Quantifying the Urban Environment: A Newly Constructed Scale of Urbanicity Outperforms the Traditional Urban-Rural Dichotomy.

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Abstract

The rapid urbanization of the developing world has important consequences for human health. Although several authorities have called for better research on the relationships between urbanicity and health, most researchers still use a poor measurement of urbanicity, the urban-rural dichotomy. Our goal was to construct a scale of urbanicity using community level data from the Cebu Longitudinal Health and Nutrition Survey. We used established scale development methods to validate the new measure, and tested its performance against the dichotomy. The new scale illustrated misclassification by the urban-rural dichotomy, and was able to detect differences in urbanicity, both between communities and across time, that were not apparent before. Furthermore, using a continuous measure of urbanicity allows for much more meaningful illustrations of the relationships between urbanicity and health. The new scale is a better measure of urbanicity than the traditionally used urban-rural dichotomy.

Introduction

"Over the last 50 years, the world has witnessed a dramatic growth of its urban population. The speed and the scale of this growth, especially concentrated in the less developed regions, continue to pose formidable challenges to the individual countries as well as to the world community. Monitoring these developments and creating sustainable urban environments remain crucial issues on the international development agenda." - United Nations Department of Economic and Social Affairs/Population Division[1]

Urbanization is an important force in human society, so much so that McMichael [2] suggests that city-living may be the "keystone of human ecology", and praises cities themselves as centers of "ideas, energy, creativity and technology." But city-living comes with important health consequences, both good and bad [3, 4]. The good would include better access to heath care, education, and social support, as well as improved water and sanitation infrastructure [2, 5]. The bad would include well documented links between urban environment and a variety of infectious and chronic diseases, poor physical activity and feeding behaviors, exposure to environmental pollution, increased tobacco, alcohol, and drug use, higher risk of injury, and higher crime rates [2, 5-10].

Additionally, city-dwellers in rapidly urbanizing developing countries often face a double burden of disease. Rapid urbanization, like that seen in the developing world, is often characterized by the development of a "peri-urban fringe" of squatter settlements [3, 11]. It is these peri-urban areas where poverty, crowding, environmental pollutants, a lack of services, and poor housing combine to create a particularly unhealthy environment, exposing their inhabitants to the "worst of both the traditional and modern world [2]."

Because the rapid urbanization of the developing world comes with so many potential negative consequences, many authorities have called for more urban-health research [1, 3, 5, 6]. Some also point out that we need to move beyond crude comparisons between the most rural and most urban, and should investigate health differences both within cites, and between them [2, 3, 5, 12].

Good empirical investigation starts with the proper measurement of all relevant variables. Investigators typically use a dichotomy to describe urbanicity, classifying regions as being either "urban" or "rural." This measurement, while common and expedient, has been criticized by some as inadequate[3-5]. One problem is that it is too simple to capture the heterogeneity within urban areas (one of the key research areas mentioned above). As noted earlier, rapid urbanization is characterized by the development of peri-urban areas and squatter settlements. The urban-rural dichotomy typically classifies these areas as urban, even though their denizens typically experience very different health risks than other urban populations.

The dichotomy also fails at detecting urban heterogeneity across time. As a "rural" area urbanizes, it may eventually reach a point when some authority declares the area as "urban." But what happens to this classification as that area continues to urbanize? In developing countries in particular, an area classified as urban 20 years ago has likely changed in important ways since then. An urban-rural dichotomy will fail to capture these changes.

Another major problem with the dichotomy is that there is no universally used definition of "urban" or "rural". Vlahov and Galea [5] illustrate this point nicely, noting that "among 228 countries for which the United Nations has data, about half use administrative definitions of urban (e.g., living in the capital city), 51 use size and density, 39 use functional characteristics (e.g., economic activity), 22 have no definition of urban, and 8 define all (e.g., Singapore) or none (e.g. Polynesian countries) of their population as urban."

The underlying problem is that urbanicity is not, in reality, a dichotomy. Imagine walking from a farm in the rural Chinese countryside to downtown Beijing. At what point on your path would you stop and declare that you have just gone from "rural" to "urban?" To ask someone to do so would be foolish, but as public health researchers many of us make this mistake regularly. Our collective attachment to the urban-rural dichotomy is so pervasive that the results from a recent search of the literature for alternate methods of measuring the urban environment were very limited (Pubmed title search: [measuring OR measure OR quantify] AND [urban OR urbanization OR urbanicity]). Three recent papers are worth noting: one on the use of remote sensing methods to measure urbanization [13], one on the validity of a survey instrument to measure the built environment [14], and one on the development of an assessment tool for collecting information on urban neighborhood characteristics [15]. In light of this research gap, our goal was to construct a valid scale of urbanicity from community-level survey data to better capture the true urbanicity of an environment.

Study Population

The data were taken from the Cebu Longitudinal Health and Nutrition Survey (CHLNS). Methodological details on the CHLNS are presented elsewhere[16, 17]. Briefly, this population-based study was designed to illuminate the exogenous and endogenous factors that link the environment and health, and has collected community level data collected from key informants, as well as individual and household level survey data.

The study began in 1983 with 3327 pregnant women living in 33 *barangays* (administratively defined neighborhoods that average approximately two km^2 in size). For the most recent follow-up survey in 2002, study participants were living in 183 different barangays. Community level data exist for every barangay in which a study participant lived for each survey year (1983, 1986, 1991, 1994, 1998, and 2002).

Scale Development

Item Selection

DeVellis [18] defines a scale as a "collection of items combined into a composite score" that are "intended to reveal levels of theoretical variables [or latent variables] not readily observable by direct means." Items were included in the urbanicity scale based on two criteria: the availability of the item among the community level data for every applicable barangay and survey year, and content validity (an *a priori* assessment of whether the item truly reflects urbanicity) based on peer reviewed literature.

Several articles make suggestions as to what characteristics constitute an urban environment (or which items we should use in a scale of urbanicity). Using factor analysis techniques, McDade and Adair [4] found that a high population density and the availability of infrastructure and services (telephone, mail, transportation, electricity, water, and health care facilities) were all correlates of urbanicity. Yach, *et al.* [3] point to several characteristics of urbanization, including rapid population growth and concentration, and improved access to employment, education, and modern health care. Vlahov and Galea [5] suggest that urbanicity is defined by the transformations that come about due to changes in population size, density, heterogeneity, and distance from other population centers. They go on to highlight the provision of health and social services, as well as alterations in the social and built environments, as important components of the urban environment.

Taking these proposed factors and the availability of the data into mind, the final scale includes the following seven items:

Population

Population Density

Communications. The availability of phone service, mail, newspapers, the internet, cable TV, and cellular phones.

Transportation. The density of paved roads, and the availability of public transportation.

Education. The presence of educational institutions, including colleges, vocational schools, primary and secondary schools.

Health. The presence of health services, including hospitals, medical clinics, maternal health clinics, family planning clinics, and community health centers.

Markets. The number of Sari stores (small, general-merchandise kiosks), and the availability of drug stores, grocery stores, and gas stations.

Each component can theoretically take a value from zero to 10, resulting in an overall scale from zero to 70 (calculations in Appendix A). Table one displays the observed mean and range of the urbanicity scale for each survey year, noting the number of barangays surveyed in each year.

The following sections document the methods used to validate this scale. Unless otherwise noted, these methods are taken directly from DeVellis [18].

Assessing Scale Reliability

Scale reliability, as defined by DeVellis [18], is "the proportion of variance attributed to the true score of the latent variable." A highly reliable scale is both accurate and increases statistical power for a given sample size when compared to less a reliable measure. It can be assessed in several ways. Here we look at *internal consistency* and *temporal stability*.

Internal Consistency

Internal consistency refers to the degree of homogeneity of the items within the scale. If the included items truly have a strong relationship with the latent variable (urbanicity), then we can expect them to be strongly related to each other. Strong correlations between the items can be explained either by causal relationships among them (unlikely) or by a shared cause.

Cronbach's coefficient alpha [REF], α, is often used as a measure of internal consistency. It is defined as the proportion of total variation in the scale that is shared. It is calculated as follows:

$$\alpha = \left(\frac{k}{k-1}\right)\left(1 - \frac{\sum \sigma_i^{\ 2}}{\sigma_{y_i}^{\ 2}}\right)$$

Where *k* is the number of items in the scale, $\sum \sigma_i^{\ 2}$ is the unshared variation among the items, and $\sigma_{y_i}^{\ 2}$ is the total variation.

Thus the equation expresses alpha by calculating the proportion of total variance that is unique and subtracting this from one to arrive at proportion of shared variance among components; this difference is then multiplied by a correction factor based on the number of items in the scale. DeVellis suggests that an alpha that falls between 0.8 and 0.9 is ideal. Table two displays the calculated alphas for each survey year of our data. They range from .8707 to .8915, indicating an ideal level of internal consistency among the scale's seven items.

Another way to assess the internal consistency of the items is to examine their *corrected item-scale correlations*, which are simply the correlations between each item and the collection of remaining items. Table three displays the corrected item-scale correlations for every item, in each year. With the exception of the Education item, the correlations are high (>.5) and statistically significant from zero ($p<.001$). For Education, the correlations ranged between .2080 and .4836. In 1983 and 1986, the corrected item-scale correlations for Education were not statistically significant from zero at $p<.05$. However, Education was still included in the scale based on its improved corrected item-scale correlations over time, the quality of the survey data used in its calculation, and the ideal values observed for the scale's alpha values when education is included.

Temporal Stability

Temporal stability is also an important indicator of scale reliability. Examining tables one through three clearly illustrates the consistency of the newly constructed scale itself (steadily increasing with time, as expected), as well as the consistent relationships between and among the scale and its components over time.

Based on this evidence of internal consistency and temporal stability, we are confident that the new scale of urbanicity is reliable, or accurately reflects the proportion of variance attributed to the true score of the latent variable, urbanicity.

Assessing Scale Validity

Scale validity refers to our confidence that the latent variable is truly the cause of item covariation (whereas reliability reflects how much the latent variable affects the items). DeVellis refers to three types of validity: content validity, criterion related validity, and construct validity. We will examine all three.

Content Validity

Content validity refers to the extent that a set of items truly represent what you intend to measure and not something else. In a perfect world, the subset of items would be randomly selected from an infinite set of items that truly reflect the latent variable. Because this is an impossible task, we can best assess content validity based on the *a priori* knowledge of experts. In our case, the inclusion of each item in the urbanicity scale is supported by multiple articles from the peer reviewed scientific literature [3-5].

Criterion Related Validity

Criterion related validity is based on the scale's empirical association to a "gold standard." The nature of the relationship (be it causal or otherwise) is not important, just its consistency. One comparison we can make is between the urbanicity scale for 1983, and a previously defined set of settlement classifications derived from household level data. These classifications were made by experienced local fieldworkers, who differentiated barangays into six settlement types based on style of housing, predominant commercial and agricultural activities, and access to services. The categories are defined as *urban core* (high density, city center), *urban squatter* (high density, poor housing), *peri-urban* (lower density, access to city center), *rural town* (services and markets), *rural non-town* (access to transportation to more urban areas), and *remote* [19]. Table four illustrates the observed relationship between the scale of urbanicity and the settlement types defined above. The relationship is exactly as we would predict: the *urban core* and *urban squatter* areas scored the highest on the scale, and the scores steadily decrease as the settlement type becomes more rural.

The Urbanicity Scale from 1983 was also compared to the 1983 census's traditional dichotomous classification of the barangays, with "urban" communities averaging a score of 32.7 (range - 17 to 49), compared to the "rural" communities which averaged a score of 12.9 (range - 5 to 27).

Construct Validity

Construct validity is "directly concerned with the theoretical relationship of a variable (e.g., a score on some scale) to other variables."[18] For instance, it is well established that urban dwellers consume more calories on average than rural residents. Similarly, urban dwellers' diets are typically characterized by a higher percentage of calories from fat. Figures one and two illustrate that the observed relationships between diet and the Urbanicity Scale are what we would predict: both total calories consumed, and the percentage of diet from fat, increase with the Urbanicity Scale.

To illustrate a negative relationship, we compared the scale of urbanicity to breastfeeding behavior. It is well documented that rural mothers tend to breastfeed their children to older ages than urban mothers (PROVE IT). Figure three shows the average age at which children stopped breastfeeding by quintile of the Urbanicity Scale. The predicted relationship is upheld by our measure of urbanicity.

The combined results from the above analysis indicate the quality of the urbanicity scale; it is reliable in that it is internally consistent and temporally stable, and it is valid in terms of its true ability to reflect urbanicity. With this valid and reliable measure in hand, we can now test it against the urban-rural dichotomy.

Intra-Urban Variability

If asked to describe the urbanicity of the original 33 barangays surveyed in 1983, an investigator using the urban-rural dichotomy could tell you only that 17 of them were rural and 16 of them were urban. Using the urbanicity scale values, the same investigator could describe the mean urbanicity score (23.1 out of 70) and its distribution (median 23, range 5 to 49), as well as comparisons between census designated urban and rural areas (urban mean score 32.7, rural mean score 12.9).

With so much variation in the urbanicity scores, we might expect some misclassification by the urban-rural dichotomy. Table five lists the original 33 barangays surveyed in 1983, their census defined urban-rural classifications, and their urbanicity scores taken form the new scale. The table illustrates the relative accuracy of the dichotomy at the extreme ends of the urbanicity scale. The highlighted section, however, contains the 13 barangays (40% of our sample) in which the urban-rural designation tends to alternate as urbanicity scores increase. The table also highlights the 25% of "urban" barangays that fell at or below the median urbanicity score, and the 18% or "rural" barangays that fell above it.

Table 5 also makes it easy to compare the highest and lowest urbanicity scores within each of the dichotomized designations. For instance, the rural community with the highest urbanicity score is Inoburan with a score of 27, which places it ahead of seven barangays normally classified as urban. Its score is 22 points higher than the barangay with the lowest score, yet both of these communities are classified in the exact same way, as "rural." Similarly, the lowest score among "urban" barangays is 17, held by Basak, which is a lower score than four rural barangays, and almost 5 times further away from the highest urbanicity score than the lowest one. Yet this barangay is classified as "urban." In our estimation, the urban-rural dichotomy is misclassifying an unacceptable proportion of barangays.

Temporal Trends in Urbanicity

Another criticism of the urban-rural dichotomy is its inability to detect changes in urbanicity over time. Table five also lists the original 33 barangays' census defined urban-rural classifications, and their urbanicity scores for 2002. It is immediately apparent that the census's urban-rural dichotomous classification did not change for a single barangay over that time, even though the average increase in urbanicity score was 10.2. Five barangays experienced an increase in urbanicity score of 20 or more (which is about the average difference in scores between urban and rural barangays in 1983), but the dichotomy is unable to reflect this since those communities were already categorized as urban in 1983.

Conclusion and Discussion

As we hoped, the urbanicity scale, if it is truly a valid measure of urbanicity, was better able to reflect differences in the urban environment than the urban-rural dichotomy. Another advantage is that the continuous nature of scale allows better graphical representations of the relationships between urbanicity and health, and makes it possible to explore dose-response relationships, often a key factor in establishing causality. Additionally, in a variety of unpublished, preliminary analyses of diet and the urban environment, the urbanicity scale has made the urban-rural dichotomy obsolete. For example, in a regression analysis of total caloric intake (dependant variable) and urbanicity, the crude effect measure estimates for both the scale and dichotomy are predictive, precise, and statistically different from zero (at $p<.05$). However, when both are included in the model, all of the variation in diet that can be explained by urbanicity is explained by the scale, and the dichotomy can be dropped out of the model with no changes to effect estimates.

The main weakness of the scale's design is that the items that make up the scale are all weighed equally. In reality, we don't know which of our items are the most important to the relationships we wish to describe. This means that a 5 point increase in an urbanicity score (e.g., through population increase) is probably not the same as another 5 point increase (e.g., through transportation increase). Future efforts will focus on teasing out the relationships among our items, and how they can individually affect human health.

Another weakness is the relatively large burden on researchers to collect these kinds of longitudinal community data. Many researchers will not have the necessary data to construct urbanicity scales for use in their own research. Because of this, we also plan to investigate other methods of quantifying urbanicity that outperform the urban-rural dichotomy, but are more conveniently collected than the scale developed here.

Because we have detailed longitudinal data on the residences of the study's subjects, other future studies will include analyses of the health differences by urban exposure due to migration or urbanization (did the mother move into a more urban area, or did the area around her urbanize?). This analysis would not be possible with the urban dichotomy.

We seem to have accomplished our main goal of constructing a valid scale of urbanicity. Hopefully we have imparted some idea of the potential of misclassification when using the urban-rural dichotomy. Because the urbanicity of an environment is commonly included in a variety of statistical analyses as a confounder, many researchers are using a potentially poor measure in their work, the urban-rural dichotomy. We look forward to others attempts to solve this pervasive problem.

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Table 1: Means and ranges of barangay urbanicity scores for each year surveyed.

	Year					
	1983	1986	1991	1994	1998	2002
Mean urbanicity Score (Range)	23.1 (5-49)	21.7 (4-48)	28.8 (5-59)	30.6 (8-59)	34.1 (8-59)	36.9 (7-60)
Number of barangays surveyed	33	33	170	172	169	183

Table 2: Cronbach's alpha for the seven items included in the scale, for each survey year.

	Year					
	1983	1986	1991	1994	1998	2002
Cronbach's alpha	.8808	.8879	.8763	.8915	.8757	.8707

Note: DeVellis desribes values falling between .8 and .9 as "very good".

Table 3: Corrected item-scale correlations for the seven items included in the scale, for each survey year.

	Year					
	1983	1986	1991	1994	1998	2002
Population	.7505	.7866	.7819	.8073	.7953	.7247
Population density	.7390	.7297	.6808	.7256	.7151	.6441
Communications	.8673	.7734	.8037	.8084	.6411	.6978
Transportation	.6463	.6089	.6338	.6479	.5717	.5580
Education	.2532*	.2080**	.3415	.4037	.4539	.4836
Health	.6769	.7705	.6912	.7632	.8125	.7460
Markets	.6793	.8213	.8104	.8383	.8266	.7960

Note: Unless otherwise noted, all corrected item-scale correlations are statistically different from zero at a p-value<.001
*p=.155, **p=.245

Table 4: Means and ranges of barangay urbanicity scores by settlement type* in 1983

	Settlement Type					
	Urban core	Urban squatter	Peri-urban	Rural town	Rural non-town	Remote
Mean urbanicity score (Range)	41.2 (23-44)	41.9(17-49)	30.7 (22-42)	26.2 (9-45)	17.2 (6-25)	12.01 (5-27)

*From [19]

Table 5. Urbanicity scores and census urban-rural classification for the original 33 barangays surveyed in 1983 and 2002.

	1983		2002		Comparison	
Barangay	Urbanicity Score	Census urban-rural classification	Urbanicity Score	Census urban-rural classification	Change in score	Change in classification
Panoypoy	5	Rural	10	Rural	5	None
Sta.Cruz	6	Rural	10	Rural	4	None
Jaguimit	7	Rural	9	Rural	2	None
Pamutan	8	Rural	12	Rural	4	None
Tolo-tolo	9	Rural	20	Rural	11	None
Caohagan	9	Rural	16	Rural	7	None
Cao-oy	10	Rural	19	Rural	9	None
Bairan	10	Rural	9	Rural	-1	None
Cogon	11	Rural	24	Rural	13	None
Danlag	11	Rural	25	Rural	14	None
Budlaan	11	Rural	16	Rural	5	None
Cantao-an	12	Rural	17	Rural	5	None
Basak 9	17	Urban*	52	Urban	35	None
Cansaga	19	Urban*	39	Urban	20	None
Pulpogan	21	Rural	35	Rural	14	None
Opao	22	Urban*	33	Urban	11	None
Basak 14	23	Urban*	50	Urban	27	None
Poblacion Central	24	Rural**	33	Rural	9	None
Mojon	25	Urban	33	Urban	8	None
Casuntingan	25	Urban	40	Urban	15	None
Balirong	25	Rural**	24	Rural	-1	None
San Roque	26	Urban	48	Urban	22	None
Inoburan	27	Rural**	32	Rural	5	None
Mantuyong	28	Urban	41	Urban	13	None
Quiot. Pardo	34	Urban	41	Urban	7	None
Poblacion 6	36	Urban	56	Urban	20	None
Basak, Pardo	38	Urban	53	Urban	15	None
Pahina, San Nicolas	41	Urban	40	Urban	-1	None
Labangon	42	Urban	58	Urban	16	None
Sambag II	42	Urban	59	Urban	17	None
T. Padilla	44	Urban	45	Urban	1	None
Poblacion 12	45	Urban	51	Urban	6	None
San Miguel	49	Urban	50	Urban	1	None

***Note*: The highlighted section contains barangays in which the urban-rural dichotomous designation oscillates at the urbanicity scores increase**
***Urban barangays at or below the median urbanicity score in 1983**
****Rural barangays above the median urbanicity score in 1983**

Figure 1. Lowess plot illustrating the relationship between the 1983 Urbanicity Scale and total caloric intake among study particpants

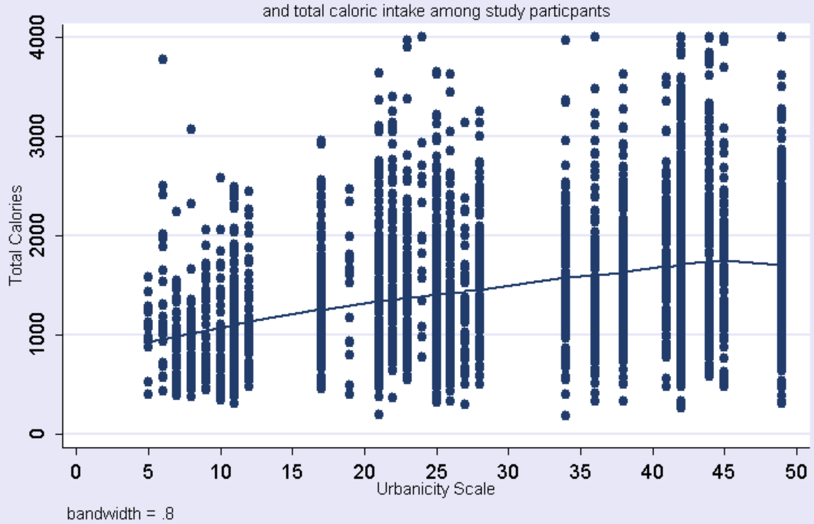
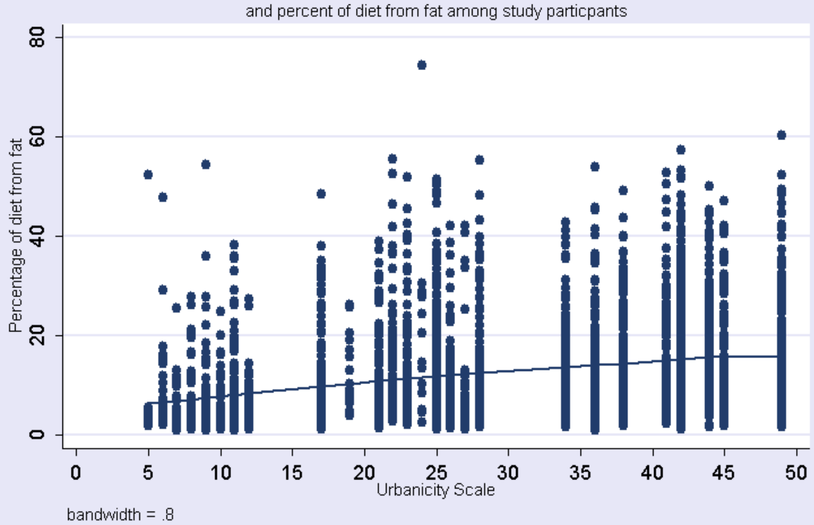
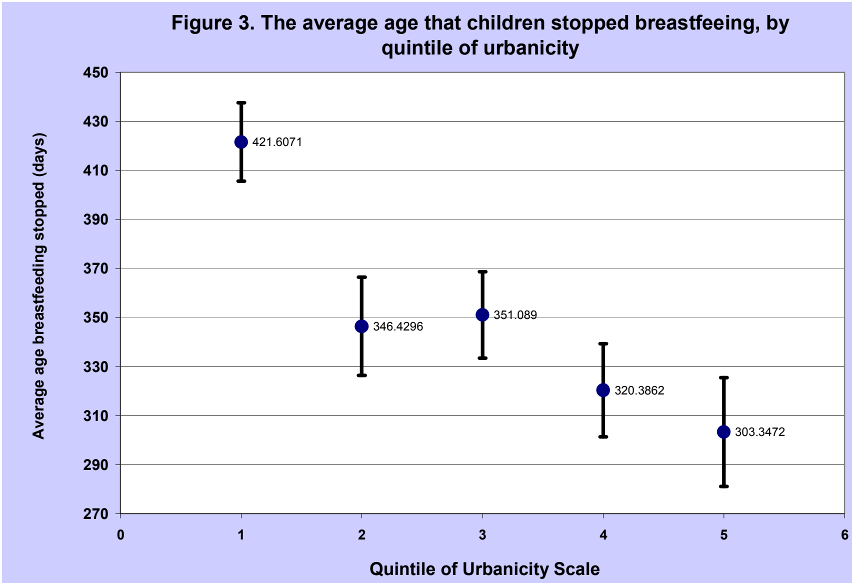


Figure 2. Lowess plot illustrating the relationship between the 1983 Urbanicity Scale and percent of diet from fat among study particpants





Appendix A

SCORES 1983

Population

0 - 0
1 - 1 to 500
2 501 to 1000
3 - 1001 to 2000
4 - 2001 to 4000
5 - 4001 to 6000
6 - 6001 to 8000
7 - 8001 to 10000
8 - 10001 to 15000
9 - 15001 to 20000
10 - >20000

Population Density (persons per km^2)

0 - 0
1 - 1 to500
2 - 501 to 1000
3 - 1001 to 2501
4 - 2501 to 5000
5 - 5001 to 7500

6 - 7501 to 10000
7 - 10001 to 15000
8 - 15001 to 30000
9 - 30001 to 50000
10 - >50000

Communication Score

2 points - Mail service
2 points - News paper
3 points - Telephone
1 point - Cell phones
1 point - Internet (1pt)
1 point - Cable (1pt)

Education

2 points each for the presence of primary intermediate schools, complete schools, secondary schools, vocational training facilities, and colleges in the barangay.

Transport

Public transport score was calculated using bus and Jeepney service. 3 points for continuous, 2 points for any daily service, 1 point for less than daily service, 0 points for no service.

Points were assigned for paved road density as follows: 0 for 0, 1 for .001 to .5, 2 for .5001 to 1, 3 for 1.001 to 5, and 4 for >5.

Health

Presence of……in the barangay	Point Value
Any Hospital	3
Pharmacy	1
Maternal Health Clinic	1
Family Planning Clinic	1
Private Medical Clinic	2
Puericulture Center	1
Rural Health Unit	1

Markets Score

Two points for the presence of grocery store(s) and gas station(s) and one point for drug store(s). The remaining five points were based on the number of "sari" stores: 0 for 0, 1 for 1-20, 2 for 21-50, 3 for 51 to 100, 4 for 101 to 200, 5 for 200+