Nutritional and Vaccination Status of Children in the Terre Noir Neighborhood of Port-au-Prince, Haiti

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BACKGROUND

History of International Nutritional Measurement and Definitions

For many years, growth has been measured as a surrogate for the overall health of individuals and populations. Though this method is insufficient for understanding the complete health of an individual or population, it acknowledges that many physiologic processes must converge to achieve normal growth.[1] Historically, young children have been the focus of surveys of growth because they are most at risk of having their physiologic processes of growth disrupted.[1] Child growth is a proxy for a child's nutritional status, which itself is a marker of dietary intake and overall health.[2] Under the UNICEF conceptual framework on causes of malnutrition, dietary intake and overall health status are related to food, health, and care resources, which are themselves determined by the political and economic structures and sociocultural environments in a country.[2]

The first use of an anthropometric measurement as a corollary of morbidity or mortality was in a 1956 paper from research in Mexico City.[3] Researchers assessed child mortality by weight, which they categorized into first-, second-, and third-degree malnutrition by the percentiles of expected average of weight-for-age.[3] These distinctions were later revised with different reference values for each category under the Harvard growth curves[4], but the 'Gomez classification' of weight-for-age would become a widespread method to measure malnutrition.[5] When the WHO distributed a combined-sexes version of the Harvard growth curves modified by Jelliffe in 1966, this curve and its methodology became a de facto international growth reference.[6, 7]

The 'Gomez classification' using weight-for-age as a measure of malnutrition has several problems, however. A low value for weight-for-age can result from one of two processes: 1) long-term, or chronic, malnutrition that results in a lowered height-for-age or 2) short-term, or acute, malnutrition that results in a lowered weight-for-height.[5] Both of these processes result in a lower weight-for-age than would be expected otherwise.

The inability to determine the relative duration of malnutrition using weight-for-age measures led researchers to debate alternative measures for assessing malnutrition for research and clinical purposes. Waterlow and other members of a 1975 WHO expert committee recommended the use of height-for-age as a marker of past nutrition and the use of weight-for-height as a marker of present nutrition in cross-sectional studies.[8] More recently, Bern et. al (1997) found weight-for-height measurements to be more correlated with mortality than weight-for-age measurements in Kenyan children.[9]

The first official international growth reference used by the WHO was the United States National Center for Health Statistics (NCHS) Growth Curves for Children 0-18 Years.[10] The NCHS curves had been developed to assess the growth of US children drawing on a more representative national sample and utilizing different metrics from the Harvard classification, including head circumference, limb circumference, and skinfold thickness, to complement weight, height, and age.[11] This use of additional metrics and its relatively large sample size for each age category led Waterlow and the expert committee to advocate for the adoption of the NCHS as the international reference.[8]

Debates regarding what statistics should be used to describe nutritional status occurred simultaneously with debates regarding anthropometric measurement types. In addition to their advocacy for different anthropometry and the adoption of the NCHS references internationally, the 1975 WHO expert committee recommended the reporting of centiles for well-nourished populations and of standard deviations from the mean for undernourished populations.[8] Standard deviations from the mean as represented by z-scores follow reference distributions more closely and are more comparable across ages and indicators than percentiles in undernourished populations.[8] Z-scores are normalized values obtained by subtracting the population mean from an individual's raw score and dividing this value by the standard deviation of the values within a population. Thus, when this US reference system was adopted as the NCHS/WHO international growth reference (hereafter referred to as the NCHS reference) in 1978, reporting of Z-scores became the international statistical comparison.[8, 11, 12]

Unfortunately, the NCHS reference also had severe shortcomings. Two age categories had been created for the NCHS reference: children from birth-36 months of age and children from 2-18 years of age. The data used to develop the curves for children from 2-18 years of age was from national samples of the Health Examination Survey (HES) II, III, and IV (this latter study also known as the first Health and Nutrition Examination Survey, or HANES).[11] The data used to develop the curves for children birth-36 months, however, came from a convenience sample in a longitudinal study of 867 predominantly formula-fed, middle-class, white children from the Fels Research Institute in Yellow Springs, Ohio.[6, 11] These children from Ohio were larger in both height and weight, on average, than children in the 2-18 years of age sample at 24 months and in height at 36 months, regardless of sex.[13] Overall, these differences created problems for measurement reference in children between 2-3 years of age.[13]

As the referent information was not created from a representative international sample, individual children from impoverished nations or situations often did not conform well.[6] Often in these situations, children were categorized as stunted (defined as >-2 standard deviations below the mean for height-for-age) or wasted (defined as >-2 standard deviations below the mean for weight-for-height) without consideration of the reference population. This also resulted in disagreement between the birth-36 months and 2-18 years international samples: the 1983 WHO global report on protein-energy malnutrition illustrated abrupt decreases in the prevalences of stunting and wasting at 24 months of age due to the shift from the birth-36 months data to the 2-18 years data.[13, 14]

Additional problems with the NCHS reference were that it included a substantial portion of the population with childhood obesity and was insufficient for healthy, breastfed infants.[15, 16] As a result of the number of obese children in the original samples, the upper distributions of its weight-for-age and weight-for-height references were highly skewed and thus overweight children being measured might be misclassified as normal weight.[15] The means of weight-for-age, height-for-age, and weight-for-length from exclusively breastfed children in favorable conditions, on the other hand, were initially higher than that of the NCHS reference but decreased from 2-12 months of age until the means of all measures were below the mean for the reference.[16]

These problems led to a call for a new international growth reference by a 1993 WHO Expert Committee, which was endorsed by the World Health Assembly (resolution WHA47.5) in 1994.[17] The study that followed to create this reference, the WHO Multicentre Growth Reference Study (MGRS), focused on approximately 8500 healthy, breastfed infants and children from six countries (Brazil, Ghana, India, Norway, Oman, and the US) who were felt to have unconstrained physiologic growth from 1997-2003.[18, 19] One group of children from birth-24 months was studied longitudinally for two years to obtain growth trajectories over time, while another group from 18-71 months of age was studied cross-sectionally.[19]

The results of the MGRS are the basis of the new WHO Child Growth Standards, released in April 2006.[20] Unlike the previous NCHS reference, these new standards characterize how children should grow based on the MGRS. Thus, future nutrition studies will be able to chart growth against an agreed-upon standard for any population in the world.

Data from previous studies using the NCHS reference, however, show significant discrepancies when compared to the new standard values.[21] For example, the comparative prevalence of underweight is 2.5 times higher in the first six months of life using the WHO standards but then decreases to below that of the NCHS reference.[21] Additionally, the prevalence of stunting increases for all age groups by approximately 10% overall, and the prevalences of wasting and severe wasting in the first six months of life increase by 2.5 times and 3.5 times that of the NCHS reference, respectively.[21]

Databases on Nutrition and Growth

Beginning in 1986, the WHO created its Global Database on Child Growth and Malnutrition to systematically organize and standardize data entry from anthropometric surveys in both developing and developed nations. This database initially presented information from 1960 onward for individual countries using the NCHS international reference guidelines to calculate growth retardation of children under the age of 5 years using weight-for-age, height-for-age, and weight-for-height at the -2 SD and -3 SD levels.[22] Additionally, the database contained information on the prevalence of overweight children using + 2 SD levels of weight-for-age.[22]

These data in the Global Database are compiled from national-level Demographic and Health Surveys (DHS) or individual research studies using standard anthropometric measurements on a probabilistic sampling procedure in a defined population. Results can be submitted from anyone using standard data entry forms available online and must include at least 400 children.[23]

The WHO Global Database on Child Growth and Malnutrition was placed online in May 1999 and continues to add data.[24] As of 2002, it contained 412 national and 434 subnational surveys from 1960 onward.[25] With the implementation of the new WHO Child Growth Standards in 2006, these data are being reformatted to the new standards in an ongoing process, though the old data from the NCHS reference are still available online.

Other national data on child growth and undernutrition are available, including those from The World Bank Group, UNICEF, the Pan-American Health Organization, and the United Nations World Food Program. Much of these data specifically related to undernourished children are shared from the DHS, however.

INTRODUCTION

Current State of World Undernutrition

Today, undernutrition across all age groups remains the leading cause of global burden of disease and plays a significant role in deaths both from infectious disease and other causes.[26-28] In its Millennium Development Goals, the United Nations pinpointed reducing worldwide hunger by half between 1990 and 2015 as one of its main targets.[29] To measure this endpoint, two indicators were chosen – the prevalence of underweight children under five years of age, and the proportion of the population below the minimum level of dietary energy consumption.[29] Weight-for-age is not favored as a sole anthropometric indicator of international undernutrition, but it can be used alongside other anthropometric indices on a large-scale to gain perspective on a population.

Attempting to halve worldwide childhood undernutrition is a difficult undertaking because related social causes of malnutrition are numerous. Factors related to malnutrition range from local energy availability to female literacy, national gross domestic product, access to housing, population density, and political stability.[30, 31] The public health consequences of malnutrition are also numerous and include increased susceptibility to disease, increased child mortality, increased strain on health resources, and lower economic productivity.[30]

A 1993 survey of international undernutrition using the WHO Global Database grouped prevalences of underweight children for 79 nations into categories of relatively low (<10%), moderate (10-19%), high (20-29%), and very high (≥30%) based on calculated values.[22] In that survey, the global prevalence of underweight children under five in developing countries was estimated to be 35.8%, with Asia containing 80% of affected children.[22] Additionally, the prevalence of stunted children in developing countries was estimated to be 43%.[22]

Since that time, several more nutritional surveys have been added to the database. Analysis of these new data has been ongoing and estimates of global malnutrition have now been made as far in advance as 2020.[25, 30, 32, 33] In each of these studies, the global prevalence of undernutrition has been found to be decreasing and is projected to continue to do so. A recent study on this topic from 2004 estimated the developing region prevalence of underweight children to be 19.3% in 2015, a decrease of approximately 36% from 1990 levels.[33]

Individual countries, however, have shown increasing prevalence across time, including Rwanda, Zambia, Algeria, Mali, the Maldives, and Venezuela.[30] Reasons for increases in these countries and others include political or economic instability, natural disasters, armed conflict, or combinations of these factors.[30] The pattern of malnutrition across time has led to a prediction that, of United Nations developing regions, only three of the ten regions in Africa and Asia will reach the Millenium Development Goal on hunger.[33] All three regions in Latin America, on the other hand, are projected to meet the goal.[33]

As mentioned previously, the prevalence of underweight children using the new WHO standard is 2.5 times higher in the first six months of life and thereafter becomes below that of that NCHS reference by 5 years of age.[21] As a result, future studies analyzing progress in reducing underweight status for the Millennium Development Goals should be calculated using the old NCHS reference.

Status of Haitian Nutrition

Haiti (Figure 1) also might suffer from increased malnutrition due to recent instability. Haiti has a long history of political turmoil and violence, including for much of the last twenty-one years. Since the departure of then-President-for-Life Jean-Claude 'Baby Doc' Duvalier in 1986, Haiti has had seventeen non-successive heads of state and multiple coups. Additionally, the United Nations has had peacekeeping forces in the country from 1994-2001 and again since February of 2004.[34]

Today, as for most of the last century, Haiti is the poorest country in the Western Hemisphere. According to the United Nations Development Program, Haiti ranks 154th out of 177 countries in its human development index and has a 2005 GDP of $450 per capita.[35, 36] The World Bank calculates the country has had a negative economic growth rate for three of the last four decades and that real per-capita GDP fell more than 1% a year from 1961-2000 for a total period loss of 45%.[35] Furthermore, the World Food Program estimates that the nation's food supply covers only 55% of the population and daily food insecurity affects 40% of Haitian homes.[37]

Even with a declining economic picture and periodic violence, Haitian nutrition as documented on a national level has been improving across time. The WHO Global Database on Child Growth and Malnutrition contains four country-level studies of the Haitian population, from 1978, 1990, 1994-5, and 2000, all using the NCHS reference.[38] The 1994-5 and 2000 studies, from DHS data, have been recently reformatted according to the WHO standard.[39]

According to the NCHS data, the prevalence of underweight children under five years of age in Haiti was 37.4% in 1978, 26.8% in 1990, 27.5% in 1994-5, and 17.2% in 2000.[38] Similarly, the prevalence of stunting was 39.6% in 1978, 33.9% in 1990, 31.9% in 1994-5, and 22.7% in 2000. Wasting fell from 8.9% in 1978 to 4.7% in 1990, increased to 7.8% in 1994-5, and fell again to 4.5% in 2000. This spike in wasting in the period from 1990 to 1994-5 coincides with an international trade embargo and three years of disorder following the first ouster of Jean-Bertrand Aristide in 1991.

Using the database portions that have be converted in terms of the WHO standard**,** the prevalence of underweight fell from 24.0% in 1994-5 to 13.9% in 2000.[39] Stunting decreased from 37.2% to 28.3% in the same period, and wasting declined from 9.4% to 5.6%. The prevalence of overweight individuals by weight/height (>+2 SD) also fell from 1994-5 to 2000, from 4.3% to 3.1%, and the prevalence of obese individuals (>+2 SD for BMI/age) fell from 5.5% to 3.9%. These changes are summarized across time in Tables 1 and 2.

Other studies of Haitian malnutrition not included in the Global Database have tended to be regional and predominantly focused from Port-au-Prince northward. The first published studies on malnutrition in Haiti were from 1958.[40, 41] Sebrell and his colleagues sampled Port-au-Prince, as well as the northern urban areas of Gonaives and Cap-Haitien and rural areas in the Artibonite River valley and the other two northern departments (the Haitian equivalent of states).[40] They focused, however, on persons ages 5 and older, used the Iowa classifications by Meredith[42] and did not study a representative sample of the population.[40]

Jelliffe and Jelliffe,[41] on the other hand, visited all five of the Haitian departments extant in the late 1950s and also sampled slums within Port-au-Prince. They focused on 1322 1-3 year old children, though they also sampled 575 infants and an additional 273 children between the ages of 3-6.[41] Using the Gomez classification, they found levels of malnutrition in infants to be 17% with 1st degree, 15% with 2nd degree, and 1% with 3rd degree. In 1-3 year-old children, these levels of malnutrition increased in each category to 37% with 1st degree, 21% with 2nd degree, and 3% with 3rd degree. In the 3-6 year-old children, prevalence was 40% with 1st degree, 23% with 2nd degree, and 1% with 3rd degree.

In general, results in this study from the two southern departments (Ouest, in which Port-au-Prince is located, and Sud) were similar to the national estimates for 1-3 year-old children (38% Ouest, 36% Sud with 1st degree; 14% Ouest, 22% Sud with 2nd degree; and 2% Ouest, 3% Sud with 3rd degree).[41] The urban slums in Port-au-Prince, on the other hand, had slightly higher levels of 1st and 2nd degree malnutrition in 1-3 year-olds than either the Ouest or Sud departments (43% with 1st, 23% with 2nd). The authors also performed physical exams on their sample and found 7% of children had clinical evidence of kwashiorkor.

In a study published in 1963, King et al. published data from three groups of children: wealthy children from Port-au-Prince in private schools, poorer children in Port-au-Prince enrolled in free government-run schools, and rural children from villages north of the capital.[43] Though they did not publish centiles of how children were growing, they did illustrate that wealthy children, on average, grew similarly to the Iowa reference, while both poor, urban children and rural children did not.[43] The rural children also grew along a lower average growth curve than the poor, urban children. The authors, however, did not localize the poor, urban children to any particular slum or region of the capital and only used children ages 6 and above from within either category in Port-au-Prince. Another study by King and collaborators in 1968 found a general caloric deficit of 500-600 calories per day in Haiti.[44]

Another study in 1981 compared privileged Haitian, Egyptian, and Togolese children to both the NCHS reference and to the Haitian children in the 1978 national survey.[45] The children from the 1978 sample are approximately 1.0 SD shifted to the left of the NCHS reference for weight-for-height and 2.0 SD shifted to the left for height-for-age.[45, 46] Privileged children from Haiti again grew very similar to those children in the NCHS reference.[45]

Haiti expanded to nine departments, from its previous five, sometime after 1968. A CDC study in the northernmost five of the nine departments in Haiti during a drought in those areas in 1990 found prevalences of 40.6% for stunting, 34% for underweight, and 4.2% for wasting in children under the age of five.[47] These are higher than the national averages for stunting and wasting from the same year and do not include the urban center of Port-au-Prince, where children have had better growth outcomes due to the presence of a small, wealthy elite. These data are currently in the NCHS dataset for the Global Database.

Additional studies have corroborated DHS data from 1994-95 showing a spike in acute malnutrition in that time period. A study from the Grand-Anse department in the southwestern part of the country showed a spike in severe malnutrition by weight-for-age measures in the 1991-1994 embargo period compared to both the pre-embargo and post-embargo periods.[48] Additionally, a nationwide network of health centers also reported an increased prevalence in moderate and severe malnutrition in children presenting to the centers from 18% in 1993 to 24% by the end of 1994.[49]

Another DHS was performed in 2005, but has yet to be included in the WHO Global Database on Child Growth and Malnutrition[50]. This study involved 2841 total children representing each department and both rural and urban areas. Overall, 22.2% of children in this sample were underweight, including 10.2% in the Aire Metropolitaine (primarily Port-au-Prince), 15.4% in all urban areas, and 25.5% in rural areas. Additionally, 23.8% of children were stunted, including 12.5% in the Aire Metropolitaine, 15.1% in all urban areas, and 28.1% in rural areas. Finally, 9.1% of children were wasted, including 4.9% in the Aire Metropolitaine, 7.0% in all urban areas, and 10.2% in rural areas. Data on overweight and obese children have not been reported. These data are summarized in Table 2.

Current Levels of Haitian Anemia

Iron-deficiency anemia is the most common nutritional disorder in the world, affecting more than 2 billion people worldwide.[51] It is also one of the ten leading factors of global disease burden.[52] The WHO estimates a 19% prevalence of anemia throughout the Americas region as a whole in the years 1990-1995[53].

The Vitamin and Mineral Nutrition Information System (VMNIS) Database on Anaemia of the WHO contains estimates for every country.[54] The most recent data for Haiti in the database come from the 2000 DHS.[55] This survey found 65.3% of pre-school age children (aged six months through five years) had hemoglobin concentrations under 110 g/L (11.0 g/dL) and 1.6% had concentrations under 70 g/L (7.0 g/dL).[56] Additionally, this survey found 54.8% of non-pregnant women ages 15-49 to have hemoglobin concentrations under 120 g/L (12.0 g/dL).[56]

Data from the 2005 DHS found 60.7% of 2599 children ages 6-59 months from throughout Haiti to be anemic, with hemoglobin concentrations under 110 g/L.[50] Additionally, it found 2.3% of these children to be severely anemic (hemoglobin concentration below 70 g/L). In general, anemia peaked at age 12-17 months at 77.2% and declined steeply from there to 46.9% of children ages 48-59 months.[50] The 2005 DHS also found 48.4% of women aged 15-19 to be anemic, with hemoglobin concentrations <120 g/L. These data are summarized in Tables 3 and 4.

Current Haitian Vaccination Rates

In its *World Health Report 2005*, the WHO estimated 1.4 million deaths occurred due to vaccine-preventable diseases in children under 5 years of age in 2002 (equivalent to 14% of under-5 mortality worldwide).[57] Incidence of these vaccine-preventable diseases is jointly tracked from UN Member States by the WHO and UNICEF and is available online from 1980 onwards in many countries for diphtheria, measles, pertussis, polio, neonatal tetanus, total tetanus, and yellow fever.[58] Additionally, information on mumps, rubella, and congenital rubella syndrome is available from 1999 in many countries.[58]

According to this reported information, Haiti had much higher rates of vaccine-preventable diseases prior to 1990 than it has had since 1995.[59] Data from 1990-1994/5 are not available, presumably due to the coup and unrest surrounding the end of the first Aristide presidency.[59] Haiti has not had a reported case of measles or polio since 2001, and diphtheria and pertussis had been under 44 cases annually from 1994-2004.[59] In 2005, however, there was a spike in diphtheria to 204 cases and in pertussis to 496 cases.[59] This correlates temporally with the recent political unrest. Data from 2006 are provisional but again show a decrease in cases to pre-2005 levels.[59]

Haiti's current national guidelines are for children to receive BCG at birth; DTP at 6, 10, 14, and 66 weeks; measles at 9 months; OPV at <15 days, 6, 10, 14, and 66 weeks, as well as another booster later in life; Td at 180, 181, 193, 205, and 217 months; and vitamin A at 6, 10, and 14 months.[60] This is summarized in Table 5.

Survey information on vaccination rates in many countries comes from the DHS, which occurred in Haiti in 1994-5, 1999, and 2005, and involved 633, 1225, and 1135 children, respectively. Estimated vaccination coverage information, on the other hand, is reported to WHO/UNICEF either directly by governments, by the number of vaccinations administered by healthcare providers, or by other methods. Prior to 1998, the WHO/UNICEF database does not specify whether information was from administrative records, surveys, or other sources.[61] Thus, the origin of the annual estimate of vaccination coverage prior to that date is unknown.

In the case of Haiti, vaccination rates from the DHS have been higher than those reported to WHO/UNICEF from either the government or from the numbers of doses reportedly administered by the health sector.[61] Official WHO/UNICEF estimates have closely followed the DHS projections. The DHS estimates of vaccination coverage in children under 12 months of age and between the ages of 12-23 months from either vaccination card presentation or oral report in Haiti have increased for all vaccination types from 1994 until 2005.[61] From 1994-2005, coverage of vaccinations has increased in 12-23 month olds as follows – from 73% coverage to 75% coverage for BCG, from 75% to 83% for DTP1 (one dose of diphtheria, tetanus, and pertussis vaccine), from 41% to 53% for DTP3 (three doses of DTP vaccine), from 41% to 52% for Pol3 (three doses of oral polio vaccine), and from 48% to 58% for MCV (measles conjugate vaccine). In the most recent survey, vaccination cards were available for 72.9% of the 1135 children.[61]

WHO/UNICEF estimates are also available for TT2+ (at least two doses of tetanus toxoid vaccine) and vitamin A. In 1999, 52% had received TT2+, according to the DHS.[61] The 2005 estimate from WHO/UNICEF, however, is 19% of children under 5.[60] Also in 2005, WHO/UNICEF estimated 66% of children under five had received at least one dose of Vitamin A (VAD1).[62] These data are summarized in Table 6.

Family Health Ministries

Family Health Ministries (FHM), Inc., is a 501(c)3 nongovernmental organization founded in 1993 and incorporated in 2000.[63] The organization has worked in Haiti since its outset in 1993, primarily in the communities of Leogane, Fondwa, and the Terre Noir neighborhood in Port-au-Prince (Figure 2). Primary focuses of the organization are women's and children's health and education. Outreach of the organization includes nutrition programs, cervical cancer prevention, child school sponsorship, and orphanage funding and maintenance.

Beginning in 2000, FHM began a nutritional supplementation program at the Sainte Antoine School in the Fondwa region. Fondwa is a rural watershed of approximately 6000 people located 2.5 hours south of Port-au-Prince in the Chaine de la Selle mountain range. The supplementation program initially consisted of multivitamin supplementation daily for all students. This program expanded to add a once-daily meal at the Sainte Antoine School in 2004 through partnership with Food For the Poor, Inc. Food For the Poor support throughout Haiti has decreased in the wake of the political unrest, and the nutrition program was stopped in the fall of 2006. It currently is restarting with full funding from FHM beginning with the 2007 school year.

Along with the nutrition program, students from Duke University have made annual anthropometric measurements of height and weight of children at Sainte Antoine School since 2003. This data, in part, has been analyzed by FHM but is awaiting update of this year's data. Partial analysis shows an increase in wasting during the height of the political instability in 2005 (unpublished data).

Background on Terre Noir community

The Terre Noir neighborhood in Port-au-Prince, Haiti, is just north of Toussaint L'Ouverture International airport and approximately 1.3 miles from the notorious Cite Soleil slum (Figure 3). The area has traditionally been a lightly settled area comprised mainly of textile factories and sugarcane fields owned by the Rhum Barbancourt Company. Beginning with the political unrest of the early 2000s, however, people began migrating from the Cite Soleil slum into the area. At some point, the Rhum Barbancourt Company either donated the land to the Haitian state for development or simply allowed the settlers to remain in their new dwellings.

Settlement of the area has been rapid and is ongoing. Estimates of the population from stakeholders working in the neighborhood are as high as 100,000 (personal communication, Pastor Leon D'Orleans). Much of the new housing construction is concrete blocks. The neighborhood is considered by FHM to be wealthy relative to Cite Soleil and other slums within the capital.

FHM began providing medical care teams in the neighboring Cite Soleil slum in partnership with a church and school run by Pastor Leon D'Orleans in the late 1990s. Because of the increased violence after the departure of President Aristide, FHM representatives were unable to return to Cite Soleil from early 2004 until the summer of 2007. MINUSTAH, the current UN mission in Haiti, has conducted several raids in the slum,[64-66] but, even today, groups of foreigners largely are prevented from entering the neighborhood.

Due to the impossibility of working within the Cite Soleil slum, Pastor D'Orleans asked FHM to begin conducting clinics in the Terre Noir neighborhood in the early 2000s. Upon consultation with its Board, FHM decided to become more involved in the Terre Noir community and to build a clinic at another church and school site run by Pastor D'Orleans. The foundation hired two public health workers in 2004, who began collecting demographic data and GPS information on residents of the neighborhood in early 2005, as well as point data on sites of interest, such as wells and schools, within the neighborhood. To date, they have visited over 2200 houses.

The clinic finished construction in late 2006 and opened in December of that year with a complete Haitian staff consisting of a physician, nurse, and three office workers. Expectations were for the clinic to reach full capacity in approximately six months' time, but the clinic immediately began seeing more than 600 patients a month. Additionally, the clinic was able to begin distributing vaccinations almost immediately, despite usual administrative difficulties in accessing free government vaccines (personal communication, Dr. Yves).

Research Questions and Hypotheses

FHM is interested in determining the current state of health of children within the Terre Noir neighborhood in order to guide clinic and public health outreach priorities. Possibilities for programs determined in conversation with Pastor D'Orleans and Dr. Yves include nutritional supplementation programs similar to those the organization has managed in the Fondwa region and/or vaccination campaigns throughout the neighborhood. In order to determine whether these initiatives would best use of limited resources, baseline data on child nutrition and vaccination in the Terre Noir community is needed.

The following research questions are to be answered by this study:

1) How are children in Terre Noir growing relative to other Haitian children, urban Haitian children, rural Haitian children in areas such as Fondwa, and the WHO international growth standard?

H_1) Children in Terre Noir are growing comparably to other Haitian urban children and better than their rural counterparts.

2) What is the prevalence of documented vaccination within the Terre Noir neighborhood and how does this compare to other Haitian children?

H_2) Children with a documented vaccination history will be vaccinated at rates similar to those of other Haitian children.

METHODS

Data Collection

In order to sample children in the Terre Noir neighborhood for determination of nutritional anthropometric parameters and vaccination history, random GPS points were generated within the neighborhood perimeter using the Create Random Raster function in ArcGIS. Houses nearest 26 of these points with children under the age of 19 present on the date of data collection, with an adult to give consent, were sampled. After consent had been given and the necessary responses had been obtained from each member of a household, researchers proceeded to the next nearest house in an iterative manner. One point was used for each date of data collection. Data collection occurred over an eight-week period from May-July 2007.

The sex, birth date, and vaccination history were recorded by Haitian public health workers employed by FHM. Birth date was obtained from birth certificate, when available. In cases where children did not have a birth certificate available, birth date was obtained orally from either the child or another family member and corroborated by other family members when possible. All children were assessed for presence or absence of BCG scar. Vaccination history for children of all ages was obtained from vaccination cards given to parents or children at the time of vaccination. Oral vaccination histories were not recorded.

Measurements for childrens' heights/lengths, weights, head circumferences, and hemoglobin concentrations were obtained. Recumbent length was assessed without shoes, to the nearest 0.1 cm, for children unable to stand volitionally using a handheld measuring tape. Height was assessed without shoes, to the nearest 0.1 cm, for children who could stand independently using a portable stadiometer (Leicester height measure, Invicta Plastics Ltd, Oadby, UK). Children ages 12-23 months were measured recumbently if they could not stand.

Weight was assessed without shoes, to the nearest 0.1 kg, for children unable to stand on an infant digital scale (Brand Name and Model Number Here #1234). Weight was assessed without shoes, to the nearest 0.1 kg, for children who could stand volitionally using a Sunbeam Digital Lithium Scale (Health O Meter, Model # HDL200-05, Sunbeam Products, Boca Raton, FL, USA).

Hemoglobin concentrations, to the nearest 0.1 g/dL, were obtained from blood obtained from a finger stick using a HemoCue photometer (HemoCue Plasma/Low Hb, Hemocue AB, Lake Forest, CA, USA). The machine was calibrated daily according to the manufacturer's protocol.

Statistical Analyses

Children for whom no birth date or age information was given were excluded from the analysis. Children for whom age was known but not date of birth were given dates of birth corresponding to the date of data collection minus the child's age in years. Thus, children measured on 5/14/07 and reported to be four years of age would be given a date of birth of 5/14/03. This was done to reduce the likelihood that children's ages would be overestimated. Z-scores for length/height, weight, and BMI were generated for the WHO Child Growth Standards using WHO Anthro 2005.[67]

The numbers of stunted, underweight, obese, and wasted children under the WHO Child Growth Standards were calculated both including and excluding children for whom age was known but birth date was not given for children below five years of age. Analyses were performed both with and without children ages 12-23 months. Tests of association of each growth outcome with sex were performed using Fisher's exact tests in SAS v. 9.1[68]. Means of z-scores by age category for each parameter under the WHO Child Growth Standards were compared both including and excluding children for whom age was known but birth date was not given using Stata v. 9.1.[69]

The means of hemoglobin concentrations were calculated and compared by sex and age category using Student's t-tests in Stata v. 9.1.[69] Tests of association of levels of anemia with sex were performed by age category using Fisher's exact tests in Stata v. 9.1.[69] Rates of vaccination by age were calculated using Microsoft Excel 2003[70]. Statistical significance was considered to be the 0.05 level.

This research was approved by Duke University Health System IRB (Pro00000638), the UNC-CH IRB (Study #07-1410) and an Ethics Review Board in Haiti.

RESULTS

Anthropometric Results

Over the eight-week period, 437 children in the Terre Noir community had at least one anthropometric measurement. Of these 437 children, 177 were under the age of 5 years. Birth dates were given for 329 children, including 157 who were under five. Neither birth date nor age was known for nine children. These nine children were excluded from all anthropometric analyses. These data are summarized for all children and children under five in Table 7 and Figure 4. WHO Anthro 2005 excludes children with a z-score for any anthropometric measure <5 SD below the mean from that analysis, assuming these children were incorrectly measured.

Children Under Five with Birth Dates

Three children with z-scores <5 SD below the mean were excluded from the analyses of underweight and stunting. Seven children with z-scores <5 SD below the mean were excluded from the analyses of wasting and BMI-for-age. Twenty-eight of 154 children (18.2%) were underweight (z-score <2 SD below mean for weight-for-age), with a mean z-score of -0.84 (SD 1.46). Additionally, 44 children (28.4%) were stunted (z-score <2 SD below mean for height-for-age), with a mean z-score of -1.0 (SD 1.73).

Twenty-one of 150 children (14.0%) were wasted (z-score <2 SD below mean for weight-for-height). Four children (2.7%) were overweight (z-score >2 SD above mean for weight-for-height). The mean z-score for weight-for-height was -0.35 (SD 1.45). Eighteen of 150 children (12.0%) had a BMI-for-age <2 SD below the mean and five children (3.3%) were obese (BMI-for-age >2 SD above the mean). The mean z-score for BMI-for-age was -0.28 (SD 1.41). These results are summarized in Table 8.

These results are shown by age category and sex in Tables 9-11. Only one infant under six months was found to be underweight, whereas eight infants between 6-11 months of age were underweight. The percentage of children who were underweight dropped during the second year of life (months 12-23), only to rise again to similar levels >20% for children ages two, three, and four. Males were significantly less likely than females to be underweight ($p<0.05$).

The overall prevalence of stunting increased across all ages. Wasting peaked in the 6-11 month old children, with eight children (29.6%). This was approximately twice the rate seen in three and four year olds. There was no statistically significant difference in prevalence of stunting or wasting by sex. Analysis of low-BMI-for-age suggested a higher rate in females, but this was not statistically significant ($p=0.08$).

Only four children were overweight in the sample, and none were overweight at greater than two years of age. There was no statistically significant difference between sexes in prevalence of overweight or obesity. Results for each anthropometric index by sex are shown in Table 12.

Children Aged 12-23 Months with Birth Date

Children between ages 12-23 months were measured for height if they could stand volitionally. Standard measurements, however, call for children to be measured recumbently. Children measured recumbently will have higher recorded lengths than children measured upright. This will lead to overestimates of stunting and underestimates of wasting in this age group. Thus, the analyses height/length-for-age, weight-for-height, and BMI-for-age of children under five were repeated excluding children aged 12-23 months.

Recalculated rates of stunting, wasting, and obesity excluding children aged 12-23 months are shown in Table 8, alongside those for all children under five. There was no statistically significant difference in the prevalence of stunting or wasting with the removal of these children from the analysis (p-values >0.50 for all).

Children Under Five with Given Age

Results for the analysis under the WHO Child Growth Standards with the addition of children under five years of age for whom an age was given but birth date was unknown (n=20) are shown in Table 13. These children were coded such that they turned the age given on the date of data collection. None of the differences in prevalences in anthropometric measures between children given birth dates and children given either birth dates or age were statistically significant (p-values >0.20 for all).

Two of the children for whom only age was given were between the ages of 12-23 months (both said to be one year of age). Recalculation of overall percentages of stunting, wasting, and obesity without children ages 12-23 months are shown in Table 14 alongside those children with given birth date. None of the differences in prevalences in anthropometric measures between children given birth dates and children given either birth dates or age were statistically significant (p-values >0.30 for all).

With the additional 20 children, differences in prevalences of anthropometric indicators by sex were calculated. The association between sex and underweight with the added children was statistically significant ($p<0.05$). All other differences by sex were not statistically significant. These results are summarized in Table 14. Table 15 shows comparisons of Terre

Noir children for whom a birth date was given to the 2005 DHS data for Haiti as a whole, the Aire Metropolitaine (Port-au-Prince), and rural Haiti.

Hemoglobin Analysis

Hemoglobin measurements were made on 329 children (179 females, 151 males). Of these 329 children, 137 had a given birth date or age under five (65 female, 72 male) and nine had neither a known birth date nor age (six female, three male). Thirty-four children were ages 15 and older, including 10 males and 24 females.

Mean hemoglobin concentrations were similar by sex for all children, children under five, and children five and older. The mean hemoglobin concentration for children ages fifteen and older was statistically different by sex, however, with males having higher mean concentrations (120 g/L for males vs. 104 g/L for females, $p<0.05$). This information on mean hemoglobin concentration and mean hemoglobin concentration by sex for different age groups is summarized in Table 16.

Overall, 212 of the 321 children for whom an age or birth date was given (66.0%) were anemic with hemoglobin concentrations under 110 g/L, and 11 of the 321 children were severely anemic (3.4%) with hemoglobin concentrations under 70 g/L. Of the 212 children with hemoglobin concentrations under 110 g/L, 110 were female and 102 were male. Of the 11 children with hemoglobin concentrations under 70 g/L, six were female and five were male (3.5% of females and 3.4% of males). The differences in the prevalences of degrees of anemia by sex for all children, children under five, and children fifteen and older were not statistically significant. These results were suggestive for differences in rates anemia between sexes for children under five and children over fifteen, however ($p=0.07$ and 0.08, respectively). These data are summarized in Tables 17 and 18.

Children under the age of five years were separated into age categories for further hemoglobin analysis. Rates of anemia were similar in children 6-11 months, 12-23 months, and 24-35 months of age. Rates in children 36-47 and 48-59 months of age declined relative to these younger children. Severe anemia was found only in children ages 6-11 or 12-23 months of age. No child greater than 23 months of age was severely anemic. The anemia results for children under five years of age are summarized and compared to DHS data from 2005 in Table 19. Results for females fifteen years of age and older are compared to DHS data from 2005 in Table 20.

Vaccination Record Analysis

Two hundred seventy-five of the 437 children (62.9%) had received vaccinations at some point evidenced either by vaccine record or BCG scar. Of these 275 children, 117 (63 females and 54 males representing 26.8% of all children) had a vaccination record document that was presented to the researchers.

Of the 117 children with vaccination records, only four did not have a given birth date. One of these children was said to be less than one year of age, one was given a birth month that would have made him 34 months of age, one was said to be six years of age, and no age was given for the fourth. Overall, only 22 of the 116 children with vaccination records for whom an age was given were ages five and older (19.0%), and the mean age of those with vaccination records and given birth date was 42.6 months (median age 27.5 months).

Results for specific vaccinations in children above the recommended age are shown in Table 21 and against the Haitian Immunization Guidelines in Table 22. The tables do not reflect one child who had received four doses of HBV3, two doses of typhoid vaccine boosters, two doses of hepatitis A vaccine, two doses of rubella vaccine, and a *Varicella* vaccine. No other child had received the above vaccinations.

Children under the age of two were also analyzed for vaccination rates as a group and for groups aged 0-11 months and 12-23 months for comparison to DHS data. Children without vaccination records were considered un-immunized in order to generate a minimum vaccination prevalence in the community. Fifty of eighty-six children (58.1%) under the age of two had vaccination cards. Seventy children under two years of age (96.0% of those with vaccine records and 81.4% of all children under two) had received BCG vaccine. Forty-eight children (96.0% of those with vaccine records and 55.8% of all children under two) also had received at least one dose of DTP (DTP1), and 26 (52.0% of those with vaccine records and 30.2% of all children under two) had received three doses (DTP3). Twenty-five children (50% of those with vaccine records and 29.1% of all children under two) had received three doses of polio vaccine (Pol3). Thirty-seven children (74.0% of those with vaccine records and 43.0% of all children under two) had received a measles-containing vaccine (MCV).

These children were further separated into two age categories. Overall, 26 of 44 children ages 0-11 months (59.0%) presented vaccination cards to the researchers. Twenty-four of 42 children ages 12-23 months (57.1%) presented vaccination cards to the researchers. Results for these age categories are shown alongside DHS data in Table 23.

Overall, 13 children (11.1% of children with vaccination records and 3.0% of all children) were up-to-date on all vaccinations aside from supplemental vitamin A, per the Haitian

Immunization Guidelines. Nine of these 13 children had also received the appropriate number of vitamin A doses for their age. Sixty children (51.2% of those with vaccination records and 13.7% of all children) had received all the vaccines enquired about during the most recent DHS in 2005.

In order to determine if children with vaccination records were growing differently from children without vaccination records, anthropometric calculations were compared for children with and without vaccination records. Anthropometric results for all children with vaccination records and the children under five years who had received all DHS studied vaccines are compared to children without vaccination records in Table 24. There were no differences between those with vaccination records and those without vaccination records or between those receiving full UNICEF vaccination and those without vaccination records for any anthropometric measure (p-values >0.30 for all).

DISCUSSION

In general, children in the Terre Noir community are growing less well than their counterparts in the rest of Port-au-Prince. The percentages of children who are underweight, stunted, and/or wasted are higher in the Terre Noir community than the 2005 DHS samples of Port-au-Prince. This is not surprising, as many of the residents of Terre Noir are believed to have moved from the neighboring Cite Soleil slum over the past few years. Residents of Terre Noir are presumed to be than wealthier residents of the Cite Soleil slum but less wealthy than residents of much of the rest of the city or the elite communities in the hills above Port-au-Prince.

The prevalences of underweight, stunting, and wasting in Terre Noir more closely approximate the rural estimates for Haiti from the 2005 DHS samples. When considering children for whom birth date was given, a lower percentage of children in Terre Noir are underweight, a similar percentage is stunted and a higher percentage is wasted. When considering children for whom either an age or a birth date was given, the results are similar, though the percentage of stunted children decreases.

The similarity of growth of residents of Terre Noir to that of the rural Haitian population is surprising. It has been assumed by FHM that residents of Terre Noir are wealthier than the majority of rural Haitians. Many of the residents of Terre Noir have houses made predominantly of concrete, a construction material too expensive for residents in many rural areas. This assumption may be untrue, however, and these more expensive materials may be relatively cheaper and/or more accessible within the capital than wood or metal. Alternatively, persons within Terre Noir may be choosing a more expensive building material for other personal reasons, such as desirability or prestige.

The increased wasting seen within the Terre Noir community compared to both Port-au-Prince and rural Haitians is also interesting. FHM has noticed an increase in wasted school-age children in the rural area of Fondwa (David Walmer, personal communication). This trend appears to be national, as the 2005 DHS data showed an increase of wasting from the 2000 survey.[50] FHM believes this increase in Fondwa is attributable to an increasing number of people fleeing to rural areas from the urban centers during the political unrest and a general lower availability of food.

In Terre Noir, the higher prevalence of wasting may be attributable to persons now returning to Port-au-Prince. This could alleviate some of the increased food demands in rural areas but increase or concentrate the numbers of wasted individuals within urban communities. If these persons are now entering the Terre Noir neighborhood for the first time, they may be disadvantaged by not being fully integrated into social support networks. Additionally, they may not know of existing health care or nutritional programs and thus not be able to benefit from community resources. This may lead to increased stress and poorer nutritional outcomes.

Alternatively, people in Terre Noir might have been unable to leave the area during the height of the unrest. The neighboring Cite Soleil slum was the center of much of the violence, and transportation into and out of the neighboring communities might have decreased. If residents of Terre Noir were unable to leave the neighborhood, these individuals might have been unable to access foods available in rural areas or wealthy areas of Port-au-Prince due to disrupted supply chains or increased unemployment and lack of funds. This study found a cross-sectional estimate of wasting higher than that of other areas in Haiti; however, it cannot show whether wasting is increasing or decreasing in the area.

Comparing Terre Noir to the entire city of Port-Au-Prince may not be an appropriate comparison group due to its size and heterogeneity, but there are difficulties in selecting a specific department (Haitian equivalent of state) from the 2005 DHS data for direct comparison. The range of the prevalences of underweight, stunted, and wasted children in the 2005 DHS varies widely by department. In that study, the prevalence of stunting ranged from 16.2% to 37.3% across departments, that of underweight from 5.1% to 18.0%, and that of wasting from 14.2% to 31.7%.[50] In general, the Ouest department (which encompasses Port-au-Prince but does not include it for the survey) is lowest for each category, with no discernible pattern for the remaining departments. The population of Port-au-Prince and its slums comes from throughout the country; thus, no specific department can be chosen to serve as an adequate reference population.

This study found a significant difference between the sexes in prevalence of underweight children. In this study, males were less likely to be underweight than females. This contradicts the 2005 DHS, where males had higher prevalences of underweight, stunting, and wasting than females.[50]

One possible reason for increased female prevalence of underweight in children under five in Terre Noir is preferential feeding of male children. Male children in this age category, however, had a higher prevalence of anemia than female children. This increased anemia may be explained, in part, by male children's larger body sizes and increased iron needs. While it is possible male children receive more caloric intake than females but less vitamin and mineral nutrition, the differential sharing of different foods by sex in Terre Noir seems unlikely. Feeding and eating patterns of children in Terre Noir should be explored to detect differential nutritional intake by sex.

When compared to the 2005 DHS data, children under five years of age in Terre Noir across all age categories were more likely to be anemic. The data in Terre Noir showed a peak prevalence in children aged 24-35 months, whereas the DHS data had a peak at 12-23 months. Overall, these data indicate poorer vitamin and mineral intake within the Terre Noir community than Haiti as a whole.

These results are confirmed by comparison to regional DHS data, which shows children under five in urban areas are more likely to be anemic (66.9% in all urban areas vs. 57.5% in rural areas in 2005). Children in Terre Noir, however, exhibited prevalences higher than in the combined urban areas or Port-au-Prince (79.1% vs. 67.1% in Port-au-Prince). This might be further indication that children in Terre Noir are poorer than anticipated and receive less dietary variety than their rural counterparts. Alternatively, it might represent increased parasite burden leading to anemia in children in Terre Noir relative to other areas within the country.

A study of intestinal helminths in 1996 in Leogane, Haiti, found 54.7% of children had one or more of *Ascaris*, *Trichuris*, or hookworm.[71] Additionally, the study found children with hookworm were 7.6 times more likely to have *Trichuris* infections. Higher rates of hookworm infection or elevated parasite burden in Terre Noir could explain the increased rate of anemia in this neighborhood compared to other areas of Haiti.

Not surprisingly, males in Terre Noir over age 15 years are less likely to be anemic than females. Females in Terre Noir above age 15 have much higher prevalences of anemia than all women in the 2005 DHS and those women in Port-au-Prince (51.7% <120 g/L age 15-49 in Port-au-Prince in 2005 DHS vs. 84.0% in Terre Noir). Again, this is most likely attributable to decreased nutritional intake among women in Terre Noir compared to the rest of the country.

Vaccination rates in the Terre Noir community amongst children with vaccination cards are lower than that in the DHS surveys, with the exception of the BCG vaccine. Terre Noir data are not directly comparable to the DHS data, as this study only used vaccination cards and DHS uses oral histories and shot cards. Approximately 25% of children in the 2005 DHS survey had only oral histories of received vaccinations, and it is unclear how the DHS survey handles these children. As a result, DHS data on vaccination rates may be overestimated if parents over-report vaccinations. In fact, the DHS estimates are much higher than either the Haitian government's official estimates or those reported from doses actually administered within the country.[61] If it is assumed all children without vaccination cards in Terre Noir are un-immunized, a minimum estimate of vaccination rates in the community can be determined.

The Terre Noir data, even at its most optimistic (extrapolating vaccination rates from children who have vaccine records to the entire community), shows a significant need for increased vaccination follow-up. At least 62.9% of children had received BCG vaccine. Only approximately one-quarter of children had vaccination cards available, and those that did had significant declines in the percentages who had received the vaccinations recommended for older ages.

In Haiti, some parents keep important records, such as these vaccination cards or birth certificates, at school once children begin their education (Millicent Owen, personal communication). As a result, vaccination in older children may be underestimated. Children under five years of age are therefore the most likely to have vaccination records available for presentation to the researchers. Only 53% of these children did have them available for presentation, however. Although only one child with a vaccination record had not received any vaccinations, only nine had received all the recommended vaccinations for their age. Furthermore, three of these nine children were under four months of age.

Children have been receiving some vaccinations prior to the opening of the Terre Noir clinic. Vaccinations must have been available to families in the neighborhood during and in the aftermath of the recent unrest, as ~40%+ of children ages 12-23 months have received each of the vaccinations tracked by WHO/UNICEF. As much of this unrest was in the neighboring slum of Cite Soleil, the rates of vaccination in Terre Noir were higher than anticipated by FHM. The close proximity of this new clinic to children in the neighborhood may improve vaccination follow-up.

Children under five with vaccination records were not growing differently than children under five without vaccination records in the community. Children who have vaccination records may have greater resources and/or more access to health care, but it does not appear they have markedly improved health outcomes. Vaccination records often supplied birth dates for children, however, and thus children without vaccination records may have had their ages underestimated. This would lead to underestimates of anthropometric outcomes in children without vaccination records.

Alternatively, children currently living in Terre Noir may have had similar access to resources and health care and may have been vaccinated at similar rates, though not every child has a record. Given the turmoil of the recent past and the influx of families into Terre Noir, it is possible many vaccination records have been lost. As children without vaccination records are growing similarly to children with vaccination records, targeted nutritional interventions based on past vaccination history is impossible.

Limitations and Strengths

This study had several limitations. First, it relied almost entirely upon reported birth dates and ages for children within the sample. Only thirteen children had birth certificates that were shown to the researchers. While many older children might have birth certificates kept at their schools, the lack of birth certificates in younger children suggests the majority of children of all ages do not have the records. This may indicate that the majority of children are born at home or with only midwife support.

If children are born outside of hospitals and parents have little record of actual birth date, the ages reported in this study may be subject to question. Many families in Haiti consider the birth date of their children to be on the date of christening, and this can occur either days or weeks after the actual birth date (Millicent Owen, personal communication). As a result, children's ages reported in this study are more likely to be underestimates rather than overestimates of actual age. If children's ages are likely to have been underestimated during this study, estimates of underweight, stunting, and wasting also would be underestimated. This potential underestimation may mask a true difference in growth between those with and without vaccination records.

Second, children with reported ages or birth dates between 12-23 months were measured for height or length based on whether or not they could stand. These children were not marked as measured either standing or recumbently. This error prevented interpretation of stunting or wasting information in this age group because height/length corrections could not be applied to the data. It is possible many of these children were older than two years of age due to age misclassification, but this could not be ascertained definitively. The use of standing measures for these children leads to systematic undermeasurement of height, which would lead to an overestimate of stunting and underestimate of wasting. Removal of the children aged 12-23 months did not lead to any statistically significant changes in the results.

Third, this study only analyzed vaccination data from children with vaccination records. Given the number of children who had received BCG evident by scar but did not have a vaccination record, the percentages of children receiving vaccines may be underestimated. In particular, the prevalence of received vaccines given early in life alongside BCG, such as DTP1 or Pol1, might be significantly underestimated. Additionally, the estimates of vaccination in older children may be artificially low if these children keep vaccination records at school. It is unclear how reliable oral reports for each vaccination might have been, however, so FHM chose to make a minimum estimate of vaccination within the community.

Fourth, this study researched children present at home on the date of data collection. Families present at home may have been poorer or less healthy than other families that were not present on the date their area of Terre Noir was visited. Children whose families have market stalls or other employment may accompany parents to the place of work during the day. Thus, researchers may have sampled a non-representative population for the community, resulting in an overestimation of rates of stunting, wasting, and underweight.

The GPS random sampling for the study is a strength. Prior to the initiation of the GPS sampling, the public health workers had been surveying families linearly along roads in the community and returning daily to the same areas. With the GPS sampling, this and future study instruments will be able to be implemented in a random manner and achieve representative geographic sampling much more quickly and efficiently.

A major strength from the foundation's standpoint has been the ability to increase awareness of the new clinic within the community. Many individuals were not aware of its opening and the public health workers have now had the opportunity to inform them about the clinic and its services. The poor vaccination follow-up in Terre Noir, in particular, might be improved with increased awareness of vaccination availability at the clinic.

Additionally, the foundation has ceased hemoglobin sampling. This decision was reached because the majority of the residents of Terre Noir are anemic and each of the Hemocue microcuvettes costs $1 US. As an alternative, public health workers now distribute albendazole doses to reduce possible helminth infections and a one month supply of multivitamins to each child in the surveyed households.

Future Directions

Family Health Ministries has begun integrating the nutrition survey with its general demographic survey using the GPS sampling. This will enable the foundation to correlate growth with housing ownership status, construction materials, and family size throughout the community. Future studies will be able to study diseases of interest in the community, such as diarrheal illnesses. Additionally, the foundation hopes to integrate illness and demographic data spatially with clinic health records using a GIS database to gain greater insight into the health of residents of Terre Noir.

Figure 1. Map of Haiti[72]

Table 1. Prevalence of Underweight, Stunted, and Wasted Haitian Children Under 5 y/o by 1978 NCHS Reference, in Percents*

Condition	1978	1990	1994-5	2000
Underweight	37.4	26.8	27.5	17.2
Stunted	39.6	33.9	31.9	22.7
Wasted	8.9	4.7	7.8	4.5

*From WHO Global Database on Child Growth and Malnutrition

Table 2. Prevalence of Underweight, Stunted, Wasted, Overweight, and Obese Haitian Children Under 5 y/o by WHO Child Growth Standard, in Percents

Condition	1994-5*	2000*	2005†	2005†♦
Underweight	24	13.9	22.2	10.2
Stunted	37.2	28.3	23.8	12.5
Wasted	9.4	5.6	9.1	4.9
Overweight	4.3	3.1	-	-
Obese	5.5	3.9	-	-

*From WHO Global Database on Child Growth and Malnutrition

†From 2005 DHS Survey. Data on overweight and obese children not available.

♦For Aire Metropolitaine (Port-au-Prince).

Table 3. Prevalence of Anemia and Severe Anemia in Haitian Children Under 5 y/o*

Condition	2000	2005
Anemic (<110 g/L)	65.3	60.7
Severely Anemic (<70 g/L)	1.6	2.3

*From DHS data

Table 4. Prevalence of Anemia in Haitian Children Under 5 y/o, by Age Category*

Age Category	2000	2005
6-11 mos	82.1	73.8
12-23 mos	80.0	75.3
24-35 mos	63.6	61.6
36-47 mos	60.3	51.1
48-59 mos	48.3	46.9

*From DHS data

Table 5. Haitian Immunization Schedule

Vaccination	1st	2nd	3rd	4th	5th	6th
BCG	Birth					
DTP	6 wks	10 wks	14 wks	66 wks		
OPV (polio)	<15 days	6 wks	10 wks	14 wks	66 wks	Unspecified
MCV	9 mos					
TT2+	180 mos	181 mos	193 mos	205 mos	217 mos	
VAD1	6 mos	10 mos	14 mos			

Table 6. Vaccination Rates by Vaccine Type for Haitian Children 12-23 months of age, in Percents*

Vaccination	1994-5	2000	2005
BCG	73	71	75
DTP1	75	76	83
DTP3	41	43	53
Pol3	41	43	52
MCV	48	54	58

*From DHS data

Figure 2. Map of FHM Projects in Haiti.
Sites of FHM projects in green.

Figure 3. Terre Noir Neighborhood in Port-au-Prince, Haiti.
Neighborhood outlined in white.
Image Source: Digital Globe, 2007. Europa Technologies, 2007. Accessed using Google Earth.

Table 7. Children in Terre Noir Study

Category	Total	Under 5 y/o
Number	437	177
Number Female	235	89
Number with known Age	428	177
Number with known Birth Date	319	157
Number Female, known Birth Date	168	83

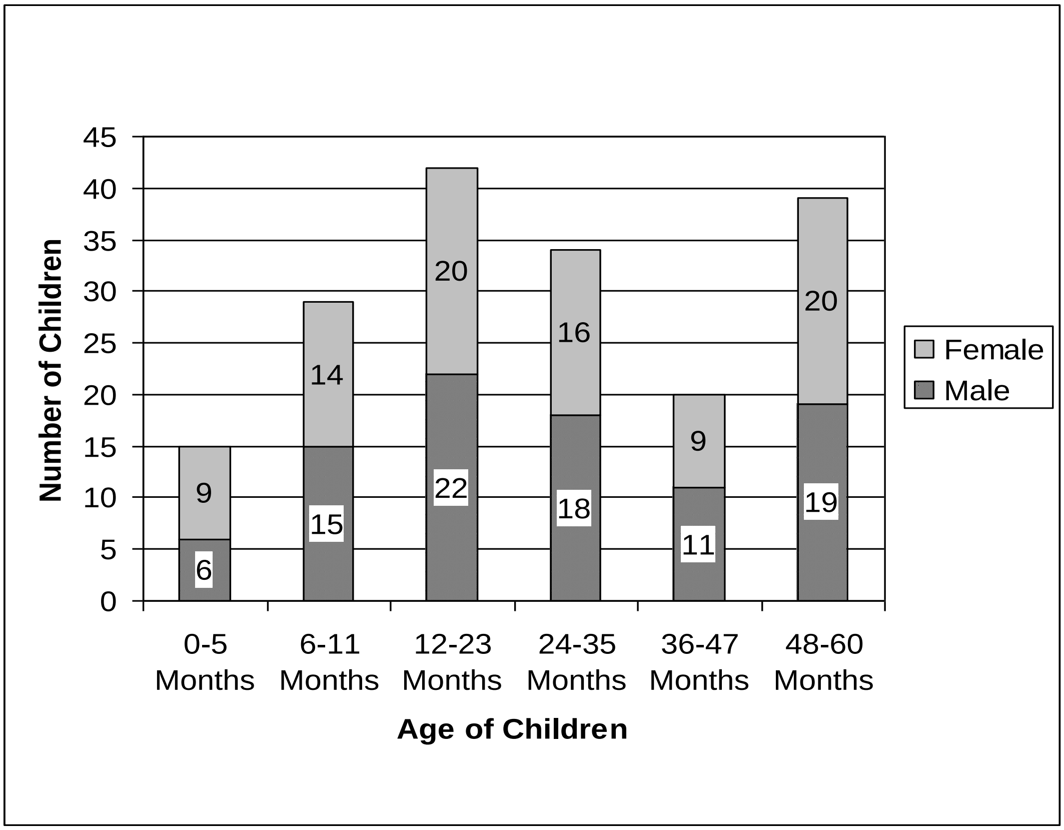

Figure 4. Age and Sex Distribution of Children in Terre Noir Study

Table 8. Percent Underweight, Stunted, Wasted, and Obese In Children With Given Birth Dates

Measure	% Children Under 5 Affected§	% Children, Excluding 12-23 months±
Underweight*	18.2	-
Stunted	28.4	28.1
Wasted	14.0	16.4
Obese	3.3	2.7

§Percentages are calculated from the 157 children under 5 with given birth dates

±Percentages are calculated from the 115 children ages 0-11 months or 24-60 months of age with given birth dates

*Underweight percentages were not recalculated as they are not dependent on height/length measurements

Table 9. Anthropometric Measures By Age Category In Children With Given Birth Dates

Age Category	Percent Underweight (Number)	Percent Stunted (Number)	Percent Wasted (Number)	Percent Overweight (Number)	Percent Low BMI (Number)	Percent Obese (Number)
Total:	18.2 (28)	28.4 (44)	14.0 (21)	2.7 (4)	12.0 (18)	3.3 (5)
0-5 mos	6.3 (1)	18.8 (3)	13.3 (2)	13.3 (2)	6.7 (1)	6.7 (1)
6-11 mos	28.6 (8)	25.0 (7)	29.6 (8)	3.7 (1)	29.6 (8)	3.7 (1)
12-23 mos	7.5 (3)	29.3 (12)	7.5 (3)	2.5 (1)	7.5 (3)	7.5 (3)
24-35 mos	23.5 (8)	29.4 (10)	9.1 (3)	0.0 (0)	6.1 (2)	0.0 (0)
36-47 mos	21.4 (3)	33.3 (5)	14.3 (2)	0.0 (0)	7.1 (1)	0.0 (0)
48-60 mos	22.7 (5)	33.3 (7)	14.3 (3)	0.0 (0)	14.3 (3)	0.0 (0)

Table 10. Anthropometric Measures By Age Category In Males With Given Birth Dates

Age Category	Percent Underweight (Number)	Percent Stunted (Number)	Percent Wasted (Number)	Percent Overweight (Number)	Percent Low BMI (Number)	Percent Obese (Number)
Total:	11 (8)	31.5 (23)	9.9 (7)	1.4 (1)	7.0 (5)	4.2 (3)
0-5 mos	14.3 (1)	14.3 (1)	16.7 (1)	0.0 (0)	0.0 (0)	0.0 (0)
6-11 mos	13.3 (2)	21.4 (3)	26.7 (4)	6.7 (1)	26.7 (4)	6.7 (1)
12-23 mos	0.0 (0)	36.4 (8)	0.0 (0)	0.0 (0)	0.0 (0)	9.5 (2)
24-35 mos	11.8 (2)	35.3 (6)	5.9 (1)	0.0 (0)	0.0 (0)	0.0 (0)
36-47 mos	0.0 (0)	28.6 (2)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)
48-60 mos	42.9 (3)	50.0 (6)	16.7 (1)	0.0 (0)	16.7 (1)	0.0 (0)

Table 11. Anthropometric Measures By Age Category In Females With Given Birth Dates

Age Category	Percent Underweight (Number)	Percent Stunted (Number)	Percent Wasted (Number)	Percent Overweight (Number)	Percent Low BMI (Number)	Percent Obese (Number)
Total:	24.7 (20)	25.6 (21)	17.7 (14)	3.8 (3)	16.5 (13)	2.5 (2)
0-5 mos	0.0 (0)	22.2 (2)	11.1 (1)	22.2 (2)	11.1 (1)	11.1 (1)
6-11 mos	46.2 (6)	28.6 (4)	33.3 (4)	0.0 (0)	33.3 (4)	0.0 (0)
12-23 mos	15.8 (3)	21.1 (4)	15.8 (3)	5.3 (1)	15.8 (3)	5.3 (1)
24-35 mos	35.3 (6)	23.5 (4)	12.5 (2)	0.0 (0)	12.5 (2)	0.0 (0)
36-47 mos	37.5 (3)	37.5 (3)	25.0 (2)	0.0 (0)	12.5 (1)	0.0 (0)
48-60 mos	13.3 (2)	26.7 (4)	13.3 (2)	0.0 (0)	13.3 (2)	0.0 (0)

Table 12. Comparison of Anthropometric Measures By Sex, In Children With Given Birth Dates

Condition	Number Male (%)	Number Female (%)	p-value*
Underweight	8 (11.0)	20 (24.7)	0.04
Stunting	23 (31.5)	21 (25.6)	0.48
Wasting	7 (9.9)	14 (17.7)	0.24
Overweight	1 (1.4)	3 (3.8)	0.62
Low BMI	5 (7.0)	13 (16.5)	0.08
Obese	3 (4.2)	2 (2.5)	0.67

*two-sided p-values using Fisher's exact test

Table 13. Anthropometric Measures In Children With Given Birth Date & Given Age

Measure	% Affected, Given Birth Date§	% Affected, Given Age§	% Affected, Excluding 12-23 Month Olds, Given Birth Date±	% Affected, Excluding 12-23 Month Olds, Given Age±
Underweight*	18.2	17.2	-	-
Stunted	28.4	25.7	28.1	24.2
Wasted	14.0	14.1	16.4	16.4
Obese	3.3	3.5	2.7	1.4

§Percentages are calculated from the 177 children under 5 with given birth dates or ages

±Percentages are calculated from the 133 children ages 0-11 months or 24-60 months of age with given birth dates or ages

*Underweight percentages were not recalculated as they are not dependent on height/length measurements

Table 14. Anthropometric Measures By Sex In Children With Given Age

Condition	Male	Female	p-value*
Underweight	9 (10.4)	21 (23.9)	0.03
Stunting	24 (27.9)	21 (23.6)	0.60
Wasting	7 (9.9)	14 (17.7)	0.27
Overweight	1 (1.4)	3 (3.8)	1.00
Low BMI	5 (7.0)	13 (16.5)	0.09
Obese	3 (4.2)	2 (2.5)	0.44

*two-sided p-values using Fisher's exact test

Table 15. Percentages of Underweight, Stunted, Wasted, or Obese Children Under 5 by Given Birth Date in Terre Noir, Compared to DHS Data

Condition	2005, Total	2005, A. M.*	2005, Rural	Terre Noir	Terre Noir, Excluding 12-23 months
Underweight	22.2	10.2	25.5	18.2	18.2
Stunted	23.8	12.5	28.1	28.4	28.1
Wasted	9.1	4.9	10.2	14	16.4
Obese	-	-	-	3.3	2.7

*For Aire Metropolitaine (Port-au-Prince)

Table 16. Summary of Hemoglobin Concentrations By Age Category and Sex*

Category	Overall Mean	Mean, Male	Mean, Female	p-value†
All children	103	103	103	0.99
Children Under 5	99	98	99	0.81
Children 5 and Older	106	107	105	0.46
Children 15 and Older	109	120	104	0.02

*All means reported in g/L

†Between males and females.

Table 17. Percentages of Children With Anemia, By Age Category and Sex

Category	Overall	Male	Female	p-value*
All children	66.0	69.0	63.6	0.31
Children Under 5	79.6	86.1	73.9	0.07
Children 15 and Older	74.2	50.0	84.0	0.08

*Between males and females.

Table 18. Percentages of Children With Severe Anemia, By Age Category and Sex

Category	Overall	Male	Female	p-value*
All children	3.4	3.4	3.5	1.00
Children Under 5	2.2	1.4	3.1	0.35
Children 15 and Older	2.9	0.0	4.0	0.71

*Between males and females.

Table 19. Percentage of Anemic Children in Terre Noir By Age Category, Compared to DHS Data

Age Category	DHS, 2005	Terre Noir
6-11 mos	73.8	88.9
12-23 mos	75.3	89.7
24-35 mos	61.6	90.0
36-47 mos	51.1	68.8
48-59 mos	46.9	56.5

Table 20. Percentage of Anemic Females Aged 15 Years and Older in Terre Noir, Compared to DHS Data

Age Category	DHS, 2005	Terre Noir
Ages 15-49	45.8	84.0*
Ages 15-19	48.4	84.0

*No women aged 20-49 in Terre Noir were measured for hemoglobin concentration

Table 21. Children in Terre Noir With Vaccination Records Who Had Received Specific Vaccinations

Vaccination	Percent vaccinated
BCG	87.2
DTP1	95.7
DTP3	63.4
Pol3	62.5
MCV	78.4
Vit A1	76.1
Vit A3	23.3
HBV1	3.4
HiB1	2.6

Table 22. Children in Terre Noir Who Had Received Specific Vaccinations, With Haitian Immunization Guidelines*

Vaccination	1st	2nd	3rd	4th	5th	6th
BCG	**Birth**					
Overall (With Vaccination Record)	62.9 (87.2)					
DTP	**6 wks**	**10 wks**	**14 wks**	**66 wks**		
Overall (With Vaccination Record)	25.6 (95.7)	19.1 (73.2)	16.6 (63.4)	7.6 (54.9)		
Polio	**<15 days**	**6 wks**	**10 wks**	**14 wks**	**66 wks**	**Unspecified**
Overall (With Vaccination Record)	25.2 (94.0)	21.1 (78.6)	16.7 (62.5)	8.6 (33.0)	2.2 (15.7)	0.0 (0.0)
MCV	**9 mos**					
Overall (With Vaccination Record)	18.7 (78.4)					
TT2+	**180 mos**	**181 mos**	**193 mos**	**205 mos**	**217 mos**	
Overall (With Vaccination Record)	0.7 (2.6)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	
VAD1	**6 mos**	**10 mos**	**14 mos**			
Overall (With Vaccination Record)	20.1 (76.6)	8.5 (34.7)	5.3 (22.7)			

*Numbers represent percentages of children above the recommended age

Table 23. Children in Terre Noir Who Had Received Specific Vaccinations, With DHS National Data

Vaccination	DHS, 2005*	Terre Noir, aged 12-23 mos	Terre Noir, aged 0-11 mos
BCG	75	76.2	84.1
DTP1	83	54.8	56.8
DTP3	53	38.1	22.7
Pol3	52	40.5	18.2
MCV	58	40.5	13.6

*Includes children ages 12-23 months both with and without vaccination records

Table 24. Anthropometric Results for Children in Terre Noir With Vaccination Records and With Full UNICEF Vaccinations Compared to Children Without Vaccination Records

Measure	% With Vaccination Record (n=93)	% Fully Vaccinated* (n=58)	% Without Vaccination Record (n=82)
Underweight	19.8	21.4	14.6
Stunted	28.6	20.0	22.9
Wasted	12.9	12.1	15.0
Obese	4.5	3.6	2.5

*Indicates children that had received all vaccinations appropriate for age enquired about during DHS surveys

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