GH1

MAIN REPORT (Summary Report)
PRIPODE/CICRED PROJECT

POPULATION, DEVELOPMENT AND ENVIRONMENT IN METROPOLITAN ACCRA: A TWO PHASE STUDY

PHASE I

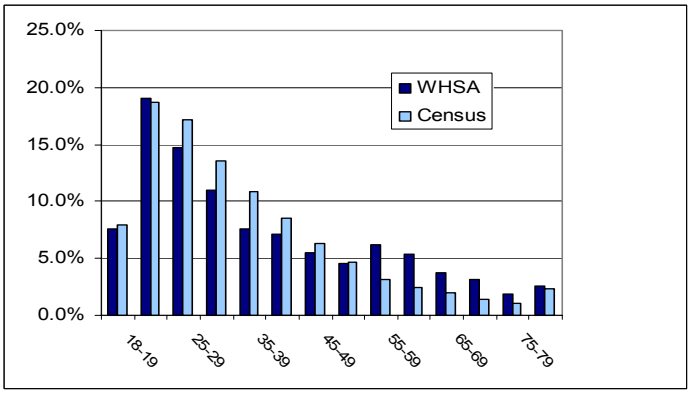
1. METHODOLOGY

Women's Health Survey Data

We draw first and most importantly from the Women's Health in Accra survey of 2003 (WHS), a sample of 3,200 women aged 18 and over living in the Accra Metropolitan Area. Data were collected between April and July 2003 and provide self-report health data, data from a clinical examination and laboratory work as well as data on the household's facilities matched to the census of 2000. Data were collected from a multi-stage probability cluster sample of 200 of the 1,724 EAs in Accra, and data for this analysis have been aggregated to the locality level, since all 43 localities were incorporated into the WHS.

The size of the original cohort was 3200 women. The initial intent of the 2003 Women's Health Study of Accra was to include all of the women in the comprehensive medical examination. The clinical examinations and laboratory tests proved more costly than anticipated and as some anticipated additional funding was not forthcoming, 1328 women, with priority given to those 50 and over, were examined in the clinic. Final numbers are shown in Table 1. The numbers are sufficient in power to detect major illnesses in the population based on the results from the comprehensive medical examination, but may be insufficient to detect rare illnesses or low-level risk factors.

Figure 1: The age distribution of the sample shows the effect of over-sampling the elderly when compared with the 2000 national population census.



The sample can be readily weighted to provide estimates of the health for all women in the city taking into account the

2000 census age distribution. The results presented below are unweighted.

Living conditions. The most co mmon type of dwelling was a compound with several rooms (62.5%), 52.5% of which were covered with a metal roof. 43.4% of the women rented the dwelling. The main source of drinking water was a pipe inside for 52.8% and a pipe outside the dwelling for 44.5%. The most common type of toilet facility was a public toilet (35.3%), followed by an improved pit latrine (16.8%), and a bucket or pan (10.5%). The main source of cooking fuel was charcoal (64.8%) followed by gas (27.2%).

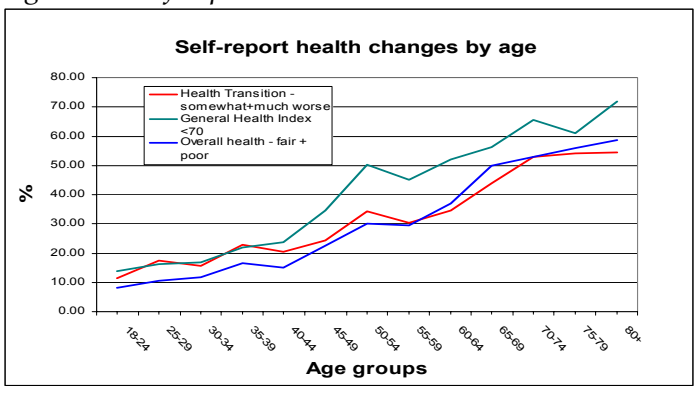
Education. Most of the women had received some level of formal education. Of the 76.6% reporting that they attended school, approximately 16% attended to the primary school level only, 54% attended middle school, 21% attended secondary school and 9% received an education higher than secondary schooling. Almost a quarter of the women reported that they were co-wives.

Health conditions reported in the home interview.

Excellent or very good health was self-reported by 45.5% of all women during the HHS, while 34.8% self-reported good health, 17.9% fair health and 1.8% poor health. In comparison to their health one year ago, 30.8% reported that their health was much or somewhat better, 46.3% the same, 20.8% somewhat worse and 1.9% much worse. 45.5% of the women reported that they felt that they were as healthy as anyone they know, while only 3.1% felt that they seem to become ill easier than other people. Only 1.0% of all women felt that their health was most likely to worsen.

The pronounced age gradient in self-reported health status is show in Figure 2. By age 60, the majority of women felt that their health was only "fair" or "poor" and compared to a year ago, a majority rated their health as "somewhat worse" or "worse". Using the SF36 General Health Index for which the US median is 72, we find that above age 60, over half are rated below 70.

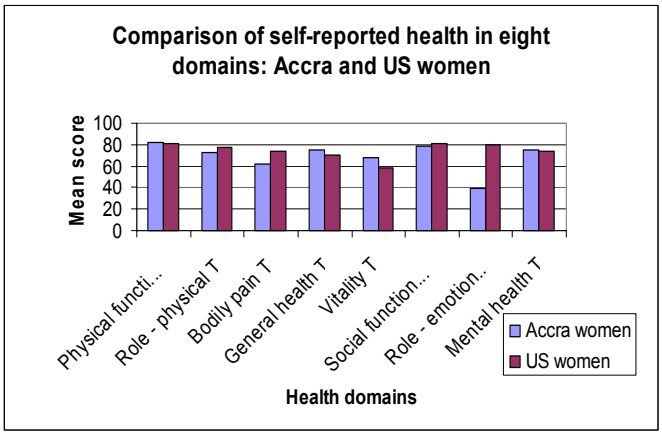
Figure 2. Self-reported health status.



For the 12 months preceding the HHS, 53.7% reported that they took measures to improve their health. The most common steps were to increase physical activity

(32.6%), to take vitamins (24.1%), receive medical treatment for illness (18.2%) and change diet or eating habits (15.9%). Of those who stated that there were barriers to health improvement measures (24.3%), the most common barriers included cost (31.1%), lack of will power or self-discipline (29%) and lack of time (21.2%). 85.1% of the women reported that their health was no financial drain for them while only 2.1% reported that they spent all of the monthly income or spent savings or borrowed money for health related reasons.

Figure 3: SF-36 scores from the household health interview.



This optimistic view of their health is reflected in the comparison of the Short Form 36 mean scores on eight health domains from the WHSA and a sample drawn from the US general population (Figure 3).[1] Note that the Accra results have not been standardized by age for the comparison with the US data for this preliminary presentation. Apart from the lower scores on the Role-emotional scale (unable to work as much or as carefully, accomplished less due to poor health), the Accra women's self-reported health compares favourably with those in the US, especially with reference to the measure of vitality (more full of pep and energy and less tired and worn out than their US counterparts). These data present a *prima facie* case for an analysis of the cut point shift and their determinants in the Accra population[2].

Social History. Most of the women have never smoked (98.5%) and 1.1% are current smokers. 42.2% of women reported that they consumed alcohol, with most of the women who consume alcohol report drinking one or two drinks at weekends. Most of the women (65%) were gainfully employed, 11.5% were students, and the rest were retired, unemployed unable to work or unemployed able to work.

Health conditions reported during the comprehensive medical examination

Hospitalizations and Outpatient Clinic Visits. Of the 1328 women examined, 618 (46.5%) of whom were aged 50 and over, 59.2% of women ever had been hospitalized, mostly for delivery (30.2%), gynaecologic problems (17.7%),

abdominal pain (8.5%) or malaria (4.1%). In all, 90.5% had ever been to an out-patient facility for fever (25.2%), a routine exam (9.4%), whole body pain (7.1%), abdominal pain (6.8%), gynaecologic problem (6.0%) or hypertension (5.1%). Almost all (98%) used the public health facilities for their health care.

Past Medical History. The most common conditions reported for the past 12 months were: malaria (48.6%), hypertension (23.0%), arthritis or joint pain (12.0%), diabetes (4.1%), asthma (3.1%), and anaemia (3.0%).

Review of Systems. Table 1 depicts the most common symptoms of the previous 4 weeks experienced by at least 20% of the women. Fever was the most common symptom that prompted the women to seek medical care (43.0%).

Table 1. Common symptoms reported in the 4 weeks before interview.

Symptom	% experiencing symptom	% seeking medical care
Pain, anywhere	44.9	30.3
Headaches	38.1	23.8
Worry	36.0	0.8
Blurry vision	31.8	18.5
Joint pains	30.0	23.5
Abdominal pain	26.5	15.8
Fever	22.3	43.0
Numbness, anywhere	22.1	18.3
Dysmenorrhoea	22.0	19.4
Pins and needle sensation	21.7	17.9
Fatigue	21.5	22.3
Chronic back pain	21.5	23.7

Screening measures for breast and cervical cancer. Only 11.9% of women reported that a clinical breast examination had *ever* been performed for them while 34.9% of the women performed a self-breast examination at least monthly. 1.5% had a mammogram, most reported that the test was normal, and 4.2% of the women had a breast biopsy, either as a fine needle aspiration or as an open biopsy. Five of the 1328 women reported a prior diagnosis of breast cancer; three were less than 40 years old at the time of diagnosis. Approximately 35% of the women reported *ever* having a pelvic examination. By the evaluation of the dates of the last pelvic examination provided by the women, most were for obstetrical reasons. Only 1.9% of the women reported having a Papanicoulau (Pap) smear performed and 80% of those reported that the test was normal. No woman in the study stated that she was ever diagnosed with cervical cancer, ovarian cancer or uterine cancer.

Reproductive History. The mean age of first sexual intercourse was 18.9 years $\pm$ 3.1 years old and 95.7% of the women reported to have ever had sex. The mean age of the first full term delivery was 21.3 $\pm$ 5.0 years. The average number of

lifetime sexual partners for the entire cohort of sexually active women was 2.6 $\pm$ 2.3 and the average number of children was 5.9 $\pm$ 3.5. For the entire cohort, 38.4% had a known miscarriage, 11.0% reported at least one stillbirth, and 43.5% reported having an induced abortion. There was a general trend in increasing use of abortions with younger age, particularly in the 18 to 25 year olds. At the time of the examination, 45.6% were pre-menopausal, 47.8% (no menses for 12 months and not pregnant) were post-menopausal. 5.5% were peri-menopausal and 1.2% were unsure of their menopause status. Oral contraceptives were ever used even for a short duration by 22.7% of the women. There was no significant difference for ever use of oral contraceptives when analyzed for age greater than or less than 50 years. Of the women aged 18 to 25 years, 79.1% were sexually active and 84.1% of those young women had never used oral contraceptives, 69.1% experienced unprotected sexual intercourse the last time they had sex and 61.1% had undergone an induced abortion. Hormone replacement therapy (HRT) was ever used in 13.7% of post-menopausal women. Post-menopausal women who were age less than 50 years old were significantly more likely ($p \leq 0.01$) to have ever used HRT than post-menopausal women over age 50 years.

Family History. A family history of the illnesses of their parents and any brother (same mother, same father) and any sister (same mother, same father) was obtained. Hypertension was the most common illness, being diagnosed in the fathers (10.9%), mothers (17.9%), sisters (9.4%) and brothers (4.9%). A history of stroke was reported in fathers (5.1%), mothers (5.4%), sisters (1.7%) and brothers (1.2%). A history of diabetes was reported in fathers (2.9%), mothers (3.4%), sisters (2.3%) and brothers (3.0%).

Reliability of answers. At the conclusion of the history, the physician's were asked to score the woman's responses. The physicians judged that 97.5% of the women's answers to the questions were reliable, not reliable in 0.8% and uncertain in 1.6% of all women seen for medical examination.

Health conditions identified in the physical examination.

A comprehensive evaluation was conducted including an assessment of the woman's vital signs, vision, gait, mobility, general constitution, integument, head, ears, eyes, nose and throat, lungs, breasts, cardiovascular system, abdomen, extremities, neurological and psychiatric findings, short-term memory, cervix and uterus. Only the most striking results are summarized here.

Hypertension. Hypertension, as defined by a systolic blood pressure $\geq$ 140 mm Hg or diastolic blood pressure $\geq$ 90 mm Hg, was identified in 47.8% and 45.3%, respectively, of all women examined. The range of systolic blood pressures ranged from 80 to 230 mm Hg. The range of diastolic blood pressures ranged from 50 to 150 mm Hg. Table 2 compares blood pressure results by age group.

Table 2. Blood pressure levels from the clinic examinations.

Blood pressure levels (BP) by Age Group		18-25	26-39	40-54	> 55	Total
Upright Systolic BP	< 140	94.1%	88.3%	46.1%	18.0%	50.5%
	≥ 140	4.1%	10.4%	53.4%	79.3%	47.8%
Upright Diastolic BP	< 90	89.6%	86.5%	46.5%	26.4%	52.8%
	≥ 90	8.1%	11.3%	53.0%	71.1%	45.3%

Overweight/ Obesity. WHO defines overweight as those with a Body Mass Index (BMI) ≥ 25 and obesity as those with a BMI ≥ 30 and morbid obesity as BMI ≥ 40. [3] In this study population, 65.9% of women met the criteria for a diagnosis of overweight and 33.5% as obese and 6.1% as morbidly obese. Another index to measure risk for obesity related disease is the Waist Hip Ratio (WHR) that quantifies the relationship between measurements of waist and hips. Overall obesity, however, is still of greater risk than body fat storage locations or WHR. A WHR ≥1.0 is in the danger zone, with risks of heart disease and other ailments connected with being overweight. For men, a ratio of .90 or less is considered safe, and for women, .80 or less.[4] In our study population, 67.0% of all women had a WHR of > 0.8 and 4.3% had a WHR of 1.0 or greater. Evidence from epidemiological studies shows waist circumference to be a better marker of abdominal fat content than WHR, and that it is the most practical anthropometric measurement for assessing a patient's abdominal fat content before and during weight loss treatment.[5] The WHSA identified 50.7% of the women with an abdominal girth >88 cm.

Vision. Visual acuity was measured by the Rosenbaum Pocket Vision Screener. Few women who stated that they wore glasses brought them for their clinical examination, so most of the readings are uncorrected. When glasses were available, the visual acuity was performed with and without the glasses. These data represent uncorrected visual acuity. A normal exam 20/20 was recorded for 8.4% of all women examined. 41.0% of examined women had a visual acuity of 20/40 or better and 59.0% had a visual acuity of 20/60 or worse.

Pelvic examination. A pelvic examination was recorded for 1206 (90.7%) women. The external examination was determined to be abnormal in 11.5% of the women with prolapse of the bladder, prolapse of the uterus, genital lesions and evidence of circumcision being the most common reported abnormalities. The internal examination was reported to be abnormal in 37.2% of the women. Of the 1206

women who had consented to the internal pelvic examination, 583 women were age 50 years or older (48.3%). There were a total of 13 (1.0%) cervical lesions that were suspicious for malignancy on the clinical examination, 8 (61.5%) in the group of women age 50 and greater. Bloody cervical discharge was identified in 25 of the 583 women (4.3%) age 50 years and older compared to 22 of 623 women (3.1%) aged less than 50 years (p= NS).

Summary results of the laboratory testing.

HIV testing was performed using the Determine HIV 1/2 Rapid Test (Abbott Laboratories, Abbott Park, Il.). All positive and indeterminate tests were repeated using the InstantScreen Rapid HIV 1/2 Assay (Morwell Diagnostics GmbH, Zurich, Switzerland). A total of 1307/1328 (98.4%) women consented for HIV testing. 35 (2.7%) of these women tested positive by a rapid test and by a confirmatory test. [6]

The complete blood count was performed by an automated analyzer. Results are available for 970 women. Anaemia, as defined by a haemoglobin less than 12 g/dl was identified in 254 (26.3%) of all women tested. Only 3.5% of the women tested had a haemoglobin level < 10g/dl. Of those diagnosed with a haemoglobin less than 12 g/dl, 41.6% had MCV RBC micro indices suggestive of microcytic anaemia and none had an index suggestive of a macrocytic anaemia. An assessment of haemoglobin type was available for 582 women. Sickle cell anaemia (SS) was identified in 1 of 1049 (0.1%) women evaluated. The most common haemoglobin types were normal (AA) identified in 72.8%, AC variant in 9.8% and sickle cell trait (AS) in 15.5% and other (1.8%).

Fasting blood glucose (FBG) was analyzed in 624 women. The upper normal limit is > 6.5 (mg/dl). The FBG was reported to be elevated in 68 (10.9%) of the women. Fasting cholesterol, triglycerides, HDL, and LDL test kits were obtained from Randox Laboratories, Ltd., Crumlin, Northern Ireland. All samples were run twice for confirmation at NMIMR. These results reveal that over 25% of the women tested have an elevated serum cholesterol level, a significant risk factor for heart disease.

The slides for the Pap smears were read by the pathologists at Korle Bu Teaching Hospital. The Pap smear was judged to be satisfactory for 66.7% of the smears and inadequate for assessment for 2.4% of all Pap smears submitted to pathology. Most (89.9%) of the specimens were read as no dyskaryosis, a normal result. Only 1% (n=8) of the smears were read as having mild, moderate or severe dysplasia. There were no cases of cervical cancer identified based on the

Pap smear results for any age group. Statistical analysis was performed using the goodness of fit chi-square test to determine if the observed results were significantly different from the expected results. The analysis was performed by recoding the original reports into the Bethesda classification.[7] There is a statistically significant difference ($p \leq 0.001$) in the observed results and the expected results of the Pap smear readings. An NIH R03 has been submitted to review these slides at Beth Israel Deaconess Medical Center.

New cases identified: diabetes, hypertension, cataracts and obesity.
Table 3 reflects the comparisons of data from the women who completed the HHS and the CMLE (n=1328). A total of 812 new cases of diabetes, hypertension, cataracts and obesity were identified in the WHSA and 58.0% of the new cases were in women age $\geq$ 50 years.

Table 3. Number of cases identified by different instruments.

	Household survey	Medical history or reported symptoms	Labs or exam	New cases	New Cases for women age $\geq$ 50 years old
Diabetes	48	54	68	57	14
Hypertension	314	304	632	328	225
Obesity	44	n/a	445	401	209
Cataracts	20	17	63	26	23
Total	426	375	1208	812	471 (58.0%)

Comparing results from the household health survey and the comprehensive medical examination.

Hypertension. During the HHS, 314 women (24.0%) reported a previous diagnosis of hypertension compared to 304 (23.0%) women at the CMLE. This is a significant positive correlation between the HHS and the CMLE reporting ($p<0.01$). Hypertension, as an objective finding, was identified in 47.8% of all women see in the clinic. There was a significant positive correlation between self-reported hypertension and blood pressure measurement.

Diabetes. A significant correlation in reporting a previous diagnosis of diabetes was identified in this study. During the HHS, 48 women (3.7%) reported having been diagnosed with diabetes compared to 54(4.1%) from the CMLE ($p<0.01$). Of those women who know that they had been diagnosed with diabetes, 37.0%

($p<0.01$) had an elevated fasting blood glucose level on the morning of the examination.

Arthritis or joint pain. There was a positive correlation in reporting between the HHS and the CMLE ($p<0.01$) for arthritic symptoms and joint pain. No measured assessment was made for arthritic joints during the clinical examination.

Chronic Back Pain. More women reported chronic back pain during the HHS (42.0%) compared to reporting during the CMLE (21.5%). This difference in reporting is significant ($p=0.14$).

Obesity. The women were asked if they were obese during the HHS. Of the 1311 that responded, 44 (3.4%) stated that they were obese. At the CMLE, weight and height measurements were taken and BMI calculated. There was a significant underreporting ($p=0.04$) of self-reported obesity from the HHS in comparison to the BMI calculated from the clinical data.

Depression There was a significant underreporting of depression during the CMLE compared to the HHS ($p=0.029$). Only 8 (<1%) of the women stated that they had been depressed during the CMLE as compared to 26 (2%) of the women during the HHS. None of these 26 women reported depression at the CMLE.

Asthma There was a significant positive correlation ($p<0.01$) between HHS and CMLE for a self reported diagnosis of asthma. The number of women with an abnormal pulmonary examination was higher than the reported number of women with asthma, but the clinical examination did not differentiate between pulmonary wheezing secondary to asthma vs. other chronic lung diseases such as emphysema.

Cataracts. There was a positive correlation between self reported cataracts between the HHS and the CMLE history reporting. ($p<0.01$). However, there was no correlation between the physical examination findings of the eyes and a history of cataracts.

Discussion

Reported malaria continues to be a significant health problem for adults. We will address this issue in more detail in the longitudinal study by including a smear for parasites and information on diagnosis and therapy. The results of the 2003 Women's Health Study of Accra are consistent with reports that chronic illnesses such as diabetes and hypertension present a serious health problem to the developing world populations.[8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18] Although heart disease has not been considered a major problem in African populations until recently, cerebral vascular disease (CVD) was identified in 2001 as the cause of death in 11% of autopsies performed at Korle Bu Teaching Hospital. [19] Hypertension was the dominant risk factor for both hemorrhagic strokes and a major factor in

infarctions. The relative risk of death secondary to a stroke was significantly higher for women in comparison to men. This may account for the high prevalence of hypertension but few women were found with a history or evidence of a cerebral vascular accident or CVD in the WHSA.

Diabetes appears to be an important emerging disease and public health problem in African cities. [20, 21, 22,] There are no data available to date on the mortality, morbidity or disability associated with diabetes. Amoah et al reported on the prevalence of Type II diabetes in a community based study of Greater Accra. [23] In their study, 4733 Ghanaians aged 25 years and older were randomly selected from three community sites. Contrary to a previous study that found only a 0.2% prevalence of diabetes in Ghana, they found the crude prevalence rate to be 6.3%. The prevalence increased with increasing age with 13.4% of those 64 years and older diagnosed with diabetes. Diabetes was more common in males than females (7.7% vs. 5.5%, $p<.05$). Worsening glycemic status was associated with increases in age, body index, and systolic and diastolic blood pressure. These results are consistent with the findings from the 2003 WHSA.

There are also serious concerns that important health issues such as mental illness and depression may be neglected in developing countries.[24, 25] In the WHSA, women were more likely to report depression in the HHS than the CMLE. In the longitudinal study, we will address mental health in more detail in the home interview.

The prevalence of HIV/AIDS is low in Ghana in comparison to other African countries. While the 2002 reported prevalence rate remains low (3.0% in the general population, 2.7% amongst women in the Women's Health of Accra Study of 2003), it is still a significant public health concern. HIV sero-prevalence has increased in commercial sex workers from 2% in 1986, 40% in 1990, 73% in 1997 and as high as 82% in 1999 in some areas. [26] These calculations are based in the previously published estimates for 1997 and 1999 and recent trends in HIV/AIDS surveillance in various populations. The current estimates do not claim to be an exact count of infections. These estimates are constantly being revised as countries improve their surveillance rates.

Data on the incidence and prevalence of cervical cancers in the developing world are incomplete and fragmentary. [27] There are many indications that cancers of the cervix represent problems of a public health dimension, but no data regarding the incidence of precursor lesions amenable to early interventions. Unfortunately, the risk factors for cervical cancer are widely prevalent in these

countries. Even the simplest technique of a Pap smear is used infrequently in these medically under-served populations. [28, 29]

In assessing the results from the physical examination, the one area that must be addressed in the next study is the low number of funduscopic examinations performed. Few physicians had an ophthalmoscope and/or an otoscope and few knew how to perform a proper examination. This is particularly problematic because of the high number of women who have cataracts, hypertension and diabetes. The other most frequently skipped examination included the rectal examination, short-term memory and the reflexes, although supplies and reflex hammers were available to all study physicians. The investigators will emphasize the importance of these examinations in the proposed study by providing ophthalmoscopes and otoscopes and individual instruction to the examining physicians.

Since demographic surveys now include a substantial health component, the reliability of common questions on illness is important to establish. More comparative work using studies with standard protocols and multiple measures of the different dimensions health status is now necessary. The contribution of the "anchoring vignettes", questions on a range of conditions used to standardize responses, appears to have been useful as a means of adjusting for the well-known problem of cut-point shifts in severity assessments by age and socio-economic status.

Census Data

We also draw upon a 10 percent sample of households from the 2000 Census of Population and Housing of Ghana created for us by Ghana Statistical Service for the Greater Accra Metropolitan Area. Variables that are available to us from the census are shown in Table 4. An examination of the variables shows the concern that the government has about local-level determinants of health, because there are several questions about housing type, connection to water and sewerage, bathroom facilities, and kitchen type/cooking methods, all of which are suspected of having health correlates.

Table 4.- Variables Available from the 2000 Census in Ghana

Type of Residence
Relationship to Head
Sex
Age
Nationality (Ghana/other ECOWAS/African not ECOWAS/not African)
Ethnicity (see Table 2 for detail)
Birthplace (born here/born elsewhere)
Birthplace, if outside of Accra
Usual Residence
Residence in 1995
Religion
Marital Status
Literacy
Ever Attended School
Highest Level of Schooling
Highest Grade (in years of schooling)
Labor Force Status
Days worked
Hours worked
Occupation
Industry
Employment Status
Employment Sector
Male Children Ever Born
Female Children Ever Born
Male Children Surviving
Female Children Surviving
Children Born Last 12 Months
Total Children Ever Born
Dwelling type

Outer wall material
Floor material
Roof material
Tenure
Owner
Rooms
Bedrooms
Lighting source
Water source
Toilet Facilities
Ownership of Toilet
Cooking source
Kitchen type
Bathing type
Solid waste disposal method
Waste water removal method

With the assistance of boundary descriptions from the Ghana Statistical Service and a high resolution Quickbird satellite image from Digital Globe, we were able to produce a digital map (shapefile) of all of Accra's enumeration areas. However, as noted above, because of the sampling strategy employed for the WHS, we have aggregated the data up to the locality level, which represents clusters of enumeration areas, as defined by Ghana Statistical Services. There are 43 localities within Accra and our analysis will focus on them because, unfortunately, there are no administrative units between the 1,724 enumeration areas and the 43 localities, each of which contains an average of 40 enumeration areas.

Remotely Sensed Data

Remotely sensed data represent images taken from a distance. Images are generally characterized according to resolution and bandwidth. Resolution refers to the size of the image captured by the smallest pixel (picture element) in the image. Thus, a 1-meter image means that the smallest pixel in the image is 1 meter by 1 meter in size on the ground. One meter images tend to be the highest resolution data available from commercial satellites. More detailed imagery typically requires the use of aerial photography. Images also vary according to the bandwidth of energy captured by the image, ranging from panchromatic (gray scale) to multi-spectral (visible red, green, blue, and near-infrared bands, as well as shorter-wave infrared bands that are not visible to the naked eye), and thermal bands that detect surface temperature rather than brightness.

In order to appreciate the value of remotely sensed imagery for analysis of urban places, it is crucial to understand exactly what it is that can be extracted from such images. The image itself is composed of a mosaic of individual pixels from which information has been captured for an area on the ground that is equal to the resolution of the image. The information is recorded for each of the pixels identified with each land cover class. Each image depends upon the particular sensor but typically the brightness within a given band is assigned a digital number. The combination of digital numbers of reflectance across the different bands of light represents the spectral signature of that pixel. Each spectral signature is associated with a particular type of land cover (e.g, vegetation, soil, water, impervious surface). The more bands there are in a sensor the more detailed the land cover classification can be. If there are only a few bands it is possible to differentiate vegetation from non-vegetation, but with more bands it may be possible to differentiate a field of corn from a field of wheat or, within the urban area it may be possible to differentiate a tin roof from a tile roof. The typical tradeoff in imagery is that lower resolution imagery will have more bands than higher resolution imagery. Our team's experience working with imagery for urban places suggests thus far that higher resolution is more important in characterizing an urban place than is the number of bands available for analysis (Rashed and Weeks 2003; Rashed *et al.* 2003; Weeks, Larson, and

Fugate forthcoming). This is because the built environment is, obviously, configured differently than the natural environment and the two most useful ways that we have found of quantifying urban places from imagery are in terms of (1) the proportional abundance or composition of fundamental land cover classes; and (2) the spatial configuration

The first task in using the data recorded for each pixel is thus to determine what type of land cover is represented by that pixel. Does it represent vegetation (and perhaps a specific type of vegetation), or bare soil, water, shade, or an impervious surface (such as the roofing material of a building or the asphalt or cement of roads)? These are the basic building blocks of the natural and built environment and each type of land cover is associated with a particular spectral signature. The higher the resolution (i.e., the smaller the pixel size) the more accurately we are able to classify a pixel because it is more likely that the pixel will include only one type of land cover. On the other hand, for lower resolution images, the more likely it is that the pixel will represent a mixture of different land covers, forcing us to make decisions about how appropriately to classify the image. Once we have classified the image according to land cover (the physical property as seen from the air), we are in a position to use information from other sources to make inferences about the way in which the land is being used (which is a socially derived category). From this process we are able to create variables describing the environmental context of a specific place. Thus, when we aggregate the land cover data for all pixels in an area (such as a census tract) we have a measure of the area's land cover composition.

In classifying the data by land cover class, we have previously employed Ridd's (1995) V-I-S (vegetation, impervious surface, soil) model to guide a spectral mixture analysis of medium-to-high resolution multi-spectral images for Cairo for 1986 and 1996, in a manner similar to methods used by Phinn and his colleagues for Brisbane, Australia (Phinn *et al.* 2002), and by Wu and Murray (2003) for Columbus, Ohio. The V-I-S model views the urban scene as being composed of combinations of three distinct land cover classes. An area that is composed entirely of bare soil would be characteristic of desert wilderness, whereas an area composed entirely of vegetation would be dense forest, lawn, or intensive fields of crops. At the top of the pyramid is impervious surface, an abundance of which is characteristic of central business districts, which are conceptualized as the most urban of the built environments.

Spatial dimensions of health

Our overall methodology was as follows: (1) summarize data on health levels from the WHS at the locality level; (2) summarize data on poverty from the census at the locality level; (3) summarize data from the imagery at the locality level; (4) run regression models to assess the extent to which measures of poverty can predict health levels in each locality; (5) assess data from the imagery for

their ability to approximate levels of poverty in each locality; and (6) use data from the imagery as proxies for poverty to assess their ability to predict health levels at the locality level.

With the assistance of boundary descriptions from the Ghana Statistical Service and a high resolution Quickbird satellite image from Digital Globe, we were able to produce a digital map (shapefile) of all of Accra's enumeration areas. However, as noted above, because of the sampling strategy employed for the WHS, we have aggregated the data up to the locality level, which represents clusters of enumeration areas, as defined by Ghana Statistical Services. There are 43 localities within Accra and our analysis will focus on them because, unfortunately, there are no administrative units between the 1,724 enumeration areas and the 43 localities, each of which contains an average of 40 enumeration areas.

2. RESEARCH FINDINGS

Spatial inequalities in health

The Women's Health Survey focused on women of reproductive age, but oversampled older women. In order not to bias the results by locality in terms of potential large differences in age structure, we restrict our analysis to women aged 18-54. We examined a wide range of potential health indicators, exploring the distributions of each in order to find those that exhibited sufficient variable to be indicative of inequalities. The final list of candidate variables included the following: (1) self-reported overall level of health, standardized through the use of vignettes based on the WHO model; (2) self-reported limitations on vigorous activity during the four weeks prior to the survey, dichotomized into those with at least some limitations and those with no limitations; (3) self-reported bodily pain, dichotomized into those with mild to very severe pain and those with no pain; (4) self-report of every having been diagnosed as having malaria; and (5) the number of other self-reported diagnoses besides malaria.

The overall values for these measures are summarized in Table 5. On a five-point scale from one (best health) to 5 (worst health), the average is 2.5, 42.3 percent of women reported some limitations to vigorous activity, 38.1 percent reported mild to very severe bodily pain, 50.1 percent of women There are, of course, significant correlations among these variables, and we assessed the relative importance of them as a group through the use of principal components analysis. As shown in Table 5, the variables produced two factors with eigenvalues greater than 0.9, together explaining 72 percent of the overall variance among the variables. The most important of the variables, clustering together, are mean self-reported health and limits to vigorous activity. The existence of bodily pain is an important second dimension, and the malaria diagnosis is linked a little more

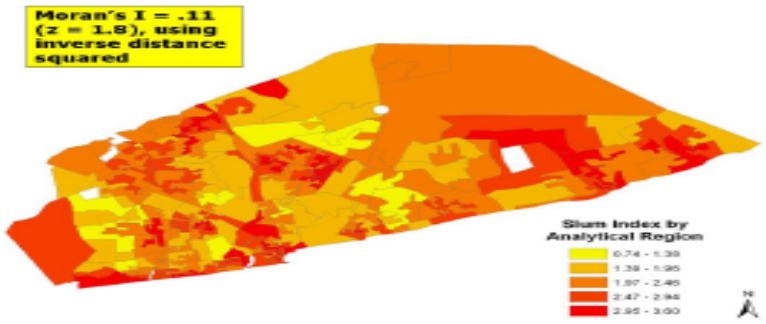
closely to that than to the first component, although it is not clearly in either component. Similarly, the number of diagnoses other than malaria are split into their association with the two components.

Table 5: Health Levels Among Women Aged 18-54 in Accra, Ghana

Variable	Overall average:	Overall Standard Deviation	Factor 1 Score	Factor 2 Score
Mean self-reported Health	2.5	0.34	.867	.093
Limits to vigorous activity	42.3%	15.9	.881	.165
Mild to very severe bodily pain	38.1%	14.6	.047	.934
Malaria diagonosis	50.1%	19.6	.516	.608
Mean n of diagnoses	0.3	.585	.452	

The data show that there are clear, but differing, spatial patterns with respect to health levels in Accra. Figure 2 reveals the pattern for self-reported health. Moran's I, which measures the extent of spatial autocorrelation (non-randomness in the average level of self-reported health by locality) is statistically significant beyond the .05 level. The percentage of women by locality with some limits to vigorous activity show a similar spatial pattern, which is also statistically significant non-random. In both cases the poorest levels of health are found in the historically oldest sections of the downtown area. The spatial pattern with respect to bodily pain is slightly different. The percent of women diagnosed with malaria shows yet a different pattern in that it is highest in the center section, regardless of proximity to the coast, and lower on the east and west peripheries. This suggests a geographic pattern that may be indicative of water patterns for mosquito habitat. The pattern for all other diagnoses seems to suggest that proximity to Korle Bu Teaching Hospital increases the likelihood of being diagnosed with disease.

The figure below summarizes graphically the index of deprivation developed in this project.



Spatial Inequalities in Poverty

We used data from the census, rather than from the WHS, to measure poverty, but we restricted the analysis to data for women aged 18-54 in order to be consistent with the population for which we had measured health levels. After doing exploratory statistical analysis on a wide range of potential predictors of levels of poverty in each locality, we narrowed the choice to the following variables: (1) percent of the population with less than a secondary education (highly correlated with all measures of education, which is correlated generally with income); (2) percent of economically active women of reproductive age who are working in the informal sector; (3) the mean number of rooms per household dwelling; (4) percent of homes without their own water closet; and (5) percent of households in which charcoal is the fuel for cooking. As can be seen in Table 6, these variables all combined into a single factor when we applied principal components analysis. Given the large size of all factor coefficients, we used the factor score as a measure of poverty/socioeconomic status of each locality.

Below, we summarize the distribution of the "best" and "worst"areas in Accra:

Table 6: Measures of poverty by locality, Accra, Ghana

Variable	Overall average:	Overall standard deviaton	Factor 1 Score= poverty/SES
Pct with less than secondary education	**27.8**	**9.6**	**.858**
Pct working in informal sector	**64.8**	**8.7**	**.838**
Mean N of rooms	**2.5**	**0.52**	**-.879**
Pct w/o WC	**69.6**	**19.8**	**.938**
Pct cook w/charcoal	**60.0**	**15.3**	**.961**

The spatial pattern of poverty by locality can be seen in Figure 7. While in general the older sections of Jamestown and Ushertown have the highest poverty (and the worst health levels), the spatial pattern of poverty is not exactly the same as any of the health indicators. Nonetheless, there is a clear spatial pattern, as evidenced quantitatively by the high and statistically significant Moran's I.

Does poverty predict health at this spatial scale of aggregation?

Although there are significant spatial patterns to health indicators, and significant spatial patterns to poverty, the latter is not generally predictive of the former, as can be seen in Table 7.

Table 7. Regression of Poverty on Health Indicators

Variable	Standardized Beta Coefficient	t-score
Poverty Score	.361	-2.42
Dependent variable is self-reported health score		
R = .361		
Adjusted R2 = .108		
No outliers; little evidence of heteroscedasticity; Moran's I for residuals = .33; Z(I) = 1.69 at 1500m		

The highest ordinary least-squares regression of poverty was found with respect to the self-reported score on overall health. The data in Table 7 show, however, that variability in poverty from locality to locality was able to explain only 11% of the variation in health levels from locality to locality. Although this was statistically significant, it is obviously not as high a level as we would have expected. Also, we found that there was no evidence of spatial autocorrelation in the residuals, indicating that there was no underlying spatial pattern that was not captured by the regression model.

The spatial distribution of these health indices is summarized in the figure below:

What is the spatial pattern of data from the satellite imagery?

In this paper we report only the analysis of proportional abundance of land cover classes drawn from our classification of the multispectral Quickbird image of Accra. Note that the image does not cover all of the study area, so our analysis is confined to 39 of the 43 localities (and for some of the eastern localities, the imagery covers only part of the area, but we summarized those data nonetheless). In contrast to work done in arid climates such as Egypt, tropical areas such as Accra have significant vegetative canopies that hide the underlying land cover on the ground. In particular, it is not obvious in many areas how much land area might be devoted to impervious surface or bare soil underneath the canopy. However, we also found that there is considerable and reasonable variability in vegetation that may serve as a useful proxy for what is happening on the ground. We used two measures of vegetation—the proportional abundance of land area within each locality for which the land cover class was identified as vegetation, and then a more nuanced measure of vegetation known as the normalized difference vegetation index (NDVI). The spatial patterns of both are quite similar and are shown in Figures 8 and 9.

Can the Imagery Variables Be Used as Proxies for Poverty and/or Health?

The data in Table 8 show that both measures of vegetation are highly but inversely correlated with poverty—the less vegetation in an area, the higher is the poverty level. Or, put another way, it is in the wealthier areas that there is the greatest amount of vegetation per area. The proportional abundance of vegetation and the NDVI both explain nearly two-thirds of the variability from locality to locality in the poverty index.

Table 8: Vegetation as a Predictor of Poverty Levels by Locality

Variable	Standardized Beta Coefficient	t-score
Pct Vegetation	-.793	-7.92
Dependent variable is poverty score for locality		
Adjusted R2 = .62		
No outliers; evidence of heteroscedasticity;		
Moran's I for residuals=.43, Z(I)=2.26 at 1500m		
Variable	Standardized Beta Coefficient	t-score
NDVI	-.798	-8.04
Dependent variable is poverty score for locality		
Adjusted R2 = .63		
No outliers; little evidence of heteroscedasticity; Moran's I for residuals = .21, Z(I)=1.83 at 2000m		

However, we have already seen that poverty is not as good a predictor of health indicators as we had anticipated, so a proxy measure of poverty is unlikely to be a good proxy measure of health indicators. This is born out by the regression results shown in Table 9, where it can be seen that neither measure of vegetation is a statistically significant predictor of self-reported health (or any of the other health indicators—data not shown).

Table 9: Vegetation as a Predictor of Health Levels by Locality

Variable	Standardized Beta Coefficient	t-score
Pct Vegetation	-.283	-1.77
Dependent variable is self-reported health score aggregated at the locality level		
Adjusted R2 = .05		
Two outliers; some evidence of hetero-scedasticity; Moran's I for residuals = .44; Z(I)= 2.24 at 1500m.		
Variable	Standardized Beta Coefficient	t-score
NDVI	-.295	-1.85
Dependent variable is self-reported health score aggregated at the locality level		
Adjusted R2 = .06		
One outlier; some evidence of heteroscedasticity; Moran's I for residuals = .38; Z(I)= 1.92 at 1500m.		

Additional relevant materials

Duda RB, Darko R, Adanu RMK, Seffah J, Anarfi JK, Gautam S, Hill AG. HIV prevalence and risk factors in women in Accra, Ghana: Results from the Women's Health Study of Accra. AJTMH, 73(1):63-66, 2005.

Duda RB, Chen GL, Hill AG, Darko R, Adanu RMK, Seffah, J, Anarfi JK. Screening for cervical cancer still not included as routine health care for women. http://www.medwellonline.net Int J Trop Med, 1(1):1-6, 2005.

Chen GL. Hill AG, Seffah J, Darko R, Anarfi JK, Duda RB. Epidemiology of cervical cancer and dysphasia in a cross-sectional of women in Accra, Ghana. http://www.medwellonline.net Int J Trop Med, 1(1):7-11,2005.

Duda RB, Darko R, Adanu RMK, Seffah J, Anarfi JK, Hill AG. Prevalence of Obesity in an Urban West African Population: Results of the Women's Health Study of Accra. Submitted to African J Health Sciences, 2006.

Adanu RMK, Hill AG, Darko R, , Seffah J, Anarfi JK, Duda RB. Secular trends in menarcheal age in Ghanaian women. J Obstetrics and Gynecology, accepted 2006.

Hill AG, Anarfi J, Darko R, Adanu RMK, Seffah J, Duda RB. Measuring population health: The design and conduct of women's health in Accra, Ghana. Submitted to BMJ, 2006.

Duda RB, Kim MP, Darko R, Adanu RMK, Seffah, J, Anarfi JK, Hill AG. Prevalence of elevated blood pressure in women residing in Accra, Ghana: report of the Women's Health Study of Accra. Accepted, International J of Cardiology, 2006.

Hill AG, Anarfi J, Adanu RMK, Seffah J, Darko R, Duda RB. The health of urban women in Africa: Results from a community-based study of women's health in Accra, Ghana. Submitted to BMJ, 2006.

Duda RB, Anarfi J, Darko R, Adanu RMK, Seffah J, Hill AG. The health of the "older women" in Accra, Ghana: Results of the Women's Health Study of Accra. Submitted to J Cross-Cultural Gerontology, 2006.

Weeks, J et al The impact of neighbourhood structure on health inequalities in Accra. PAA, March 2006.

Weeks, J et al (in press) Ethnic residential patterns as predictors of intra-urban child mortality. *Urban Geography*.

Weeks, J et al (in press) Is the worst health found in the worst slums? *Annals of the Assoc of Amer Geographers*

References

1 Ware, JE. SF-36 Health Survey. Manual and Interpretation Guide. New England Medical Center, Boston, MA. 1993.

2 Tandon, A, CJL Murray, JS Salomon and G King. 2003. Statistical models for enhancing cross-population comparability. Chapter 55 in: Health systems performance assessment. Edited by CJL Murray and DB Evans. WHO, Geneva.

3 WHO. Obesity epidemic puts millions at risk from related diseases. Press Release WHO/46. www.who.int/archives/inf-pr-1997/en/pr97-46.html. 12 June, 1997.

[4] NHLBI: Obesity education initiative electronic textbook – appendices. www.nhlbi.nih.gov/guidelines/obesity/e_txtbk/appndx/apndx8.htm.

[5] NHLBI: Clinical guidelines on the identification, evaluation, and treatment of overweight and obese adults in adults – Executive Summary. www.nhlbi.nih.gov/guidelines/obesity/sum_rec.htm.

[6] Duda RB, Darko R, Adenu RA, Seffa J, Anarfi J, Hill AG. The prevalence of HIV in women in Accra: Results from the WHSA. Submitted, *AIDS*, 2004.

[7] National Cancer Institute Workshop. The 1988 Bethesda System for reporting cervical/vaginal cytological diagnoses. *JAMA* 262:931-934, 1989.

[8] Amoah AGB, Owusu S, Acheampong JW, et al. A national diabetes care and education programme: the Ghana model. *Diabetes Research and Clinical Practice* 49:149-157, 2000.

[9] van der Sande, MAB et al Nationwide prevalence study of hypertension and related non-communicable disease in The Gambia. *Tropical Medicine and International Health*; 2:1039-48, 1997.

[10] van der Sande, MAB et al. Blood pressure patterns and cardiovascular risk factors in rural and urban Gambian communities. *Journal of Human Hypertension*; 14:489-96, 2000.

[11] Anim JT. Pattern of atherosclerosis in a Ghanaian adult population: an autopsy study. *Afr J Med Sci* 16(4):203-213, 1987.

[12] Cooper R, Rotimi C, Ataman S, et al. The prevalence of hypertension in seven populations of West African origin. *Am J Public Health* 87(2):160-168, 1997.

[13] Cappuccio FP, Plange-Rhule J, Phillips RO, Eastwood JB. Prevention of hypertension and stroke in Africa. *Lancet* 356:677-678, 2000.

[14] Burdon J. Figure of $1800 per life saved seems optimistic. *BMJ* 317:76.

[15] Anim JT. Pattern of atherosclerosis in a Ghanaian adult population: an autopsy study. *Afr J Med Sci* 16(4): 203-213, 1987.

[16] Anim JT. Cerebral macroaneurysms in a Ghanaian adult population: An autopsy study. *Atherosclerosis* 54:37-42, 1985.

[17] Amoah AG and Kallen C. Aetiology of heart failure as seen from a National Cardiac Referral Centre in Africa. *Cardiology* 93:11-18, 2000.

[18] Pobee JO. Community-based high blood pressure programs in sub-Saharan Africa. *Ethn Dis* 3:S38-45, 1993.

[19] Wiredu EK, Nyame PK. Stroke-related mortality at Korle Bu Teaching Hospital, Accra, Ghana. *East Afr Med J* 78:180-184, 2001.

[20] WHO Study Group, Diabetes Mellitus, World Health Organization, Geneva, Switzerland, *Tech. Rep. Ser*. 727, 2985.

[21] King H and Rewers MG. Diabetes in adults is now a third world problem. *Bulletin of the World Health Organization* 69:643-648, 1991.

[22] Amoah AGB, Owusu S, Saunders JT, et al. Facilities and resources for diabetes care at regional health facilities in southern Ghana. *Diabetes Research and Clinical Practice* 42:123-130,1998.

[23] Amoah AGB, Owusu S, Adjei S. Diabetes in Ghana: a community based prevalence study in greater Accra. *Diabetes Res Clin Prac* 56: 197-205, 2002.

[24] Cooper R, Rotimi C, Ataman S, et al. The prevalence of hypertension in seven populations of west African origin. *Am J Public Health* 87(2):160-168, 1997.
[25] Cooper R, Rotimi C, Ataman S, et al. The prevalence of hypertension in seven populations of west African origin. *Am J Public Health* 87(2):160-168, 1997.
[26] Ghana Epidemiologic Fact Sheet on HIV/AIDS and sexually transmitted infections. UNAIDS/WHO 2000 Update. www.aids.africa.com
[27] Lunt R. Worldwide early detection of cervical cancer. *Obstet Gynecol* 63:708-713, 1984.
[28] Chirenje ZM, Rusakaniko S, Kirumbi L, et al. Situation analysis for cervical cancer diagnosis and treatment in east, central and southern African countries. *Bull World Health Organ* 79:127-132, 2001.
[29] Fonn S, Bloch B, Mabina M, et al. Prevalence of pre-cancerous lesions and cervical cancer in South Africa – a multicentre study. *S Afr Med J* 92:148-156, 2002.