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**Are Stunted Child/Overweight Mother Pairs a Distinct Entity or a Statistical Artifact? Demographic and Health Surveys, 1991-2009.**

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An abstract of
A thesis submitted to the Faculty of the
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## Abstract

**Are Stunted Child/Overweight Mother Pairs a Distinct Entity or a Statistical Artifact? Demographic and Health Surveys, 1991-2009.**
**By Sara Dieffenbach**

Stunted child/overweight mother pairs [SCOWT] have been viewed as a distinct entity, and much effort has been put forth to characterize the environments that create these dual burden households. We hypothesize that the prevalence of SCOWT pairs is not independent of the prevalence of overweight mothers and stunted children in the general population.

We analyzed data from the Demographic and Health Surveys from 1991-2009 for this secondary data analysis. Datasets were included if the maternal BMI and the height-for-age z-scores for children were reported. Mothers were included if they had a living child between two and five years old and were not currently pregnant.

Of 1,708,688 households in 131 datasets, 339,202 households met inclusion criteria. The median prevalence of maternal overweight, childhood stunting and SCOWT pairs was 19.6% (range 1.6%-70.7%), 27.3% (range 6.65%-50.8%), 3.3% (range 0.5%-16.0%), respectively. The mean difference between the observed and expected prevalence of SCOWT pairs was -1.18% (95% CI -1.32%, -1.04%). Only two datasets had an observed prevalence of SCOWT pairs that was higher than the expected prevalence. SCOWT prevalence was more strongly associated with maternal overweight than with child stunting. We found that the prevalence of SCOWT pairs is dependent primarily on the prevalence of maternal overweight.

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## Background

Globally, the prevalence of overweight and obesity is increasing. There are currently more than 1 billion overweight and over 300 million obese adults worldwide (1). Overweight and obesity are often thought of as challenges that affluent societies face, but in reality, these problems are increasingly pervasive in developing countries (2, 3). In fact, the majority of adults who are overweight or obese today live in the developing world (4). Many developing countries, however, still face challenges with poor nutrition in both adults and children (5). In children, chronically inadequate nutrition can lead to stunted growth, or "stunting," a situation in which the child has a low length or height compared to what would be expected based on their age (6). Stunting is not the same as "underweight" (lower than expected weight for age), and can coexist in the same individual with overweight (7). Stunting represents the result of multiple insults to the growth of the child, including low birth weight and food insecurity (8). According to UNICEF, developing countries had a mean prevalence of stunting in children under five years of 39% in 2000 (9). One 2008 study estimated that 178 million children worldwide are stunted (10), and most of the stunted children live in sub-Saharan Africa and south-Central Asia. However, stunting prevalence is decreasing in many parts of the developing world: for example, in Equatorial Guinea, stunting decreased from 57.9% to 45.3% between 1997 and 2004 (11). Despite similar improvements in many other countries, stunting continues to be a major global public health problem. When a society is afflicted with both overweight and stunting, it is deemed to be a "dual-burden society[1]."

[1] "Dual-burden" societies can also refer to societies grappling with noncommunicable diseases and infectious diseases, as well as other opposing societal problems. For the purposes of this paper, "dual-

The dual-burden society is seen most commonly in developing countries that are experiencing rapid economic growth. People in these "transitional countries" are undergoing major changes in their level of urbanization, their average income, the kinds of jobs they hold, the types of foods they eat, and the availability of luxury items such as televisions and cars (4). All of these changes are associated with higher levels of overweight and obesity. When a society that struggled with food insecurity begins this economic transition, it makes sense that as parts of society begin to change, the prevalence of overweight and obesity will first increase in the transforming parts of society, while the prevalence of stunting remains static in the rest society that has yet to transition—leading to the dual-burden society that we observe today.

One of the most important facets of this transition is the nutrition transition—the societal shift from traditional diets to more Western eating patterns, and represents changes in developing countries that include declining food prices and increased urbanization (12). These new diets are marked by higher intakes of animal protein, fats and oils, refined carbohydrates, and sugar-sweetened carbonated beverages. Many studies have shown that the Western diet leads to a less favorable level of nutrition than other dietary patterns. For example, Heidemann et al used the Nurses' Health Study in the United States to compare "prudent" and "Western" dietary patterns. He found that women who ate the Western diet had higher intakes of trans fats and other "bad" fats and lower intakes of fiber and vitamins like folate than did women on the prudent diet (13). Another feature of the Western diet is more access to

burden" will refer to a society or household unit in which adult overweight and childhood stunting are present.

processed food, which can have a negative impact on body weight as well. One study performed in Guatemala showed a direct correlation between a larger amount of processed food consumed and increased BMI (14).

However, the dietary changes are not the only part of the economic transition that leads to obesity. Increased urbanization, more sedentary jobs, and more hours spent in the car or in front of the television ensure that the increased calories taken in are not appropriately spent (12). These societal shifts, working together, result in changes in the prevalence of overweight and obesity among those individuals who have access to this new way of life.

Genetics and epigenetics also play an important role in the development of a dual burden society. Genes determine how an individual will respond to excess energy intake and excess fat accumulation in their body (15). It is a common observation that overweight and obesity runs in families; in fact, obesity is 40-70% heritable (15). However, changes in genetics cannot explain the rapid increase we are seeing in obesity across the developing world. This has led to the "thrifty gene hypothesis," which theorizes that individuals who had the genetic predisposition to metabolically cope with chronic nutritional shortages were protected in historical environments where food insecurity was a major problem. In situations like what many transitional countries experience today, these individuals are at a disadvantage because any excess nutrition they obtain will immediately be stored as fat. These individuals are genetically programmed to develop overweight and obesity in situations of plenty; their bodies are simply trying to prepare for expected food shortages. Although there has been no proof of this hypothesis to date (4), it is compelling to think that this may be one facet of the explanation for current challenges with overweight and obesity.

Epigenetic changes affect the expression of DNA but, unlike genetic changes, do not change the actual DNA sequence (15). Epigenetic changes, commonly called “imprinting,” are instigated by a variety of factors, such as environmental exposures (16-18). While much remains unknown about how epigenetics functions, it is thought to have a role in the development of obesity. Many diseases that result from pathologic imprinting have obesity as a feature (15). A number of studies have investigated how early environmental situations, including the intrauterine environment, lead to epigenetic changes which can permanently affect metabolism (15). For example, it has been shown that maternal weight loss can reduce the risk of obesity in children (15), suggesting that the mother’s weight loss “turns off” genes in her child that would otherwise predispose them to gain weight. In contrast to the genetically mediated thrifty genotype, there has been proposed a “thrifty phenotype” that is epigenetically mediated. This hypothesis suggests that intra-uterine malnutrition turns on genes that cause fat to be centrally deposited later in life (4). If an individual with this tendency were to encounter food shortage later in life, their excess abdominal fat might provide crucial protection to their internal organs. However, in the current environment of nutritional excess, these epigenetic changes lead to a higher risk of central obesity, which is the type of obesity most associated with complications such as diabetes (19). Extrauterine environmental exposures also play a role. One prospective birth cohort study found that children who were stunted at birth are more likely to become obese as adults (20). This also suggests that adipose-promoting genes are “turned on” by an environment of food shortage early in life.

These factors all contribute to the prevalence of overweight and obesity in a population, but that only makes up half of the dual-burden society. Many countries still struggle with food insecurity and malnutrition for parts of their population. The historical and economic factors that have led to serious challenges with food security for developing countries are slowly improving, if at all. For individuals that don’t have access to the changes brought about by a transitioning economy, stunting and undernutrition remain a major problem.

The economic and nutrition transitions are leading to an increased prevalence of overweight and obesity in developing countries, and to a steady, albeit slow, decline in childhood stunting. Any large population will have a range of lifestyles, nutrition habits, and body types. However, it may seem odd that the seemingly opposite phenomena of undernutrition and overnutrition can coexist in the same household (21). Various combinations of stunted or underweight and overweight household members have been researched (22). In a study performed by Doak et al in China, Russia, and Brazil, the prevalence of the dual-burden household was found to be 8% in China and Russia and 11% in Brazil (22). Interestingly, among these countries, Brazil is the one experiencing the fastest rate of transition. Doak et al also found that the dual-burden households represented a significant portion of all households that contained an underweight individual, suggesting, as was previously mentioned, that underweight in childhood is associated with the development of overweight in adulthood (22).

A commonly studied dual-burden household combination is that of the stunted child and overweight mother (SCOWT) (16). The prevalence of SCOWT pairs has been reported to be highest in lower-middle income countries, especially those in Latin America and the Middle East (22). In one study performed in Brazil, 25% of malnourished children had mothers that were overweight (23). Once the child is weaned, a child generally eats what his or her mother eats. Faber et al studied maternal and child dietary patterns in South Africa and found that the types of foods consumed by mothers and their children were similar, with the main differences being in portion size and fruit intake (the children ate more fruit) (24). Interestingly, in this population, the mothers had a mean BMI of 28.3, suggesting a significant amount of overweight, and the children had a mean height for age score (HAZ) of -0.54, representing mild stunting. Beyond a shared diet, children and their mothers share genes, environmental influences, and many of the lifestyle factors that contribute to increased body weight. All of these variables should cause maternal and child weight status to be similar—so how do we explain SCOWT pairs?

There have been several hypotheses as to why these dual-burden households occur. The first is that there has been a distancing of household nutrition relationships (16). As individuals have to rely less on meals taken at home for nourishment, they have increased access to food outside the home, and their individual lifestyle decisions play a more important role. This would have a much larger effect on adult dietary patterns than childhood dietary patterns. Perhaps the adults are eating an overabundance of calories from low-nutrient density foods, while the children, who are eating similar low-quality foods, are unable to get the nutrients needed to grow.

As was reported by Heidemann et al, a Western diet is less nutritious yet higher in calories than a more traditional diet (13). Despite having food security, these families may not be getting good nutrition.

Public health professionals have begun to wonder, however, if the occurrence of stunted children and overweight mothers is truly a reflection of societal changes in nutrition status, or if there is an independent process going on that leads to the clustering of overweight and stunted individuals in households. This process might be related to socioeconomic status, urban or rural residence, and other factors.

If SCOWT pairs represent a distinct subset of the population of mothers and children in the developing world, their emergence would elicit several concerns. Nutrition programs aim to provide adequate amounts of high quality food to facilitate optimal child growth. If the previously mentioned hypothesis is true, then nutrition programs have to shift their focus to the quality of the food rather than just the quantity. As Garrett and Ruel pointed out, food security does not guarantee good nutrition in developing countries (16). Thus, a high prevalence of SCOWT might suggest that public health professionals need to refine their strategies to consider the unique status of these mothers and children. Similarly, a casual observer might see a high prevalence of overweight adults in a society and assume that everyone has access to sufficient nutrition, however, as can be seen in these dual-burden households, there may still be large numbers of children who lack access to the right food to grow. It would not be a successful public health intervention that included stunted children in a weight-reduction program, or one that included overweight adults in a program aimed at increasing calorie intake. Finally, there are long-term implications of this phenomenon. As was mentioned, it has been suggested that children who have stunted growth are more prone to develop obesity later in life when food is abundant (21). This may be contributing to the prevalence of SCOWT pairs that we observe today.

There have been a number of studies investigating the epidemiology and causes of SCOWT pairs (8, 16, 18, 19, 22, 23, 25-27). Factors studied have included maternal characteristics such as education level and age, child characteristics such as birth order and number of siblings, and family characteristics such as urban/rural residency and wealth. These studies have not found consistent predictors of SCOWT between countries.

However, others have suggested that the "problem" of SCOWT pairs may not reflect a process independent of maternal overweight and childhood stunting (18), that the number of SCOWT pairs in a population is simply a reflection of its components. In any society, no matter how wealthy or impoverished, there will be individuals who are overweight and there will be individuals who are stunted. If you have enough members of each of these groups, they will overlap in communities and families. Perhaps the number of overweight individuals has increased rapidly due to the nutrition transition, yet the number of stunted children has stayed the same (18), leading to a high enough prevalence of SCOWT pairs that researchers and public health professionals have begun to take notice.

In this analysis, we use the Demographic and Health Surveys (DHS) to estimate the prevalence of SCOWT pairs in a range of developing countries over the past twenty years. We estimate the expected prevalence of SCOWT pairs based on the underlying population levels of maternal overweight and childhood stunting. By comparing the expected and observed prevalence of SCOWT pairs, we aim to determine if SCOWT pairs are a result of nonrandom clustering (22), or if the number of SCOWT pairs in a population is simply a function of the number of overweight women or the number of stunted children in a population.

## Literature Review

First, we searched PubMed to find the relevant literature. Our search terms included "childhood stunting," "maternal overweight," and "dual-burden household." The results were limited to English-language papers. We included articles that studied at least the SCOWT or underweight child/overweight mother pair when examining underweight/overweight or stunted/overweight relationships within a home. We also hand-searched the references of these studies for further sources.

We found 29 relevant articles from the PubMed search, six of which met our inclusion criteria. After hand-searching the references of these studies, we included three more articles. The prevalence of overweight mothers, stunted children, and either underweight/overweight or SCOWT pairs and other pertinent findings from these studies are presented in Table 1.

## Methods

For this secondary data analysis, we used DHS data from 1991 to 2009, which included waves DHS-II to DHS-V. The DHS is a cross-sectional survey, performed approximately every five years in developing countries around the world. The DHS works to improve "understanding of health and population trends in developing countries" (measuredhs.com). It is funded by the US Agency for International Development. Overall sample size ranges from 5,000 to 30,000 households per survey. We included all surveys that provided body mass index (BMI) data for the mother and height and weight data for children.

For each dataset, we excluded women with missing BMI data, women who had no children, and women who reported being currently pregnant. We only included children two to five years of age in the analysis, because height-for-age z-scores are unstable prior to age two (28, 29) and the DHS does not include anthropometric measurements for children over age five. For women who had more than one child between two and five years old, we only included the youngest child in the analysis, because this child likely has the closest nutritional relationship with his or her mother (24). If this child was reported as nonliving, we removed the household from the analysis. We defined extremes of height and weight for both mothers and children as greater than five standard deviations above or below the mean, and any observations with BMI or height-for-age scores outside these limits were treated as errors and deleted. In later DHS datasets, "de facto" members of the household were allowed to respond to the survey. When these members were responsible for the survey completion, we deleted these observations from the analysis. Because we are concerned with strictly mother-child pairs, it was not appropriate to analyze pairs that included a non-family member in lieu of the mother. Finally, we removed any duplicates within the dataset.

We analyzed the data using SAS version 9.2 (Cary, N.C.). We calculated the prevalence of maternal overweight and of childhood stunting. Maternal overweight was defined as BMI $\geq 25$ kg/m$^2$ (30). BMI was calculated by dividing the mother's reported weight in kilograms by her height in meters squared. Childhood stunting was defined as a height-for-age score greater than or equal to two standard deviations below the mean according to the WHO Child Growth Standards (31). SCOWT pairs were defined as a mother and child in the same household where both of the above were present. We also collected data on the personal and household characteristics of women and children who were members of SCOWT pairs. This information included gender of the child, urban/rural residence, number of children in the family, years of maternal education, lactation status of the mother, and measures of wealth such as TV, radio, and refrigerator ownership, and type of toilet facility.

We calculated the expected number of SCOWT pairs within a dataset as the number of overweight mothers times the number of stunted children, divided by the total number of observations. We calculated the difference between the observed and the expected prevalence of SCOWT pairs, and calculated the adjusted Wald 95% confidence interval for each observed SCOWT pair prevalence. We used linear regression to estimate the relationship between the prevalence of childhood stunting and SCOWT pairs and between the prevalence of maternal overweight and SCOWT pairs. Finally, we created a surface plot showing the relationship between the prevalence of maternal overweight, childhood stunting, and SCOWT pairs. Because of the large gaps in the data (i.e. we did not have a country/year with a value at each prevalence), we smoothed the plot by filling in the empty cells with the mean of all the original data points within seven units on each side.

## Results

In the initial DHS datasets, there were 1,956,335 households in 131 datasets from 54 countries. 789,432 households had no data for mother's BMI; 46,804 households had no age-eligible children; 13,800 women reported being pregnant; 12,999 children were nonliving, and 9,696 women and children had extreme BMI or height-for-age values. Many of the households removed from analysis fell into more than one of the above categories. The analytic sample included 121 datasets from 54 countries, for a total of 394,644 households (Table 2).

Across datasets, the median prevalence of each factor was: maternal overweight 19.6% (range 1.6%-70.7%), childhood stunting 27.3% (range 6.65%-50.8%), and SCOWT pairs 3.3% (range 0.5%-16.0%) (Table 2). The differences between the observed and expected prevalence of SCOWT pairs ranged from -3.2% to 0.2%, with a mean of -1.18% (95% CI -1.32%, -1.04%).

For 119 out of the 121 datasets, the expected prevalence of SCOWT exceeded the observed prevalence. The exceptions were Egypt (2008), which had an observed prevalence of 16.0% (95% CI: 15.1%, 17.0%) and an expected prevalence of 15.9%, and Moldova (2005), which had an observed prevalence of 2.7% (95% CI: 1.9%, 3.9%) and an expected prevalence of 2.5%. Both of these expected prevalences were well within the 95% confidence intervals for the observed prevalences, showing that the observed prevalence of SCOWT pairs is not statistically different from the expected prevalence. There were also several datasets in which the expected prevalence fell outside of the 95% CI around the observed prevalence of SCOWT pairs. Although in these situations the observed and expected prevalences are statistically different, they just show that the observed prevalence of the SCOWT phenomenon is significantly less than the expected prevalence based on the joint probability of the stunted child and overweight mother occurring together.

The number of SCOWT pairs increased steadily with prevalence of maternal overweight ($R^2$=0.62, Figure 1), but was not related to prevalence of childhood stunting ($R^2$=0.04, Figure 2). Maternal overweight was inversely associated with childhood stunting ($R^2$=0.47 in a quadratic model; Figure 3).

Figure 4 presents a three-dimensional view of the relationship between maternal overweight (x-axis), childhood stunting (z-axis), and SCOWT pair prevalence (y-axis). This graph shows the general trend of these relationships, which is supported by the linear regression models. As the prevalence of maternal overweight increases, the prevalence of childhood stunting decreases and the prevalence of SCOWT pairs increase. The prevalence of SCOWT pairs is at its highest when the prevalence of maternal overweight and childhood stunting are both at their highest.

## Discussion

Many countries face an increasing prevalence of adult overweight while still struggling with childhood stunting (8, 16, 21, 22). It is important to determine if SCOWT pairs represent an independent process, and therefore, if they need to be addressed separately by public health professionals and policy makers. Our results, from a comprehensive and exhaustive analysis of 121 population-based datasets, provide strong evidence that SCOWT pairs are dependent primarily on the prevalence of overweight women among the general population and do not represent a statistically independent process.

Our data show that as the prevalence of overweight mothers increases, the prevalence of childhood stunting decreases, and the prevalence of SCOWT pairs increases. This supports the etiology of the dual-burden household suggested by Jehn and Brewis, who proposed that a cause of SCOWT might be a rapidly increasing number of overweight women against a static or slowly decreasing background of childhood stunting (18). Our analysis confirms that the variation in prevalence of SCOWT pairs is driven by the prevalence of maternal overweight, and is only weakly (and inversely) related to the prevalence of child stunting, which in turn is driven by the inverse association of maternal overweight with childhood stunting. When maternal overweight is held constant (as seen in Figure 4), child stunting becomes a positive predictor of SCOWT prevalence.

These results tell us that the changes transitioning countries face lead to dramatically increased maternal overweight and slightly decreased childhood stunting, which together lead to a degree of overlap between the two in families. Just because there is not a third, independent, SCOWT-producing process going on does not mean that there are not biological and social processes at work in these societies that need attention from public health professionals. However, by addressing the changes in society that lead to childhood stunting and maternal overweight, the SCOWT "problem" will eventually resolve.

*Strengths and Limitations*

The greatest strength of our research is the large number of households analyzed from a wide range of developing countries. Since there is so much variability in prevalence of child stunting, maternal overweight, and SCOWT pairs between countries and over time, our large sample allows us to see the global picture over almost two decades. Table 1 shows that many of the previous studies have only examined SCOWT pairs in one country at one time. Other strengths of this research include the fact that we used age-appropriate measurements to assess overweight and underweight status. Other studies have used BMI to categorize both children and adults (22), yet BMI is not always appropriate for children (21). Other studies have looked at underweight children who reside with overweight mothers (18, 22, 25). However, stunting and overweight can exist in the same individual (7). By choosing to measure stunting, regardless of weight status, we are measuring chronic malnutrition in these children. Similarly, we confined our analysis to mother-child pairs, and we further limited it to very young children. Mother-child pairs have the most closely related nutrition status of any family members (18), a relationship that weakens once the child enters school. The same cannot be said for other family members, who may have different food exposures outside of the home (21).

The major limitation of our analysis is that we analyzed a secondary data source. While the DHS uses well-validated survey methods, we lack direct control of how the variables of interest were collected and recorded. We minimized errors by deleting extreme values. However, our extensive exclusion criteria resulted in a large portion of our sample being removed, which may affect the quality of the final results.

Other limitations lie in the assumptions we made while analyzing the data. For example, we assumed that any woman with a BMI in the overweight range was truly overweight. Similarly, we ignored natural variations in height when investigating stunting. A child that is very short might be classified as “stunted” when, in fact, they are just much shorter than average. This could have had a real effect on our results, albeit a small one. It has been observed that short women are more likely to be overweight and to beget short children (19). This might inflate the prevalence of SCOWT pairs. We also made assumptions about other characteristics of the mothers and children in SCOWT pairs. Another assumption we made was that none of the children in the sample were getting the majority of their calories from breast milk. For example, we collected information on the lactation status of the mothers, but we assumed that because all children in the survey were older than two years old that it was not these children that were being breastfed (11), a variable that would significantly affect a child’s nutritional status.

*Public Health Importance and Policy Implications*

As we have shown, SCOWT pairs are not a distinct entity separate from the components of childhood stunting and maternal overweight. Because of this, public health professionals do not need to design interventions to address the specific status of SCOWT pairs; rather, interventions can continue to target the far more common underlying problems of stunting and overweight.

The causal mechanisms behind SCOWT pairs have garnered much interest. After all, stunting represents a chronic state of malnutrition, while overweight represents an excess of nutrition, and their occurrence in the same family draws interest. Childhood stunting and adult overweight are the results of different processes. A stunted child can be underweight, normal weight, or overweight. An overweight adult can have a history of stunted growth or normal growth.

This raises an important question: should we even be comparing the development of stunting in children and overweight in adults? The processes that lead to the former are completely different from the processes that lead to the latter. Our research suggests that there is not an independent process leading to SCOWT pair development, that the known causes of stunting and overweight are what are at work here.

SCOWT pairs do highlight an important fact that is often glossed over: individuals that are overweight may still be undernourished. The mechanisms we have examined suggest that mothers in SCOWT pairs can be overweight while still being undernourished, and the children are often both undernourished and stunted. When designing future nutrition programs, regardless of the imbalance they hope to correct, this distinction will be crucial to keep in mind. If large quantities of low-quality food continue to be funneled into developing countries, this dual burden will only worsen over the coming years.

The policy implications of these findings go far beyond the small number of women and children in SCOWT pairs. The overweight women and stunted children in SCOWT pairs represent real challenges facing global health. The number of overweight women is increasing worldwide. This global weight gain is largely caused by high-calorie, low-nutrient, processed foods that are cheap and readily available coupled with a decrease in physical activity. Children remain stunted because these foods do not have the nutrients they require to flourish. The development of SCOWT pairs suggests that these foods have detrimental effects on both children and adults. Hopefully these results and other similar findings will prompt governments to craft food policies that protect both adults and children from these foods.

### *Future Directions*

Currently, public health professionals can go into the field with confidence that these dual-burden households do not need a nutrition intervention separate from the rest of the population. However, it is important for all nutrition interventions to remember the root causes of SCOWT pairs in mind as they design their programs. As was mentioned, just providing lots of food to individuals in developing countries might not correct childhood stunting. Similarly, implementing physical activity programs won't be enough to combat adult overweight and obesity. The current trends in developing countries add urgency to the need to intervene on behalf of both stunted children and overweight adults before another generation develops high rates of overweight in adulthood while their children don’t get the proper nutrition to grow.

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Table 1a: Results of Literature Review (Multiple-Country Papers)

| Author (Reference) | Type of Study | Data Source | Countries Included | Prevalence of Childhood Stunting | Prevalence of Maternal Overweight | Prevalence Of SCOWT | Summary of Findings |
|---|---|---|---|---|---|---|---|
| Doak et al (22) | Secondary Data Analysis | Country-specific national surveys | Brazil, China, Russia | NR | NR | 8-11%* | There are a large number of dual-burden households in these countries. Urban residence was the only factor associated with over/under in all 3 countries. |
| Garrett and Ruel (8) | Secondary Data Analysis | DHS | 27 in Africa, 8 in Latin America, 7 in Asia | 8.9%-56.1% | 2.0%-70.8% | 0.9%-16.0% | SCOWT Prevalence is related to the underlying prevalence of stunting and overweight, and is generally related to GDP. |
| Garrett and Ruel (16) | Ecological Study/Secondary Data Analysis | DHS | 23 in Africa, 8 in Latin America, 5 in Asia | 9.3%-54.7% | 2-55% | <10% - 14% | There are different effects of risk factors on SCOWT prevalence in different regions. SCOWT pairs may represent differences in how adults and children experience the nutrition transition |

| Author (Reference) | Type of Study | Data Source | Countries Included | Prevalence of Childhood Stunting | Prevalence of Maternal Overweight | Prevalence Of SCOWT | Summary of Findings |
|---|---|---|---|---|---|---|---|
| Jehn and Brewis (18) | Secondary data analysis | DHS | 11 in Africa, 6 in Latin America, 1 in Asia | 18.1%-62.1% | 3.6%-70.4% | 0.3%-5.3%* | Were not able to identify specific factors that put mothers or children at risk for being in SCOWT pairs. |

Table 1b: Results of Literature Review (Single-Country Papers)

| Author (Reference) | Type of Study | Data Source | Country Studied | Prevalence of Childhood Stunting | Prevalence of Maternal Overweight | Prevalence of SCOWT pairs | Summary of Findings |
|---|---|---|---|---|---|---|---|
| Barquera (19) | Secondary Data Analysis | Mexican Nutrition Survey (1999) | Mexico | 17.3% | 57.4% | 6.2% | In countries undergoing the nutrition transition, maternal adiposity and childhood stunting are associated. |
| Doak and Adair (25) | Secondary Data Analysis | 1993 China Health and Nutrition Survey | China | NR | NR | 8.1%* | The under/over household has characteristics that represent the effects of a rapid nutrition transition. There were not many sociodemographic features that were statistically different between under/over |

| Author (Reference) | Type of Study | Data Source | Country Studied | Prevalence of Childhood Stunting | Prevalence of Maternal Overweight | Prevalence of SCOWT pairs | Summary of Findings |
|---|---|---|---|---|---|---|---|
| | | | | | | | households and under/under or over/over. |
| Lee (26) | National Survey | Living Standards Measurement Survey (2000) | Guatemala | 52% | 43.4% | 18.2% | SCOWT households are significantly different from "normal" households. One important positive predictor of SCOWT was maternal short stature. |
| Raphael (27) | Household Survey | Household Survey of one Shantytown | Haiti | 32% | 23% | 11% | The prevalence of SCOWT pairs is much higher in a poor urban environment than would be expected based on the national sample from the DHS (3%). |
| Rodrigues (23) | Secondary Data Analysis | Nationally Representative Survey | Brazil | NR | 36.7% | 1.3%* | Low concordance between nutritional status of mothers and children. |

* Only underweight child/overweight mother prevalence was reported for this study.

Table 2: Prevalence of Maternal Overweight, Childhood Stunting, and Observed and Expected Prevalence of SCOWT Pairs in 121 DHS datasets.

| **Country** | **Year** | **Mother-child pairs** | **Maternal Overweight** | **Childhood Stunting** | **SCOWT Pairs** | | | |
|---|---|---|---|---|---|---|---|---|
| | | n | % | % | % | 95% CI | **Expected** (%) | **Difference (%)** |
| Armenia | 2005 | 887 | 31.3% | 11.3% | 3.2% | (2.2%, 4.5%) | 3.5% | -0.4% |
| Azerbaijan | 2006 | 1265 | 41.5% | 20.8% | 8.5% | (7.1%, 10.2%) | 8.6% | -0.1% |
| Bangladesh | 1996 | 3187 | 2.7% | 49.8% | 0.6% | (0.4%, 0.9%) | 1.3% | -0.8% |
| Bangladesh | 1999 | 3628 | 5.2% | 40.2% | 1.1% | (0.8%, 1.5%) | 2.1% | -1.0% |
| Bangladesh | 2004 | 4207 | 6.8% | 38.7% | 1.4% | (1.1%, 1.9%) | 2.7% | -1.2% |
| Bangladesh | 2007 | 3727 | 9.8% | 32.6% | 1.7% | (1.3%, 2.2%) | 3.2% | -1.5% |
| Benin | 1996 | 1859 | 9.0% | 23.2% | 1.2% | (0.8%, 1.9%) | 2.1% | -0.9% |
| Benin | 2001 | 2399 | 15.7% | 25.7% | 2.8% | (2.2%, 3.5%) | 4.0% | -1.2% |
| Benin | 2006 | 6901 | 16.1% | 33.3% | 3.5% | (3.1%, 4.0%) | 5.4% | -1.9% |
| Bolivia | 1994 | 2008 | 32.9% | 24.2% | 7.3% | (6.3%, 8.6%) | 8.0% | -0.6% |
| Bolivia | 1998 | 3747 | 43.4% | 23.4% | 9.4% | (8.5%, 10.3%) | 10.2% | -0.8% |
| Bolivia | 2003 | 5878 | 47.4% | 23.2% | 9.4% | (8.7%, 10.2%) | 11.0% | -1.6% |
| Bolivia | 2008 | 5301 | 51.6% | 17.4% | 7.9% | (7.2%, 8.6%) | 9.0% | -1.1% |
| Brazil | 1996 | 2792 | 33.6% | 9.2% | 2.8% | (2.3%, 3.5%) | 3.1% | -0.3% |
| Burkina Faso | 1993 | 2548 | 9.6% | 25.7% | 1.5% | (1.1%, 2.1%) | 2.5% | -0.9% |
| Burkina Faso | 1998 | 2398 | 6.8% | 29.4% | 1.7% | (1.2%, 2.3%) | 2.0% | -0.3% |
| Burkina Faso | 2003 | 5047 | 7.5% | 33.7% | 1.5% | (1.2%, 1.9%) | 2.5% | -1.0% |
| Cambodia | 2000 | 2094 | 5.7% | 38.9% | 1.8% | (1.3%, 2.5%) | 2.2% | -0.4% |
| Cambodia | 2005 | 2412 | 8.6% | 34.7% | 2.9% | (2.3%, 3.7%) | 3.0% | -0.1% |
| Cameroon | 1998 | 1339 | 23.1% | 26.7% | 4.0% | (3.1%, 5.2%) | 6.2% | -2.1% |
| Cameroon | 2004 | 1810 | 25.5% | 28.1% | 5.3% | (4.3%, 6.4%) | 7.2% | -1.9% |
| CAR | 1994 | 1658 | 6.6% | 29.9% | 1.4% | (0.9%, 2.1%) | 2.0% | -0.6% |
| Chad | 1996 | 2985 | 7.2% | 32.5% | 1.8% | (1.4%, 2.4%) | 2.4% | -0.5% |
| Chad | 2004 | 2239 | 11.0% | 31.9% | 3.0% | (2.4%, 3.8%) | 3.5% | -0.5% |
| Colombia | 1995 | 3091 | 40.3% | 11.5% | 3.6% | (3.0%, 4.3%) | 4.6% | -1.0% |
| Colombia | 2005 | 9218 | 39.4% | 10.1% | 3.6% | (3.2%, 4.0%) | 4.0% | -0.4% |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Comoros | 1996 | 658 | 19.8% | 29.2% | 3.5% | (2.3%, 5.2%) | 5.8% | -2.3% |
| Congo | 2005 | 2523 | 24.0% | 20.2% | 4.4% | (3.7%, 5.3%) | 4.8% | -0.5% |
| Cote d'Ivoire | 1994 | 2656 | 13.9% | 23.0% | 2.0% | (1.5%, 2.6%) | 3.2% | -1.2% |
| Cote d'Ivoire | 1998 | 970 | 21.0% | 20.4% | 3.1% | (2.2%, 4.4%) | 4.3% | -1.2% |
| Dominican Republic | 1991 | 1781 | 26.4% | 16.4% | 3.5% | (2.7%, 4.4%) | 4.3% | -0.9% |
| Dominican Republic | 1996 | 2225 | 35.8% | 10.2% | 2.2% | (1.7%, 3.0%) | 3.7% | -1.4% |
| DR Congo | 2007 | 1649 | 13.0% | 30.4% | 2.9% | (2.2%, 3.9%) | 3.9% | -1.0% |
| Egypt | 1992 | 4203 | 57.6% | 22.5% | 11.2% | (10.3%, 12.2%) | 12.9% | -1.7% |
| Egypt | 1995 | 5727 | 49.6% | 28.1% | 11.6% | (10.8%, 12.5%) | 13.9% | -2.3% |
| Egypt | 2000 | 6260 | 70.2% | 17.7% | 10.9% | (10.2%, 11.7%) | 12.4% | -1.5% |
| Egypt | 2003 | 3695 | 66.3% | 15.8% | 8.8% | (7.9%, 9.8%) | 10.5% | -1.7% |
| Egypt | 2005 | 7475 | 70.7% | 21.1% | 13.6% | (12.8%, 14.4%) | 14.9% | -1.3% |
| Egypt | 2008 | 5889 | 69.1% | 23.0% | 16.0% | (15.1%, 17.0%) | 15.9% | 0.1% |
| Ethiopia | 2000 | 5024 | 3.6% | 42.2% | 0.7% | (0.5%, 0.9%) | 1.5% | -0.9% |
| Ethiopia | 2005 | 2193 | 4.7% | 38.3% | 1.1% | (0.8%, 1.7%) | 1.8% | -0.7% |
| Gabon | 2000 | 2039 | 25.0% | 20.2% | 3.3% | (2.6%, 4.2%) | 5.0% | -1.8% |
| Ghana | 1993 | 1509 | 12.5% | 23.3% | 1.9% | (1.3%, 2.7%) | 2.9% | -1.0% |
| Ghana | 1998 | 1732 | 14.7% | 22.9% | 2.1% | (1.5%, 2.9%) | 3.4% | -1.3% |
| Ghana | 2003 | 1993 | 20.7% | 25.6% | 3.4% | (2.7%, 4.3%) | 5.3% | -1.9% |
| Ghana | 2008 | 1541 | 26.1% | 19.6% | 2.7% | (2.0%, 3.7%) | 5.1% | -2.4% |
| Guatemala | 1995 | 4401 | 30.3% | 44.7% | 10.7% | (9.8%, 11.7%) | 13.5% | -2.8% |
| Guatemala | 1998 | 2058 | 39.8% | 42.2% | 14.3% | (12.8%, 15.9%) | 16.8% | -2.5% |
| Guinea | 2005 | 1614 | 10.5% | 29.9% | 2.2% | (1.6%, 3.0%) | 3.2% | -1.0% |
| Haiti | 1994 | 1514 | 11.4% | 24.4% | 2.0% | (1.4%, 2.8%) | 2.8% | -0.8% |
| Haiti | 2000 | 3250 | 22.3% | 17.8% | 2.6% | (2.1%, 3.3%) | 4.0% | -1.3% |
| Haiti | 2005 | 1618 | 21.2% | 17.9% | 2.0% | (1.5%, 2.9%) | 3.8% | -1.7% |
| Honduras | 2005 | 6226 | 43.1% | 24.1% | 7.9% | (7.2%, 8.6%) | 10.4% | -2.5% |
| India | 1998 | 18348 | 5.8% | 39.7% | 1.3% | (1.1%, 1.4%) | 2.3% | -1.0% |
| India | 2005 | 25122 | 10.9% | 34.2% | 2.3% | (2.1%, 2.5%) | 3.7% | -1.5% |
| Jordan | 1997 | 2559 | 61.6% | 7.9% | 4.1% | (3.4%, 5.0%) | 4.8% | -0.7% |
| Jordan | 2002 | 2544 | 65.6% | 9.0% | 5.7% | (4.8%, 6.6%) | 5.9% | -0.3% |
| Jordan | 2007 | 2230 | 65.7% | 12.2% | 7.1% | (6.1%, 8.3%) | 8.0% | -0.9% |
| Jordan | 2009 | 2361 | 69.3% | 6.7% | 4.3% | (3.6%, 5.2%) | 4.6% | -0.3% |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kazakhstan | 1995 | 560 | 24.6% | 14.3% | 2.7% | (1.6%, 4.4%) | 3.5% | -0.8% |
| Kazakhstan | 1999 | 425 | 22.1% | 11.3% | 1.4% | (0.6%, 3.1%) | 2.5% | -1.1% |
| Kenya | 1993 | 2698 | 13.8% | 28.3% | 3.0% | (2.4%, 3.7%) | 3.9% | -0.9% |
| Kenya | 1998 | 2669 | 14.6% | 29.5% | 2.5% | (1.9%, 3.1%) | 4.3% | -1.8% |
| Kenya | 2003 | 2781 | 20.1% | 26.2% | 3.3% | (2.7%, 4.1%) | 5.3% | -1.9% |
| Kenya | 2008 | 3011 | 22.2% | 26.7% | 4.7% | (4.0%, 5.5%) | 5.9% | -1.2% |
| Kyrgyz Republic | 1997 | 765 | 17.8% | 24.4% | 3.9% | (2.7%, 5.6%) | 4.4% | -0.4% |
| Lesotho | 2004 | 980 | 39.1% | 35.2% | 11.7% | (9.9%, 13.9%) | 13.8% | -2.0% |
| Madagascar | 1997 | 2187 | 4.4% | 43.2% | 1.1% | (0.7%, 1.6%) | 1.9% | -0.8% |
| Madagascar | 2003 | 2643 | 8.2% | 39.3% | 2.3% | (1.8%, 2.9%) | 3.2% | -1.0% |
| Madagascar | 2008 | 2943 | 5.6% | 38.6% | 1.7% | (1.3%, 2.2%) | 2.2% | -0.5% |
| Malawi | 1992 | 1806 | 10.8% | 37.4% | 3.7% | (2.9%, 4.6%) | 4.0% | -0.4% |
| Malawi | 2000 | 5445 | 11.7% | 40.3% | 3.9% | (3.4%, 4.4%) | 4.7% | -0.8% |
| Malawi | 2004 | 4705 | 11.2% | 43.0% | 3.8% | (3.3%, 4.4%) | 4.8% | -1.0% |
| Mali | 1995 | 3498 | 8.8% | 27.3% | 1.5% | (1.1%, 1.9%) | 2.4% | -1.0% |
| Mali | 2001 | 5251 | 14.0% | 32.8% | 2.7% | (2.3%, 3.2%) | 4.6% | -1.8% |
| Mali | 2006 | 5982 | 17.6% | 30.4% | 4.5% | (4.1%, 5.1%) | 5.4% | -0.8% |
| Moldova | 2005 | 1055 | 34.3% | 7.3% | 2.7% | (1.9%, 3.9%) | 2.5% | 0.2% |
| Morocco | 1992 | 2563 | 32.8% | 21.0% | 4.8% | (4.0%, 5.7%) | 6.9% | -2.1% |
| Morocco | 2003 | 3732 | 42.5% | 17.6% | 5.4% | (4.7%, 6.2%) | 7.5% | -2.1% |
| Mozambique | 1997 | 2842 | 9.6% | 29.8% | 1.5% | (1.2%, 2.1%) | 2.9% | -1.3% |
| Mozambique | 2003 | 4901 | 13.5% | 34.4% | 2.8% | (2.4%, 3.3%) | 4.7% | -1.8% |
| Namibia | 1992 | 1619 | 18.6% | 28.4% | 3.0% | (2.3%, 4.0%) | 5.3% | -2.2% |
| Namibia | 2006 | 2593 | 28.8% | 22.4% | 4.5% | (3.8%, 5.4%) | 6.5% | -2.0% |
| Nepal | 1996 | 2864 | 1.7% | 45.2% | 0.5% | (0.3%, ).8%) | 0.8% | -0.3% |
| Nepal | 2001 | 3764 | 3.9% | 43.9% | 1.4% | (1.1%, 1.9%) | 1.7% | -0.3% |
| Nepal | 2006 | 3287 | 5.3% | 37.4% | 0.9% | (0.6%, 1.3%) | 2.0% | -1.1% |
| Nicaragua | 1998 | 4290 | 37.7% | 22.0% | 6.7% | (6.0%, 7.5%) | 8.3% | -1.6% |
| Nicaragua | 2001 | 3970 | 43.8% | 16.9% | 5.9% | (5.3%, 6.7%) | 7.8% | -1.9% |
| Niger | 1992 | 2306 | 14.5% | 30.7% | 2.2% | (1.7%, 2.9%) | 4.5% | -2.2% |
| Niger | 1998 | 2942 | 10.1% | 35.9% | 2.1% | (1.7%, 2.7%) | 3.6% | -1.5% |
| Niger | 2006 | 2023 | 19.8% | 38.1% | 4.3% | (3.5%, 5.3%) | 7.5% | -3.2% |
| Nigeria | 1999 | 1009 | 19.5% | 41.7% | 7.3% | (5.9%, 9.1%) | 8.2% | -0.8% |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nigeria | 2003 | 2334 | 19.6% | 32.9% | 4.4% | (3.6%, 5.3%) | 6.4% | -2.1% |
| Nigeria | 2008 | 10037 | 20.4% | 35.0% | 5.2% | (4.8%, 5.7%) | 7.1% | -1.9% |
| Peru | 1991 | 4603 | 37.2% | 25.3% | 8.1% | (7.4%, 9.0%) | 9.4% | -1.3% |
| Peru | 1996 | 9622 | 42.1% | 24.6% | 8.3% | (7.9%, 9.1%) | 10.3% | -2.1% |
| Peru | 2000 | 8189 | 45.2% | 24.3% | 8.9% | (7.7%, 8.8%) | 11.0% | -2.1% |
| Peru | 2004 | 7745 | 50.1% | 20.0% | 8.5% | (8.3%, 9.5%) | 10.0% | -1.5% |
| Rwanda | 2000 | 3435 | 14.5% | 35.1% | 4.0% | (3.4%, 4.7%) | 5.1% | -1.1% |
| Rwanda | 2005 | 2046 | 11.7% | 37.6% | 3.2% | (2.5%, 4.0%) | 4.4% | -1.2% |
| Senegal | 1992 | 2249 | 16.5% | 21.4% | 1.9% | (1.4%, 2.6%) | 3.5% | -1.6% |
| Senegal | 2005 | 1654 | 19.6% | 15.3% | 2.0% | (1.4%, 2.8%) | 3.0% | -1.0% |
| Sierra Leone | 2008 | 1283 | 28.6% | 28.1% | 7.1% | (5.8%, 8.6%) | 8.1% | -1.0% |
| Swaziland | 2006 | 1416 | 54.9% | 20.2% | 10.3% | (8.8%, 12.0%) | 11.1% | -0.8% |
| Tanzania | 1991 | 3570 | 10.4% | 39.2% | 2.6% | (2.2%, 3.2%) | 4.1% | -1.5% |
| Tanzania | 1996 | 3135 | 13.4% | 41.0% | 2.5% | (2.0%, 3.1%) | 5.5% | -3.0% |
| Tanzania | 2004 | 4173 | 15.3% | 32.6% | 3.3% | (2.8%, 3.9%) | 5.0% | -1.7% |
| Togo | 1998 | 2802 | 10.3% | 21.1% | 1.5% | (1.1%, 2.1%) | 2.2% | -0.6% |
| Turkey | 1993 | 2030 | 51.3% | 14.9% | 7.3% | (6.3%, 8.6%) | 7.7% | -0.3% |
| Turkey | 1998 | 1817 | 52.6% | 13.4% | 6.9% | (5.8%, 8.1%) | 7.1% | -0.2% |
| Uganda | 1995 | 2691 | 10.9% | 30.2% | 2.5% | (1.9%, 3.1%) | 3.3% | -0.8% |
| Uganda | 2000 | 2661 | 22.0% | 50.8% | 3.0% | (2.4%, 3.7%) | 4.3% | -1.4% |
| Uganda | 2006 | 1177 | 13.1% | 27.3% | 1.9% | (1.2%, 2.8%) | 3.6% | -1.7% |
| Uzbekistan | 1996 | 745 | 14.8% | 27.9% | 3.9% | (2.7%, 5.6%) | 4.1% | -0.2% |
| Zambia | 1992 | 2706 | 13.4% | 35.4% | 3.7% | (3.0%, 4.5%) | 4.8% | -1.1% |
| Zambia | 1996 | 3158 | 11.1% | 37.6% | 3.1% | (2.6%, 3.8%) | 4.2% | -1.1% |
| Zambia | 2001 | 3184 | 9.1% | 40.7% | 3.3% | (2.7%, 4.0%) | 3.7% | -0.4% |
| Zambia | 2007 | 2808 | 16.9% | 33.9% | 4.8% | (4.1%, 5.7%) | 5.7% | -0.9% |
| Zimbabwe | 1994 | 1671 | 21.0% | 21.2% | 3.4% | (2.6%, 4.3%) | 4.5% | -1.1% |
| Zimbabwe | 1999 | 1822 | 24.1% | 25.1% | 4.1% | (3.3%, 5.1%) | 6.1% | -2.0% |
| Zimbabwe | 2005 | 2799 | 22.4% | 27.5% | 5.0% | (4.3%, 5.9%) | 6.2% | -1.2% |

Figure 1: Relationship of Maternal Overweight and SCOWT Prevalences

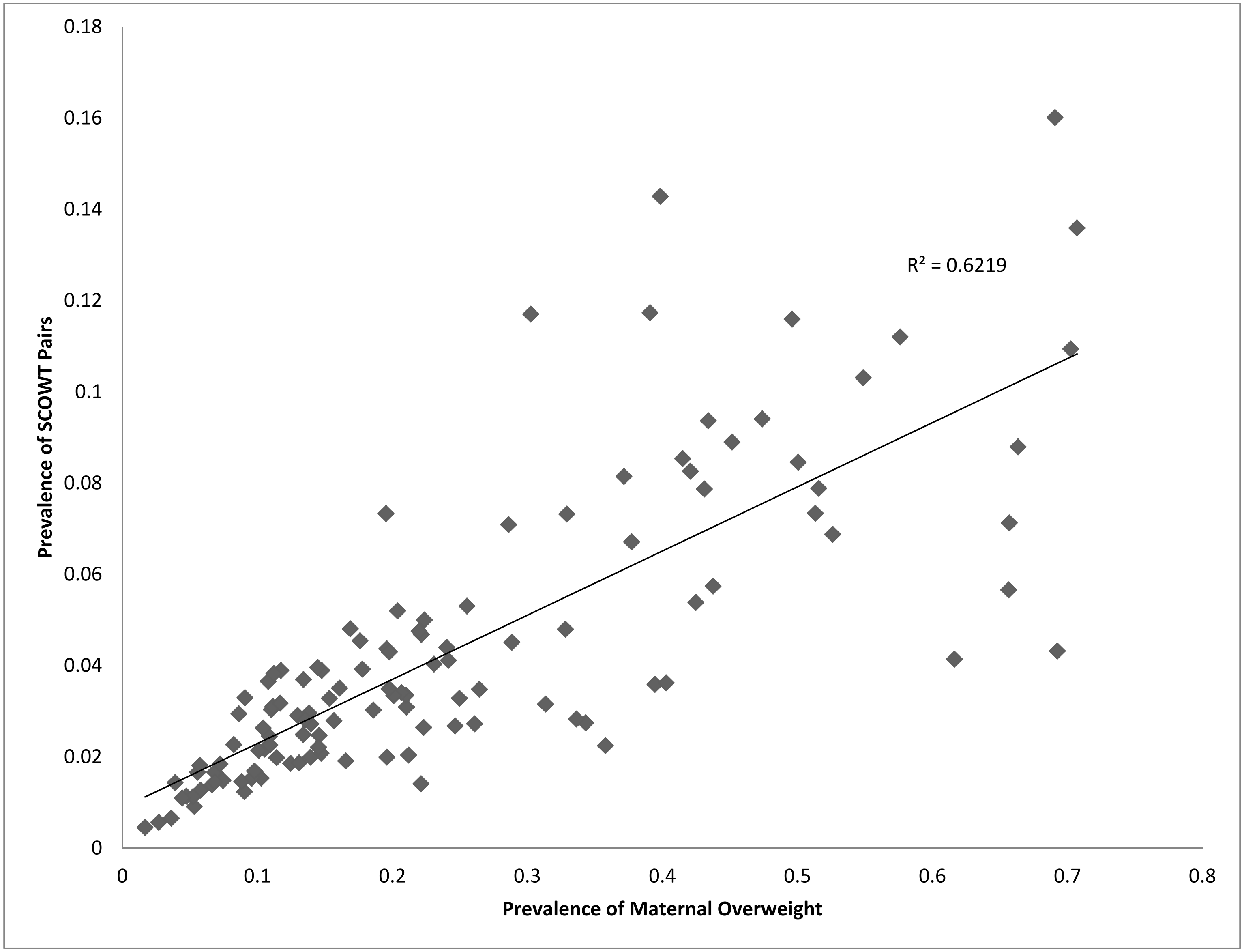


Figure 2: Relationship of Childhood Stunting and SCOWT Prevalences

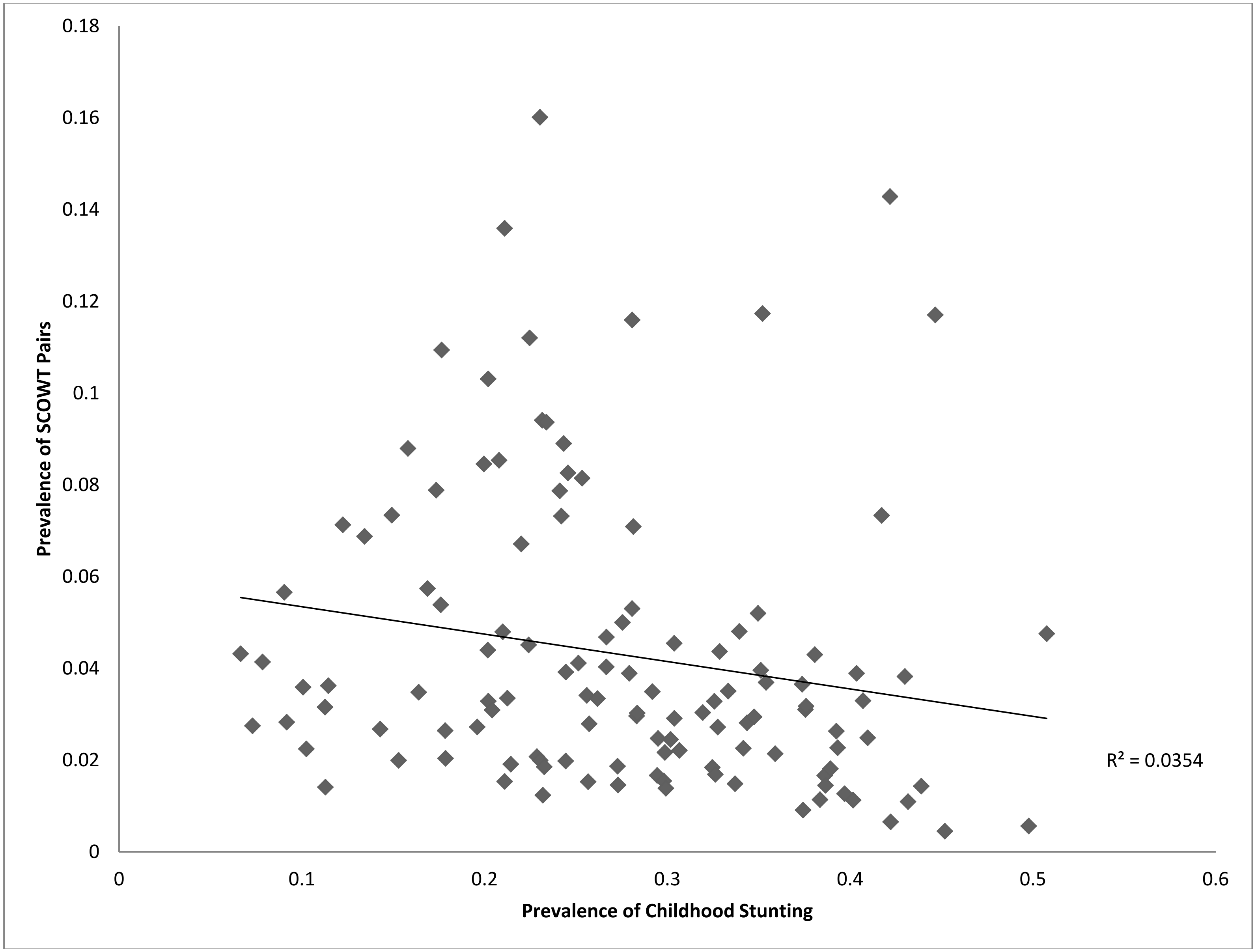


Figure 3: Relationship between Prevalence of Childhood Stunting and Maternal Overweight

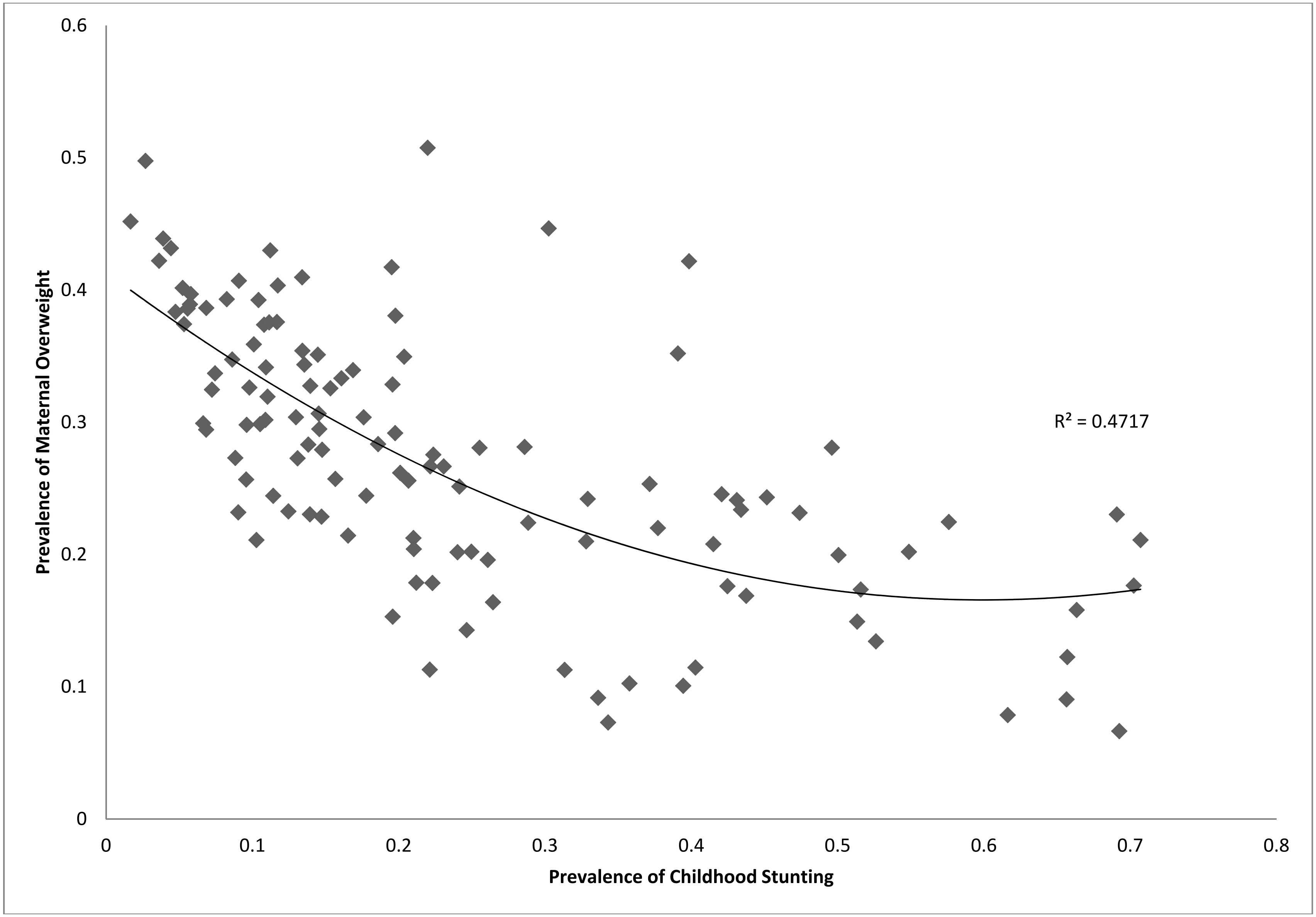
Prevalence of Maternal Overweight
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Prevalence of Childhood Stunting
R² = 0.4717

Figure 4: Prevalence of SCOWT Pairs in Relation to Maternal Overweight and Childhood Stunting among 121 DHS datasets, 1991-2009