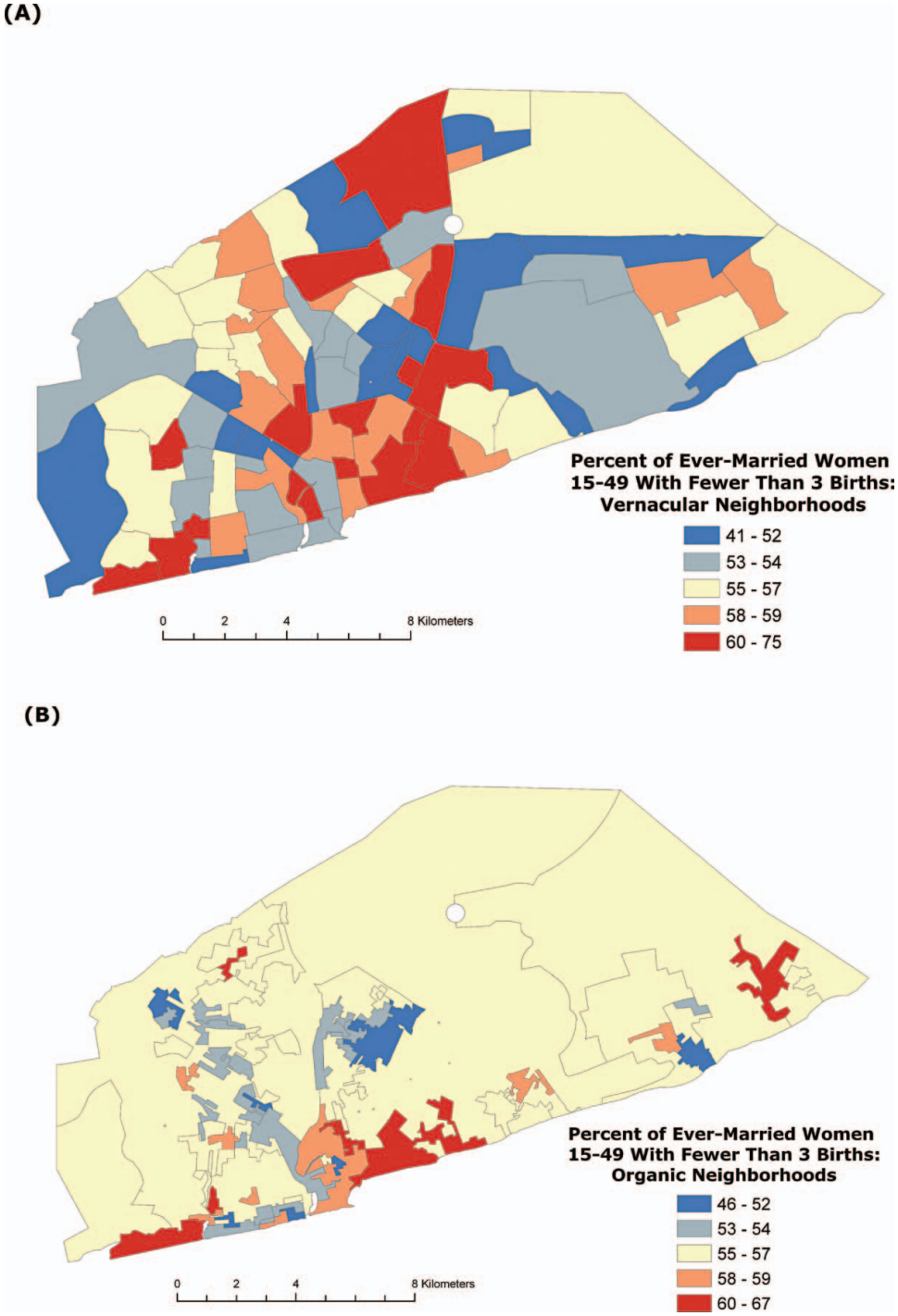

Figure 5. Percentage of ever-married Women fifteen to twenty-four years old with fewer than three children: Vernacular and organic neighborhoods. Source: Shapefile created by authors from data provided by Ghana Statistical Service.

given birth to fewer than three children as we had used to predict whether younger women had delayed marriage. The results are shown in Table 4, where it can be seen that none of the ethnic categories is statistically significant from the others in this regard. Being Protestant was associated with slighty lower fertility (because a positive value indicates having fewer than three children), whereas adherence to Islam is associated with higher fertility. None of the other religious categories was statistically significant. As was true with delayed

Table 4. Multilevel model: Individual and neighborhood factors associated with fertility levels among ever-married women in Accra, Ghana, 2000

	Model 1 single-level fixed effects				Model 2 two-level with random intercept							
					Vernacular neighborhoods				Organic neighborhoods			
	Beta	*SE*	*t*	Exp(B)	Beta	*SE*	*t*	Exp(B)	Beta	*SE*	*t*	Exp(B)
Fixed individual effects												
Akan												
Ga-Dangme	−0.008	0.038	−0.211	0.992	−0.006	0.038	−0.158	0.994	−0.009	0.035	−0.257	0.991
Ewe	0.027	0.044	0.614	1.027	0.026	0.043	0.605	1.026	0.024	0.044	0.545	1.024
Other ethnic group	0.049	0.042	1.167	1.050	0.052	0.043	1.209	1.053	0.056	0.042	1.333	1.058
Catholic												
Protestant	0.117	0.054	2.167	1.124	0.102	0.049	2.082	1.107	0.101	0.053	1.906	1.106
Pentecostal	0.017	0.050	0.340	1.017	0.014	0.046	0.304	1.014	0.007	0.051	0.137	1.007
Other Christian	0.069	0.067	1.030	1.071	0.076	0.063	1.206	1.079	0.066	0.068	0.971	1.068
Islam	−0.153	0.065	−2.354	0.858	−0.129	0.061	−2.115	0.879	−0.129	0.065	−1.985	0.879
Traditional	−0.276	0.166	−1.663	0.759	−0.278	0.166	−1.675	0.757	−0.278	0.169	−1.645	0.757
No religion	−0.062	0.084	−0.738	0.940	−0.051	0.085	−0.600	0.950	−0.061	0.086	−0.709	0.941
Other religion	0.154	0.155	0.994	1.166	0.132	0.150	0.880	1.141	0.127	0.152	0.836	1.135
No education												
Primary education	0.187	0.036	5.194	1.206	0.170	0.036	4.722	1.185	0.174	0.034	5.118	1.190
Secondary education	0.451	0.043	10.488	1.570	0.423	0.044	9.614	1.527	0.425	0.043	9.884	1.530
Postsecondary education	0.362	0.056	6.464	1.436	0.324	0.056	5.786	1.383	0.329	0.056	5.875	1.390
Not born in Accra	−0.303	0.181	−1.674	0.739	−0.784	0.257	−3.051	0.457	−0.592	0.196	−3.020	0.553
Cooks with charcoal	−0.198	0.030	−6.600	0.820	−0.167	0.031	−5.387	0.846	−0.167	0.033	−5.061	0.846
Age squared	−0.002	0.000	−20.000	0.998	−0.002	0.000	−20.000	0.998	−0.002	0.000	−20.000	0.998
Fixed neighborhood effects												
Percent Ga					−0.006	0.002	−3.000	0.994	−0.002	0.002	−1.000	0.998
Percent Protestant					0.021	0.005	4.200	1.021	0.010	0.005	2.000	1.010
STATUS of neighborhood					−0.024	0.043	−0.558	0.976	0.038	0.040	0.950	1.039
Random neighborhood intercept					2.441				2.455			
Variance (U0j)					0.009				0.003			
Deviance information criterion	31,316.72				31,267.02				31,294.57			

marriage, education was statistically significantly associated with lower fertility. Women with at least secondary education were about 50 percent more likely to have fewer than three children, compared to women with no schooling. Cooking with charcoal also was significant and in the expected direction—lower status (associated with the use of charcoal) is associated with higher fertility.

The Nagelkerke R^2 calculated for Model 1 was .30, but almost all of that effect was captured by age alone. In other words, after controlling for age, the other variables—even those that are statistically significant—contribute very little to our understanding of the variability in fertility from woman to woman. Furthermore, the contextual effects are also negligible. The DIC drops slightly when neighborhood variability is taken into account, but neither neighborhood definition contributes even 1 percent of explanation to the residual variance.

Discussion and Conclusion

The study of fertility in sub-Saharan Africa is fraught with the complexity of its family arrangements (Lesthaeghe 1989). Depending on the region and ethnic group, husbands and wives might spend little time actually living together, children might routinely be shared among families (fosterage), uncles can be more important than fathers in terms of childrearing, mothers might be more dependent on their children than on a husband for security, and women could find themselves in a polygynous relationship with an older man. These more traditional variations on family life are, of course, less common in cities, where Westernization has brought social change, not just economic change. Nonetheless, it is important to note that we have relatively few measures of these important aspects of life beyond ethnicity and religion, which serve as proxies

for the type of family system in which a woman is likely to be enmeshed.

We have shown that there is a very clear spatial pattern in Accra of delayed marriage, and it is slightly better aligned with the vernacular neighborhoods than with the organic neighborhoods. This seems to be related to the fact that delayed marriage is influenced by ethnicity and religion, and the vernacular neighborhoods appear to capture variability in these characteristics, whereas we created the organic neighborhoods on the basis of a set of variables that were defined as status, because the enumeration areas were statistically more differentiated on that basis than on the basis of ethnicity and religion.

There is a less clear spatial pattern of childbearing after marriage, but it seems more closely aligned with the organic neighborhoods than with the vernacular neighborhoods. Thus, a woman's cultural group seems to be more influential in the decision to delay marriage, whereas status seems to be the more important predictor of fertility within marriage. The slum neighborhood of Nima provides an interesting example of this. A majority of the adult population is Muslim and ethnically they are neither Ga nor Akan (the numerically largest ethnic groups in Accra). At the same time, it has one of the lowest status scores of any of Accra's vernacular neighborhoods. The cultural mix is associated with one of the highest levels of delayed marriage, but the generally low status is associated with one of the highest percentages of ever-married women with at least three children. Nima's overall level of fertility among women of reproductive age is lower than would be expected solely on the basis of status because the cultural pattern in the area is to delay marriage, even though fertility is high once a woman is married. Delayed marriage is seemingly not a route to lower fertility in this neighborhood, at least partly because it is not associated with women using that delay as an opportunity to improve their education. In Nima, 32 percent of women aged fifteen to twenty-four had no schooling, and 76 percent had less than a secondary level of education, which are among the highest levels in Accra. Nor are they working in substantially higher proportions than in other neighborhoods. Forty percent of women fifteen to twenty-four worked outside the family for even one day a week in Nima, which was only slightly higher than the average of 35 percent for all neighborhoods. It is probable that they are in charge of domestic duties within the household, perhaps including babysitting, but we could only know that from fieldwork, not from the census.

We measured the overall level of fertility in a neighborhood by creating an individual-level age-standardized measure of fertility that could then be directly aggregated to the neighborhood level. From the census we calculated the mean and standard deviation of the number of children ever born to women according to single year of age between the ages of fifteen and forty-nine. We then calculated each woman's difference from the mean for her age in standard deviation units (z scores). We label this as CEBz. Thus, a CEBz of zero means that a woman has borne exactly the same number of children as the average for all women her age in Accra. A positive value indicates that she has more children than average, and a negative value indicates that she has fewer children than the average for all women her age. We then aggregated the individual scores to the neighborhood level to generate an average fertility score for each neighborhood. This allowed us to decompose the overall level of fertility into the share attributable to delayed marriage and that attributable to childbearing after marriage.

Among the vernacular neighborhoods, the combination of the percentage of women fifteen to twenty-four who were never married and the percentage of women fifteen to forty-nine who had given birth to fewer than three children accounted for 82 percent of the variability in CEBz, and the standardized beta coefficient for delayed marriage was almost twice the size of the coefficient for fertility after marriage. Thus, we can conclude that 64 percent of the variability in overall fertility was due to delayed marriage and the remainder to childbearing after marriage. The explained variance in overall fertility was also .82 among the organic neighborhoods, and delayed marriage was the most important component but less than so than among the vernacular neighborhoods. Delayed marriage accounted for 55 percent of the overall level of fertility, and childbearing after marriage accounted for 45 percent. These calculations underscore our results that suggest that the spatial dynamics and predictors of delayed marriage are different from those of reproduction after marriage. These findings also suggest that the context within which decisions about marriage are made is likely to be different from those in which decisions will be made about how many children to have, once at risk of having children.

At the individual level, we found a measurable contextual effect only for delayed marriage and not for fertility after marriage. This is consistent with the literature, noted earlier, that neighborhood context might be more influential at the younger ages than at the older ages. However, the overall lack of explanatory power at

the individual level is puzzling. It is not simply that the contextual effects do not emerge strongly—none of the fixed effects were powerful predictors. To be sure, all relationships were in the expected direction, especially the relationship with education, but the overall size of the effects was relatively small. We tried every possible combination of variables (not shown) without any improvement in the results. The census data have the strong advantage that they permit a detailed spatial analysis, but they have the strong disadvantage that the relatively limited number of questions asked on the census appears not to be capturing those things that are most influencing reproductive decisions in Accra.

The relatively small contextual effects, regardless of how spatially bounded the context (e.g., vernacular or organic in nature), fit into the larger discussion in the literature about the nature of these effects (see, for example, Subramanian et al. 2009). Entwisle (2007) and Matthews (2008) are among those who have noted that (1) neighborhoods of residence (at which location we collect most data in the social sciences) might not be as salient as we think in determining human behavior; and (2) even if they are, the multilevel statistical techniques currently employed, as in this research, might not be as appropriate as we would like them to be for this task. We agree with both Entwisle and Matthews that the next step must involve more intensive field research that includes a clear spatial component. This might also require that we turn the tables on the usual approach to defining neighborhoods, which is, as we did in this research, to define them on the basis of the expected predictor variables, and then we see whether the observed data, in this case fertility levels, match our expectations. Most research findings, including our own in this research, produce very modest levels of explanation of behavior at the individual level and so an alternative research strategy might be to create "contexts" of high and low fertility and then investigate, through data mining and fieldwork, the factors that explain the individual variability in behavior among people living in those differing contexts.

In this article, we have been able to take only a cross-sectional slice of fertility behavior in Accra, during a transitional time when fertility had stalled in Ghana and in Accra more specifically, so we are not in a position from these data to fully understand these potentially dynamic factors underlying fertility change. Nonetheless, we have shown that an important component of the variability in fertility levels in Accra is the age at which young women marry. Over time, increasingly delayed marriage would have the effect of lowering overall levels of fertility through its tempo effect. For this to be associated with a stall in fertility, however, it would had to have meant that reproduction was actually rising within marriage. In fact, data from the DHS do show that in 2003 the number of children ever born to ever-married women aged twenty-five through thirty-nine was higher than it had been among ever-married women of the same age in 1998. From this, we can infer that the stall in fertility in Accra was due to the tempo effect from delayed marriage counterbalanced by the quantum effect of higher fertility within marriage. On the other hand, data from the 2008 DHS show that the delay in marriage leveled off between 2003 and 2008 after reaching near universality among women fifteen to nineteen and more than two thirds of women aged twenty-five to twenty-nine. At the same time, the number of children born to ever-married women was lower at every age in 2008 than it had been in 2003, leading to an overall drop in fertility among women in Accra. We will be able to test the expected spatial patterns of these changes within the city after completion of the 2010 Census of Population and Housing.

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