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FCND DP No. 94

FCND DISCUSSION PAPER NO. 94

**TARGETING URBAN MALNUTRITION: A MULTICITY
ANALYSIS OF THE SPATIAL DISTRIBUTION OF CHILDHOOD
NUTRITIONAL STATUS**

Saul Sutkover Morris

Food Consumption and Nutrition Division

International Food Policy Research Institute

2033 K Street, N.W.

Washington, D.C. 20006 U.S.A.

(202) 862-5600

Fax: (202) 467-4439

September 2000

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ABSTRACT

This paper assesses the degree to which childhood malnutrition and its contributing factors are clustered by neighborhood in seven different cities in Africa, Asia, and Latin America. The analysis is based on data from eight different national household surveys that used a two-stage sampling design (households within clusters). Spatial clustering was assessed using the intracluster correlation coefficient (r), which may be interpreted as the proportion of the total variance in a variable that is associated with the cluster to which it belongs. In general, per capita expenditures and the share of the household budget spent on food showed a high level of spatial clustering across the seven cities, but the magnitude of this clustering varied markedly from city to city. Spatial clustering in the provision of basic services also varied greatly. There was consistently little evidence of spatial clustering of infectious disease, childhood mortality, or the weight-based nutrition indicators. Age-standardized height, on the other hand, showed slightly more spatial clustering, with a median intracluster correlation of $r = 0.12$. Some cities showed relatively higher levels of spatial clustering on several measures of deprivation simultaneously, while other cities showed consistently lower levels of clustering. Many nutrition interventions are intrinsically geographically targeted. While geographical targeting tends to be administratively simpler than individual targeting and can be politically convenient, the current analysis suggests that where nutrition interventions are focused on stunting (low height-for-age), targeting by

neighborhood may often lead to unacceptably high rates of undercoverage and leakage of benefits to the nonneedy.

CONTENTS

Acknowledgments.....	vii
1. Introduction.....	1
2. Data Sources	2
3. Variables.....	7
4. Statistical Analysis.....	9
5. Results	12
6. Discussion.....	17
Appendix	23
References	27

TABLES

1. Childhood nutritional status and its contributing factors in seven developing country cities.....	8
2. Spatial clustering of childhood nutritional status and its contributing factors in seven cities.....	14
3. Pairwise correlations across nine cities between levels of spatial clustering in seven different dimensions of social deprivation.....	16

ACKNOWLEDGMENTS

Many thanks to Bynyak Sen of the Bangladesh Bureau of Statistics for facilitating access to the Bangladesh Household Expenditure Survey; to the Development Economics Research Group at the World Bank for access to the Living Standards Measurement Surveys; to Prem Sangraula at the International Food Policy Research Institute (IFPRI) for assistance in the analysis of the Nepal Living Standards Survey; and to James Garrett and Marie Ruel at IFPRI for comments on an earlier draft of this manuscript.

Saul Sutkover Morris
International Food Policy Research Institute

1. INTRODUCTION

In many developing countries, the number of malnourished children in urban areas is increasing, both in absolute numbers and as a proportion of all malnourished children (Haddad, Ruel, and Garrett 2000). In order to stem the growth of urban malnutrition, effective interventions are needed that reach those at greatest risk. Current strategies to reach these individuals appear to have been strongly influenced by the prevalent view that

Urban poverty is primarily concentrated in squatter settlements and slum areas...with overcrowding and substandard housing, lack of potable water, uncollected garbage, a high incidence of child mortality and infectious diseases, and malnutrition all being the norm. (UNICEF 1994, 2).

This statement implies that urban neighborhoods are highly differentiated with respect to manifestations of social deprivation, but that within neighborhoods, conditions are largely homogeneous. Empirical support for this claim, however, is surprisingly limited. In an examination of survey data from Abidjan and Accra (Morris et al. 2000), we found that in Abidjan, garbage collection and access to potable water were indeed unequally distributed across neighborhoods, but that nutritional status was highly heterogeneous within neighborhoods, showing no “clustering” in particular areas. In Accra, nutritional status was also heterogeneous within neighborhoods, as were many

other variables such as household income (the proxy measure for which was total expenditures), drinking water source, and education of the household head.

If nutritional status is not clustered by neighborhood, then nutrition-focused interventions that are geographically defined will lead to serious undercoverage of those at risk, as well as to provision of program benefits to the nonneedy. This conclusion applies equally to community-based nutrition projects, such as have been described in Bangladesh, Ecuador, Haiti, and Kenya (UNICEF 1994), to physical upgrading programs (Habitat 1996), and to local economic development initiatives, such as have been described in Lima, Peru (Zaaijer and Sara 1993). In this paper, therefore, we attempt to determine the degree to which malnutrition, poverty, overcrowding, substandard housing, lack of potable water, child mortality, and infectious diseases are clustered by neighborhood in seven different cities in Africa, Asia, and Latin America. In each case, our analysis is based on publicly available, large-sample, representative household survey data.

2. DATA SOURCES

This analysis uses data from eight different nationally representative surveys, all in the public domain. All the surveys used two-stage random sampling, with or without initial stratification by subnational region or type of locality. In each case, the primary sampling unit was a geographical *cluster*, usually based on administrative subdivisions

such as census tracts; the ultimate sampling unit was the dwelling or the household. In the following paragraphs, each survey is described in turn.

The *Peru Living Standards Measurement Survey, 1994* covered diverse aspects of household welfare, including the nutritional status of young children. The country was first divided into seven geographic regions (including Metropolitan Lima), then within each region clusters of 100 households were selected, and within each selected cluster, a fixed number of dwellings was chosen at random. The present analysis uses only data from households in Metropolitan Lima. Further information can be obtained from the Living Standards Measurement Surveys Website: www.worldbank.org/lsms/.

The *Panama Living Standards Survey, 1997* also covered diverse aspects of household welfare, including the nutritional status of young children. The country was first divided into 20 quasigeographic strata (including “indigenous areas,” and “areas of difficult access”). In the urban areas, clusters consisting of two or more adjacent census tracts were selected with probability proportional to size, and within each selected cluster a fixed number of dwellings was selected at random, without replacement. The present analysis uses only data from households located in Panama City (including San Miguelito). Further information can be obtained from the Living Standards Measurement Surveys Website (see above).

The *Tanzania Human Resource Development Survey, 1993–4*, a nationally representative survey of 5,000 households in Tanzania, was principally intended to investigate households’ use of and expenditures on social services, but included modules on household composition, household characteristics (including the educational levels of

household members), and expenditures. The survey was a joint effort undertaken by the Department of Economics of the University of Dar es Salaam, the Government of Tanzania, and the World Bank, and was funded by the World Bank, the Government of Japan, and the British Overseas Development Agency. Nutritional data were not collected. The sample used all 222 clusters of the National Master Sample maintained by the Tanzanian Bureau of Statistics, and within each cluster, 20–25 randomly selected households were targeted for interview. The present analysis uses only data from households located in Dar es Salaam. Further information can be obtained from the Living Standards Measurement Surveys Website (see above).

The *Tanzania Demographic and Health Survey, 1996* was designed to provide data that would allow the calculation of demographic rates and to collect reliable data on diseases and nutritional status of children under five. Information on household characteristics, including the educational levels of each household member, was also collected. First local government wards or branches were selected, then enumeration areas within these wards or branches. Finally, households were selected from a household listing on the basis of contiguity, beginning with a random number. The present analysis uses only data from households located in enumeration areas in urban segments of the Dar es Salaam region. The sample design and major findings from the survey have been published by the Tanzanian Bureau of Statistics and Macro International Inc. (1997), and documentation and the data are available from the Demographic and Health Surveys Website at www.macrint.com/dhs/.

The *South Africa Integrated Household Survey, 1993-4* covered diverse aspects of household welfare, including the nutritional status of young children. The clusters were, in most cases, Census Enumerated Sub-Districts, but where these were “relatively large” they were divided into blocks of approximately equal population size using aerial photographs. The clusters were selected by systematic sampling with probability proportional to size, and within each selected cluster a systematic sample of “stands” was selected with a fixed sampling fraction. Two sets of data were used in the present analysis: those clusters located within the borders of the Johannesburg Metropolitan Area, and those in the Cape Metropolitan Area. Further information can be obtained from the Living Standards Measurement Surveys Website (see above).

The *Nepal Living Standards Living Survey, 1997* covered diverse aspects of household welfare, including the nutritional status of young children. The country was first divided into four strata based on ecological zones and, in most cases, wards were selected as the primary sampling units using probability proportional to size. In urban areas, larger wards were first split into sub-wards of equal sizes. With the exception of the Far-Western Development Region, 12 households were selected for interview from each of the survey cluster, using systematic random sampling with replacement. The present analysis uses only data from the urban area of the Kathmandu valley. Further information can be obtained from the Living Standards Measurement Surveys Website (see above).

The *Bangladesh Household Expenditure Survey, 1995-6* was principally intended to characterize poverty in Bangladesh, and included information on expenditures,

household characteristics (including the educational levels of household members), and community characteristics. Nutritional data were not collected. Primary Sampling Units, consisting of two or more contiguous census enumeration areas with a combined population of approximately 250 households, were selected using probability proportional to size from a nationally representative sampling frame based on the 1991 population census. Twenty households were then selected from each cluster by systematic sampling with replacement. The present analysis uses only data from households located in the urban sections of the Dhaka Statistical Metropolitan Area. The sample design and major findings from the survey have been published by the Bangladesh Bureau of Statistics (1998). Further information can be obtained from the Bangladesh Poverty Assessment Website at www.worldbank.org/html/extdr/offrep/sas/bangladesh-poverty/.

The *Bangladesh Demographic and Health Survey, 1996–7* was designed to provide data that would allow the calculation of demographic rates and to collect reliable data on diseases and nutritional status of children under five. Information on household characteristics, including the educational levels of household members, was also collected. Each of the six administrative divisions in the country was divided into urban and rural areas. In the urban areas the primary sampling unit was the administrative division termed *mahalla*. These clusters were selected with probability proportional to size, and within each cluster, households were selected using systematic sampling. The present analysis uses only data from households located in the urban sections of the Dhaka Statistical Metropolitan Area. The sample design and findings from the survey

have been published by the Bangladeshi National Institute of Population Research and Training, Mitra and Associates, and Macro International Inc. (Mitra et al. 1997). Documentation and data are available from the Demographic and Health Surveys Website (see above).

Basic information on each survey sample (number of clusters and number of households per cluster) is included in Table 1.

3. VARIABLES

Variables were initially selected and then recoded as necessary to achieve comparability across surveys. Substandard housing was defined as a house with an earth floor or a house without electricity. Potable waste was defined as water from a closed system located in the home or in the yard. Spatial clustering of garbage collection could not be assessed, since this information was not collected in any of the surveys. Crowding was measured as the number of usual residents in the household divided by the total number of rooms used by them (excluding dedicated kitchens and bathrooms), except in the case of the Tanzania Demographic and Health Survey, which only collected information on the number of *sleeping* rooms. Households' relative ability to satisfy their consumption needs was determined on the basis of their per capita annual consumption expenditures (Grootaert 1982) and the proportion of the household budget used to purchase food (the "food share"). Expenditure aggregates had already been calculated for Peru, Panama, Bangladesh, Nepal, and South Africa. For Dar es Salaam, they were

Table 1—Childhood nutritional status and its contributing factors in seven developing country cities. Numbers are percentages (number with characteristic/number of observations) unless otherwise stated

	Lima	Panama	Dar es Salaam		Jo'burg	Cape Town	Kath'du	Dhaka	
			(HRDS)	(DHS)				(HES)	(DHS)
Number of clusters included in the analysis	138	148	50	27	20	21	33	34	21
Median number of households/cluster (range)	6 (5-8)	10 (2-15)	22 (4-38)	18 (5-57)	27 (3-64)	26 (11-42)	12 (12-12)	20 (20-20)	16 (11-21)
Earth floor in home	11.1% (92/831)	1.3% (18/1388)	8.2% a (93/1134)	12.3% (72/585)	0.7% (4/576)	0.4% (2/534)	31.6% (125/396)	-	19.5% (65/333)
Drinking water from a closed-system water source in the home or yard	86.4% (732/847)	98.5% (1367/1388)	50.1% (567/1121)	34.5% (202/586)	97.4% (564/579)	92.1% (491/533)	94.2% (373/396)	66.5% (452/680)	70.9% (236/333)
Electricity in the home	98.6% (835/847)	98.6% (1368/1387)	53.0% (597/1126)	45.9% (269/586)	85.1% (491/577)	82.9% (442/533)	99.5% (394/396)	88.2% (600/680)	93.1% (309/332)
Median number of persons/room (lower and upper quartiles)	0.73 (0.50-1.00)	1.25 (0.80-2.00)	2.00 (1.33-3.00)	2.00 b (1.50-3.00)	1.00 (0.50-2.00)	0.80 (0.50-1.25)	1.17 (0.82-1.50)	-	-
Median per capita household expenditure (lower and upper lower quartiles)	\$1,087 (748-1,693)	\$2,329 (1,390-3,993)	\$437 (300-736)	-	\$2,074 (1,037-5,118)	\$1,892 (1,046-3,966)	\$393 (268-639)	\$361 (246-554)	-
Median food share (lower and upper quartiles)	37.7% (27.4-47.2)	36.6% (27.9-46.5)	51.6% (44.1-59.3)	-	34.9% (20.2-49.0)	31.9% (21.0-49.1)	37.0% (27.7-47.7)	50.6% (39.0-62.9)	-
15-day prevalence of diarrhea, under 5s	12.4% (40/323)	15.8% c (86/543)	-	9.9% (33/334)	unreliable data			-	8.2% (135/147)
One-month prevalence of respiratory infection, under 5s	-	44.4% (241/543)	-	34.2% d (114/333)				-	36.7% d (54/147)
Children died as a proportion of children ever born to women aged 15-50 at time of survey	4.9% e (87/1778)	1.6% f (40/2452)	15.1% (526/3491)	14.9% f (205/1378)	-	-	13.7% g (216/1572)	-	10.2% h (91/896)
Mean height-for-age Z-score of under-5s (SD; n)	-0.49 (1.41; 299)	-0.22 (1.16; 511)	-	-1.36 (1.48; 283)	-0.53 (1.70; 171)	-0.80 (1.47; 172)	-1.29 (1.47; 86)	-	-1.60 (1.46; 132)
Mean weight-for-age Z-score of under-5s (SD; n)	0.13 (1.21; 299)	-0.01 (1.18; 514)	-	-1.05 (1.24; 283)	-0.43 (1.60; 171)	-0.42 (1.58; 172)	-0.84 (1.15; 86)	-	-1.65 (1.22; 132)
Mean weight-for-height Z-score of under-5s (SD; n)	0.57 (1.25; 295)	0.16 (1.00; 507)	-	-0.22 (1.37; 291)	-0.08 (1.56; 170)	0.10 (1.59; 171)	-0.05 (1.00; 84)	-	-0.85 (1.02; 132)

NOTES: (a) Eight households occupying more than one building double-counted in this tabulation, (b) persons/sleeping-room, (c) one-month prevalence, (d) two-week prevalence, (e) women aged 15-45, (f) women aged 15-49, (g) ever-married women, (h) ever-married women aged 10-49. Exchange rates: 1US\$=1.1 Nuevos Soles (Peru), 1.00 Balboas (Panama), 500 Shillings (Tanzania), 3.42 Rand (S. Africa), 50 Rupees (Nepal), 41.1 Thaka (Bangladesh).

calculated from the original disaggregated data using the approach suggested by Hentschel and Lanjouw (1996).

Mortality was measured as the proportion of live-born children of all women of reproductive age that had died up to the time of the survey. Infectious disease was interpreted as the proportion of children under five reported as having suffered diarrhea or respiratory infections over the previous two weeks or one month, depending on the survey. Morbidity data from the South African survey were excluded because the form of the question asked (Has any member of the household been sick or injured during the past two weeks?) was considered too nonspecific to elicit reliable information. Data from Kathmandu were also excluded because of a very large number of missing values. Finally, nutritional status was assessed using standardized measures of height-for-age, weight-for-age, and weight-for-height, based on the reference population of the National Center for Health Statistics (NCHS) (Hamill et al. 1977). Data on housing conditions, household expenditures, and childhood nutritional status were available for all seven cities; data on crowding was missing for Dhaka, and mortality data were missing for the South African cities.

4. STATISTICAL ANALYSIS

Descriptive statistics presented are proportions for dichotomous variables such as the availability of drinking water from a closed-system source; medians (with lower and upper quartile bounds) for asymmetrically distributed variables such as per capita

household expenditures, and means (with standard deviations) for the nutritional status variables, which were normally distributed. Spatial clustering was assessed using the intraclass correlation coefficient (r), which may be interpreted as the proportion of the total variance in a variable that is associated with the cluster to which it belongs.¹ This coefficient varies from 0.00 (no clustering at all) to 1.00 (all variability is at the level of the cluster, the clusters are internally homogeneous), and was estimated in two different ways depending on the type of variable. For continuous variables, r was estimated from a random-effects analysis of variance model (Snedecor and Cochran 1980), with asymptotic 95 percent confidence limits computed as described in the Stata manual (StataCorp 1999). Highly asymmetric variables, such as per capita expenditures and number of persons per room, were log-transformed prior to analysis, since analysis of variance methods are sensitive to violations of the assumption of normality. For binary variables, r was estimated using the Generalized Estimating Equation approach, assuming a logit link, binomial error structure, and exchangeable correlation among observations from the same cluster (Zeger and Liang 1986). Confidence limits are not available using this approach. In cases where the proportion of households or individuals with a particular characteristic exceeded 98 percent or was less than 2 percent, the associated intraclass correlation coefficient was not reported, since it has no meaningful interpretation in the absence of variation. Where negative intraclass correlations were estimated, these were truncated at zero in accordance with the interpretation described

¹ For a discussion of the analysis of intra-urban spatial distributions using area sampling, see the Appendix

above. It should be noted that values of $\rho = 0$ do not imply that all the clusters have the same mean; rather, they indicate that the between-cluster variance is no greater than the within-cluster variance. Consequently, two randomly selected observations from the same cluster would not be expected to be any more similar to each other than two randomly selected observations from different clusters.

As noted in our previous paper (Morris et al. 2000), any attempt to define high, low, and moderate levels of clustering is arbitrary. However, Deaton (1997) has noted that “for quantities like income and consumption in rural areas of developing countries, r is often substantially larger than zero and values of 0.3 to 0.4 are frequently encountered.” On the other hand, Bennett and coworkers (1991) note that “in practice, values above 0.4 are uncommon, except for variables which are specific to the locality rather than the household, and hence clustered by definition.” Therefore, we therefore adopted the following classification:

≥ 0.3	high intracluster correlation,
$\geq 0.2, < 0.3$	moderately high intracluster correlation,
$\geq 0.1, < 0.2$	moderately low intracluster correlation,
< 0.1	low intracluster correlation.

We wished to determine whether levels of spatial clustering in one aspect of deprivation, e.g., crowding, were systematically associated across the cities investigated with levels of spatial clustering of other variables, e.g., nutritional status. Therefore, we used the intracluster correlation coefficients for the seven dimensions of deprivation for

which we had extensive cross-city data (per capita expenditures, the budget food share, electricity supply, potable water, height-for-age, weight-for-age, and weight-for-height Z-scores), calculating Pearson's correlation coefficients (Snedecor and Cochran 1980) between each possible combination of variables. We included in this analysis the intraclass correlation coefficients from our previous analysis of Abidjan and Accra (Morris et al. 2000) to increase the sample size from seven to nine cities. In cases where two estimates of the intraclass correlation coefficient were available for the same city, the average of the two values was used. A high correlation between two variables in this analysis indicates that those cities with high levels of spatial clustering in one variable tend to be the same cities that show high levels of spatial clustering in the other variable. Conversely, a low correlation indicates that those cities with high levels of spatial clustering in the first variable show little or no spatial clustering in the second variable. All analyses were conducted using Stata v6.0 (StataCorp 1999).

5. RESULTS

Table 1 shows descriptive statistics for the seven cities. Lima, Panama City, Johannesburg, and Cape Town were middle-income cities, with median per capita expenditures in the range of US\$1,000–2,500 per annum. Dar es Salaam, Kathmandu, and Dhaka, on the other hand, were low-income cities, with median per capita expenditures below US\$500 per annum. Median households spent approximately one-half of their budgets on food in Dhaka and Dar es Salaam, and one-third or a little more

in the remaining cities. Access to potable water was extensive (>85 percent households) in Lima, Panama City, Johannesburg, Cape Town, and Kathmandu, moderate in Dhaka (67–71 percent), and limited in Dar es Salaam (35–50 percent). Similarly, access to electricity was extensive in all cities except for Dar es Salaam. More than 10 percent of homes had earth floors in Lima, Dar es Salaam (DHS sample only), and Dhaka, and crowding was most acute in Dar es Salaam and least acute in Lima. Ten–15 percent of children born to women of reproductive age had previously died in Dar es Salaam, Kathmandu, and Dhaka. In Panama City, less than 2 percent of live-born children had died. Period prevalences of diarrhea and respiratory illness were rather similar in the cities where this information was collected. Dhaka had the lowest mean nutritional status (all three indicators), followed by Dar es Salaam and Kathmandu. Lima, Johannesburg, and Cape Town had mean height-for-age Z-scores in the range 0.5–0.8, and the South African cities had mean weight-for-age Z-scores of similar magnitudes. Children in Panama City had nutritional status very similar to the North American children of the NCHS reference standard, while mean weight-for-height Z-scores were markedly above zero in Lima.

Table 2 shows intracluster correlation coefficients for the same variables in the same seven cities. Per capita expenditures showed high levels of spatial clustering in Lima, Panama City, Johannesburg, and Cape Town, moderately high levels in Dhaka and Dar es Salaam, and moderately low levels in Kathmandu. The proportion of the household budget used to purchase food showed high levels of spatial clustering in

Table 2—Spatial clustering of childhood nutritional status and its contributing factors in seven cities. Numbers are intraclass correlation coefficients

	Lima	Panama	Dar es Salaam		Jo'burg	Cape Town	Kath'du	Dhaka	
			(HRDS)	(DHS)				(HES)	(DHS)
Earth floor in home	0.28	-	0.13a	0.09	-	-	0.25	-	0.23
Drinking water from a closed-system water source in the home or yard	0.73	-	0.22	0.30	0.31	1.00	0.08	0.82	0.60
Electricity in the home	-	-	0.25	0.31	0.76	0.95	-	0.38	0.10
Persons/room(b)	0.22 (0.15-0.29)	0.27 (0.21-0.34)	0.09 (0.04-0.14)	0.03c (0.00-0.07)	0.51 (0.32-0.70)	0.46 (0.29-0.63)	0.03 (0.00-0.09)	-	-
Per capita household expenditure(b)	0.43 (0.36-0.51)	0.52 (0.45-0.58)	0.21 (0.13-0.29)	-	0.63 (0.46-0.80)	0.67 (0.52-0.82)	0.17 (0.07-0.27)	0.27 (0.16-0.38)	-
Food share(b)	0.27 (0.20-0.34)	0.43 (0.36-0.50)	0.09 (0.04-0.14)	-	0.53 (0.35-0.72)	0.56 (0.39-0.73)	0.08 (0.01-0.16)	0.19 (0.10-0.29)	-
15-day prevalence of diarrhea, under 5s	0.03	0.05d	-	0.00	-	-	-	-	0.02
One-month prevalence of respiratory infection, under 5s	-	0.16	-	0.00e	-	-	-	-	0.04e
Children died as a proportion of children ever born to women aged 15-50 at time of survey	0.06f	-	0.01	0.02g	-	-	0.04	-	0.00h
Mean height-for-age Z-score of under-5s (SD; n)	0.20 (0.07-0.34)	0.12 (0.03-0.21)	-	0.04 (0.00-0.12)	0.16 (0.00-0.32)	0.18 (0.02-0.34)	0.00 (0.00-0.22)	-	0.12 (0.00-0.28)
Mean weight-for-age Z-score of under-5s (SD; n)	0.12 (0.00-0.26)	0.05 (0.00-0.13)	-	0.08 (0.00-0.18)	0.08 (0.00-0.20)	0.08 (0.00-0.19)	0.00 (0.00-0.22)	-	0.16 (0.00-0.33)
Mean weight-for-height Z-score of under-5s (SD; n)	0.00 (0.00-0.13)	0.05 (0.00-0.13)	-	0.03 (0.00-0.10)	0.00 (0.00-0.08)	0.15 (0.00-0.30)	0.11 (0.00-0.35)	-	0.04 (0.00-0.17)

NOTES: (a) Eight households occupying more than one building double-counted in this tabulation, (b) log transformation, (c) persons/sleeping-room, (d) one-month prevalence, (e) two-week prevalence, (f) women aged 15-45, (g) women aged 15-49, (h) ever-married women aged 10-49.

Panama and the South African cities, a moderately high level in Lima, a moderately low level in Dhaka, and low levels in Dar es Salaam and Kathmandu. Access to potable water was highly spatially clustered in Lima, Johannesburg, Cape Town, and Dhaka, moderately highly clustered in Dar es Salaam, and almost unclustered in Kathmandu. Similarly, coverage of electricity was highly clustered in the South African cities, and highly to moderately highly clustered in Dar es Salaam, with equivocal findings from the two Dhaka surveys. Substandard housing, as evidenced by earth floors, showed moderately high clustering in Lima, Dhaka, and Kathmandu, but low to moderately low clustering in Dar es Salaam, while crowding showed extremely high clustering in Johannesburg and Cape Town, moderately high clustering in Lima and Panama City, and low clustering in Dar es Salaam and Kathmandu. There was virtually no indication of spatial clustering in child mortality (median $r = 0.02$) or in morbidity (median $r = 0.025$ for diarrhea and $\rho = 0.04$ for respiratory illness), with the possible exception of Panama City, where respiratory infections showed an intracluster correlation of 0.16.

Height-for-age Z-scores showed low spatial clustering in Dar es Salaam and Kathmandu, and moderately low clustering in Panama City, Johannesburg, Cape Town, and Dhaka. The highest level was seen in Lima ($r = 0.20$). It is possible to determine what this relatively high level of clustering implies for the feasibility of geographically targeting nutrition programs by ranking each cluster on the basis of its mean height-for-age Z-score and determining what proportion of stunted children (Z-score < -2) reside in the clusters with the lowest mean values. Thus, if a geographically targeted program to

eliminate stunting were able to reach 15 percent of all Lima's children, starting with those living in the clusters with the lowest mean height-for-age Z-scores and progressing to those with higher values, only 38 percent of all stunted children would be reached and 69 percent of program benefits would be given to nonstunted children.

Weight-for-age Z-scores showed low spatial clustering in Panama City, Dar es Salaam, Johannesburg, Cape Town, and Kathmandu, and moderately low levels in Lima and Dhaka. Weight-for-height Z-scores showed low spatial clustering in Lima, Panama City, Dar es Salaam, Johannesburg, and Dhaka, and moderately low levels in Cape Town and Kathmandu.

Table 3 shows cross-city correlations between levels of spatial clustering in different dimensions of deprivation. Each possible pairwise combination of a total of seven different variables is considered. The table indicates that the same cities tend to show relatively high levels of spatial clustering in electricity supply, crowding, expenditure levels, and the share of the household budget going to food, with all pairwise

Table 3—Pairwise correlations across nine cities between levels of spatial clustering in seven different dimensions of social deprivation

	Potable water	Electricity	Persons/room	Per capita expenditure	Food share	Height-for-age	Weight-for-age
Electricity in the home	0.57						
Persons/room	0.51	0.90					
Per capita expenditure	0.64	0.98	0.94				
Food share	0.58	0.96	0.96	0.99			
Height-for-age Z-score	0.69	0.77	0.83	0.80	0.76		
Weight-for-age Z-score	0.54	-0.11	0.51	0.22	0.17	0.66	
Weight-for-height Z-score	0.24	0.58	0.20	0.20	0.24	0.04	-0.18

Notes: The number of observations varies from five to nine due to missing observations, as in Table 2. Statistically significant correlations shown in bold.

comparisons for these variables showing cross-city correlations greater than or equal to 0.9. Spatial clustering of standardized height-for-age (stunting) was also strongly associated with spatial clustering in these indices of deprivation (cross-city correlations in the range 0.76–0.83). However, spatial clustering in the weight-based nutritional measures was not significantly associated at the 5 percent level with spatial clustering in other dimensions of deprivation.

6. DISCUSSION

This article examines the degree to which child malnutrition, infectious disease, and mortality, as well as poverty, overcrowding, substandard housing, and lack of access to basic services, tend to concentrate in particularly disadvantaged neighborhoods in developing country cities. Findings are presented for seven cities in Africa, Asia, and Latin America, complementing an earlier analysis that focused exclusively on two West African cities (Morris et al. 2000). The data used are all from representative household surveys that interviewed residents in 20–148 locations per city. Thus, although the full range of neighborhood variation cannot be determined, extensive geographical coverage is assured.

The results suggest that the conventional view that urban deprivation is “primarily concentrated in squatter settlements and slum areas” (UNICEF 1994, 2) greatly oversimplifies a complex reality. Although per capita expenditures and share of household budget spent on food generally showed a high level of spatial clustering across

the seven cities, the magnitude of this clustering varied markedly from city to city. Spatial clustering in the provision of basic services such as water and electricity also varied dramatically from one city to another, from virtually uniform access across clusters (as with drinking water supply in Kathmandu) to almost total concentration of services in less severely disadvantaged neighborhoods (Cape Town). There was consistently little evidence of spatial clustering of infectious disease (diarrhea or respiratory illness), childhood mortality, or the weight-based nutrition indicators. Age-standardized height showed a little more spatial clustering, with a median intraclass correlation of $r = 0.12$ across the seven cities. This was higher than the values observed for the weight-based measures ($r = 0.08$ for weight-for-age and $r = 0.04$ for weight-for-height), but was still indicative of only very moderate spatial clustering. Spatial clustering of age-standardized height showed some city-to-city variation, ranging in our sample from $r = 0.00$ in Kathmandu to $r = 0.20$ in Lima.

Combining findings from the seven cities analyzed in this paper and the two cities analyzed in our previous paper (Accra and Abidjan), it was apparent that some cities showed relatively higher levels of spatial clustering on several measures of deprivation simultaneously, while other cities showed consistently lower levels of clustering. In particular, there were high city-level correlations between levels of spatial clustering of electricity supply, crowding, household expenditure, food budget share, and age-standardized height. Cities that showed relatively higher levels of spatial clustering on all these measures were Cape Town, Johannesburg, Panama, and Lima. It can hardly be a

coincidence that the two cities that acquired their spatial structure as a result of *apartheid* were those that also showed most evidence of spatial clustering of multiple aspects of deprivation. Commenting on the challenges facing urban policymakers in Johannesburg, Beavon (1997) has said “the current urban crisis centres on redressing the legacy of the past whereby the indigenous population was consciously marginalized through a process of creating ghettos within the fabric of what was conceived to be a whites-only town.” Indeed, because of this legacy, it may be appropriate to interpret the levels of clustering seen in the South African cities as a global upper bound. Urban Panama has also been said to present “a very special case among Latin American countries, a case of poverty in the midst of wealth” (Camazón, García-Huidobro, and Morgado 1989). This situation is attributed to the exceptional openness of the Panamanian economy and the polarization of its modern and informal sectors—the so-called “global city effect.” In terms of the magnitudes of spatial inequalities, Lima appears to closely resemble Panama City, although it must have reached that stage by a quite different path: situated in the midst of a barren plain unsuitable for agriculture, the urbanized surface of the city increased 3.5-fold between 1969 and 1985 as desperately poor—and relatively low-stature—migrants poured in from the countryside (Harms 1997), presumably exacerbating spatial inequalities.

The relevance of the present findings on the spatial clustering of standardized weight-for-height is lessened by the fact that for virtually all the cities studied, the distribution of this variable coincided almost exactly with the North American reference population. This indicates that neither thinness (wasting) nor obesity is likely to be a

significant public health problem in these environments, in contrast to what was observed for age-standardized height, which was low compared to the reference population everywhere except in Panama City. The two cities where the distribution of standardized weight-for-height did not mirror the North American reference population were Dhaka, where values were low, indicating the likely presence of significant numbers of wasted children, and Lima, where values were high, suggesting a problem of obesity. However, there was no indication of spatial clustering in standardized weight-for-height in either of these cities ($p = 0.04$ and $p = 0.00$, respectively). Age-standardized weight is a nutritional indicator that represents the combined effects of linear growth (age-standardized height) and soft tissue mass (weight-for-height). In our sample of cities, levels of spatial clustering in this measure were more closely associated with the distribution of age-standardized height than with weight-for-height.

These complex patterns have important policy implications. First, it is necessary to consider whether the levels of spatial clustering of childhood nutritional status identified are sufficiently high to justify the geographical targeting of nutrition interventions in cities. Physical upgrading programs are intrinsically geographically targeted, yet the large outlays involved are frequently justified by invoking the supposed health benefits that will result. Local economic development initiatives may also have less effect on childhood nutritional status than might be imagined if large numbers of vulnerable households do not live in the target areas. With respect to community-based initiatives, some of these are necessarily geographically targeted—the *comedores*

populares or soup kitchens of Lima being an obvious example—while others, such as food and nutrition education, or micronutrient supplementation, are not. However, even when the type of intervention permits alternative approaches, geographical targeting tends to be administratively simpler than individual targeting, since geographic divisions can be assigned priority on the basis of existing aggregate data (Baker and Grosh 1994). In addition, political considerations may favor highly visible interventions in obvious “problem” communities, rather than more subtle (and usually more intrusive) approaches to identifying those in greatest need.

The current analysis suggests that where nutrition interventions are focused on stunting (low height-for-age), there may be some limited scope for targeting by neighborhood in cities with high structural inequalities, such as in South Africa and Latin America. However, even in these cases, it should be borne in mind that neighborhoods are far from homogeneous, and that both undercoverage and leakage of program benefits will result from restricting benefits to a few neighborhoods. This was evident from the example given for Lima, i.e., that if a nutrition intervention were geographically targeted using the mean height-for-age Z-score of the cluster as the targeting criterion, only 38 percent of all stunted children would be reached while 69 percent of program benefits would be given to nonstunted children. On the other hand, only in very particular cases—such as in Bangladesh—are urban nutrition programs likely to be focused on wasting (low weight-for-height), since this problem is not prevalent in most urban areas. We see no evidence that neighborhood targeting would be an appropriate strategy for measures

for the prevention of wasting or the rehabilitation of wasted children in Dhaka, since the intracluster correlation coefficient for standardized weight-for-height was negligibly low.

The low levels of spatial clustering of nutritional status observed thus pose a problem for the design of effective nutrition interventions. Previous experience in urban poverty alleviation has led many policymakers to conclude that “exclusively focusing on city-level approaches offers few prospects for directly tackling urban poverty problems at the local level” (Zaaijer and Sara 1993). Now the very same problems of undercoverage and leakage that led to disillusionment with citywide approaches are present again as arguments against excessively localized interventions in the area of nutrition. However, the implementation of nutrition programs at the citywide level is likely to be fraught with difficulties, because the resources required for endogenous development—such as effective community activist groups—are to be found at the local, not city, level. Furthermore, even if geographic targeting of nutrition interventions is inadequate, it remains to be determined what alternative model might replace the “pockets of undernutrition” framework in guiding the design of effective programs for the cities of tomorrow.

APPENDIX

Analysis of Intra-Urban Spatial Distributions Using Area Sampling

The present analysis is based on area sampling within defined urban boundaries. The principle is similar to that of “quadrat sampling,” which “involves randomly placing a quadrat of predetermined size n times over the study area, each time counting the number of points, x_i , that fall within the quadrat” (Thomas and Huggett 1980). In this case, Census Enumeration Areas (or other similar administrative subdivisions) are used instead of quadrats: although the land area of the different Census Enumeration Areas, or CEAs, may differ, they always encompass a predetermined number of households, n , making them conceptually equivalent to quadrats. Like quadrat sampling, CEA sampling lends itself to analysis of variance techniques, in which the “total variation in a set of data is separated into components associated with possible sources of variability whose relative importance we wish to assess” (Thomas and Huggett 1980, 253).

If we assume that the CEAs are simply convenience-based subdivisions of true, sociologically meaningful neighborhoods, then we can express our outcome measures (income, nutritional status, etc.) as a function of measurable determinants that operate at the household/individual level, at the neighborhood level, and also possibly at the CEA level. In addition, we anticipate neighborhood-specific and CEA-specific random- or fixed-effects giving rise to the “clustering” of outcomes at these levels. The whole relationship can be expressed as

$$y_{nci} = \mathbf{a} + \mathbf{b}_1 X_n + \mathbf{b}_2 Z_c + \mathbf{b}_3 W_i + u_n + \mathbf{x}_c + \mathbf{e}_i$$

where y is the outcome measure, subscript n denotes neighborhoods, subscript c denotes CEAs, subscript i denotes households (or individuals), \mathbf{X} are neighborhood-specific determinants, \mathbf{Z} are CEA-specific determinants, \mathbf{W} are household- (or individual-) specific determinants, \mathbf{a} is a fixed intercept term, the $\hat{\mathbf{a}}$'s are regression coefficients, u is a neighborhood-specific error-term, \hat{i} is a CEA-specific error-term, and \hat{a} is the usual household- (or individual-)specific error-term.

If we further assume that u , \hat{i} , and \hat{a} are distributed Normally with zero means and variances σ_u^2 , $\sigma_{\hat{i}}^2$, and $\sigma_{\hat{a}}^2$, then we have a random-effects model in which the total variance in our outcome measures (such as income) can be decomposed into three additive elements:

$$\mathbf{S}_{tot}^2 = \mathbf{S}_u^2 + \mathbf{S}_x^2 + \mathbf{S}_e^2$$

where σ_{tot}^2 is the total variance, σ_u^2 is the between-neighborhood variance, $\sigma_{\hat{i}}^2$ is the within-neighborhood, between-CEA variance, and $\sigma_{\hat{a}}^2$ is the within-CEA, between-household (or between-individual) variance. It should be noted that if these variance components have been derived from a model with no covariates (as in this paper), then they represent the observed spatial patterning, some of which almost certainly could be “explained” on the basis of the clustering of determinants.

This model implies that the clustering within ‘true’ neighborhoods, \tilde{n}_n , is given by:

$$r_n = \frac{s_u^2}{s_{tot}^2}$$

On the other hand, the parameter estimated in this paper is given by:

$$r' = \frac{1}{s_{tot}^2} (s_u^2 + s_x^2)$$

The difference is due to the fact that the small area sampling method is unable to distinguish between σ_u^2 and σ_i^2 , assigning them both to a single “between-CEA” variance category. It is clear that—provided there is non-zero variation at the between-CEA, within neighborhood level— \tilde{n} is always greater than \tilde{n}_n . The estimates in this paper are therefore to be interpreted as *upper bounds* to the true neighborhood clustering of deprivation.

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