MICRO-LEVEL ESTIMATION OF THE PREVALENCE OF STUNTING AND UNDERWEIGHT AMONG CHILDREN IN CAMBODIA

Ministry of Health, Royal Government of Cambodia
United Nations World Food Programme
MEASURE DHS+ / ORL Macro

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FOREWORD

We are pleased to share this copy of the preliminary report on "Micro-Level Estimation of the Prevalence of Stunting and Underweight Among Children in Cambodia." This study is the result of a collaboration between the Ministry of Planning, the United Nations World Food Programme and the *MEASURE DHS+* project, with in-kind assistance from The World Bank. We also would like to express our acknowledgement to Italian Cooperation and International Fund for Agricultural Development for supporting in publication and distribution.

Many others have been involved throughout this study. We would particularly like to thank the following partners for providing data, conceptual inputs, and comments: National Institute of Statistics, Ministry of Education, Ministry of Health, UNDP, UNICEF, UNESCO, WHO, UNFPA, European Commission, and the Asian Development Bank.

This is the first time that the small area estimation method, used widely by the World Bank to estimate poverty for small geographic areas, has been applied to a non-economic measure of wellbeing. While the results presented here are to be considered preliminary, the process and these results have been peer-reviewed by experts, and the estimates are deemed to be robust. Nonetheless, we plan to validate these estimates and produce a final technical report later this year. Although the final estimates are not expected to differ greatly from these estimates we encourage the cautious use of these estimates in the meantime.

WFP is pleased to have served as the facilitator of this study, but it is important to note that ownership of these results lies with the Ministry of Planning which fully endorses this preliminary report and the maps. We believe that these preliminary maps and the final maps to come will serve as useful tools to assist the government as well as international organizations, donors and NGOs to better target their assistance programs in Cambodia.

We deeply appreciate all the persons contributed inputs to make this report possible. By knowing where malnourished children are we can help them to have a better future.

Rebecca Hansen
WFP Representative/Country Director

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1. Introduction

Malnutrition remains a major public health concern in most developing countries. The serious impact of malnutrition on the life and health of children is well documented. For example, malnourished children are more susceptible to some infectious diseases, such as diarrhea, malaria and measles (Tomkins, A., and Watson, F., 1989; Rice, Sacco, Hyder, and Black, 2000). For many children, the cost of malnutrition is much higher; a recent report published by the World Health Organization estimated that in 2000, about 3.7 million deaths among young children worldwide were related to malnutrition (WHO, 2002). Other studies estimate that about one half of childhood deaths in developing countries are caused by undernutrition (Pelletier 1994). Malnutrition has also been associated with mortality and morbidity in later life, delayed mental development and reduced intellectual performance (see Onis, Frongillo, and Blössner, 2000).

Two recognized measures of the nutritional status of young children are height and weight. These measures are compared to those of children of the same age and gender from a healthy reference population (NCHS/WHO). Among children under five, stunting and underweight are defined, respectively, as height and weight measurements which fall below two standard deviations from the median for the reference population, adjusted for the age and sex of the child. Severe stunting and underweight are defined as height-for-age and weight-for-age measurements that fall below three standard deviations from the reference median. Although both stunting and underweight are measures of undernutrition, each captures slightly different aspects of nutritional status. Stunting or low height-for-age is a measure of chronic undernutrition and is likely to persist even after the elimination of conditions that contributed to it, such as infection or inadequate nutritional intake, or both. On the other hand, underweight or low weight-for-age is a measure of acute undernutrition and is more sensitive to short-term changes in food consumption or disease states.

The poor nutritional status of children in Cambodia is a major public health concern. Results from the 2000 Cambodian Demographic and Health Survey (CDHS) show that about 45% of Cambodian children under the age of five are stunted, and a similar percentage is underweight. About one in five Cambodian children in this age group are severely stunted, and about one in eight is severely underweight (NIS, Directorate General for Health and ORC Macro, 2000). Compared to the region as a whole where the prevalence of stunting in preschool children is estimated at 34% (Onis, Frongillo and Blössner, 2000), malnutrition is more prevalent in Cambodia.

As can be seen from the results of the CDHS, the prevalence of stunting and underweight varies by region (see Maps 1 and 2). For example, 26% of children under five in Phnom Penh are stunted, while 55% of children in Koh Kong are stunted[1]. Within the same province, the prevalence may also vary substantially. Because geographic targeting of interventions – such as food distribution – to alleviate

[1] The population density of the Northeastern provinces is low, so although the rate of malnutrition in the central provinces is lower, the actual number of malnourished children may be much higher.

undernutrition is important for efficient and effective program implementation, analyzing the geographic variation in the prevalence of malnutrition is a valuable contribution towards combating the problem. Furthermore, the move toward decentralized decision-making will likely require that estimates for small geographic areas be available to decision-makers. The ability to identify specific geographic areas where such interventions can be targeted is of particular importance in a country such as Cambodia, where limited resources are in increasingly competitive demand.

The objective of this study is to estimate the prevalence of stunting and underweight among children under five in Cambodia, for smaller geographic areas than the province-level estimates given by the CDHS. Such a finely disaggregated map of malnutrition may help decision makers better allocate limited resources towards those who need them most. To achieve this, a modified version of the small area estimation technique developed by the World Bank Development Economics Research Group was employed, using the CDHS, the Cambodian Census, and a range of geographic information. The method has been used successfully in over 10 countries to estimate poverty; in this study the method is being applied for the first time to estimate nutritional outcomes. The next sections describe the methodology and implementation, the data used, and a discussion of the results.

2. Methodology

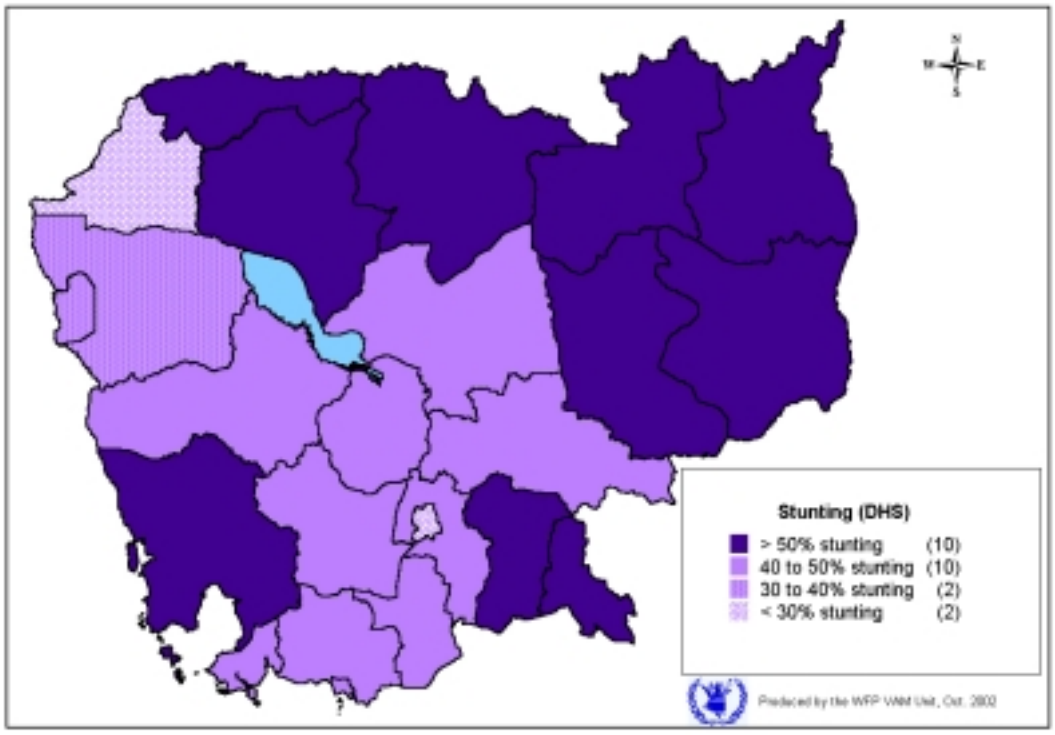
This study builds on the approach used by Hentschel et al (1999), Alderman et al (1999), and Elbers et al (2001) to estimate poverty and inequality measures for households using a combination of Census and survey data. This study is the first application of the methodology to measures of nutritional status, and is the first to predict outcomes other than consumption[2]. Although geographic data have been used in a few applications of this methodology (Mistiaen et al, 2001; Benson et al, 2002), in this case extensive use of the geographic data made a critical difference in the ability to predict stunting and underweight.

The methodology combines the detailed information available in the CDHS survey with the complete coverage of the census and geographic indicators to generate a disaggregated map of malnutrition. The CDHS survey contains the outcome variables of interest: height and weight measurements for children under age 5. Stunting and underweight are estimated from the survey data using only explanatory variables that are found in both the survey and the census, along with geographic indicators available for the entire country at the village or commune level. The resulting parameter estimates are then applied to the census data, and stunting and underweight predictions are aggregated to the lowest geographic unit possible with acceptable standard errors. Case studies using this methodology for consumption expenditure estimates show that the method provides unbiased estimates with relatively small standard errors, and is precise enough to allow for comparisons across geographic areas (Hentschel et al, 1999). Separate models were calculated for the following five ecozones in Cambodia: Urban, Plain, Tonle Sap, Coastal, and Plateau (see Table 1 and Map 3).

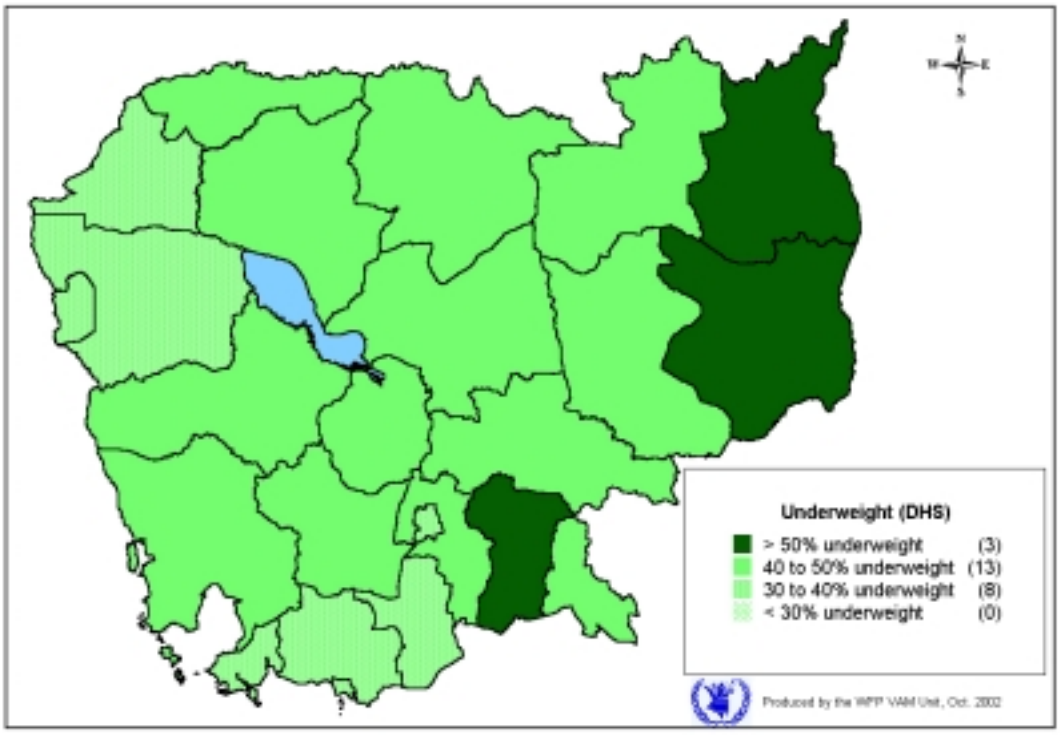
[2] The results presented here are preliminary. Further refinement may be required to improve the reliability of estimates.

The methodology also allows for the estimation of standard errors associated with the predictions of underweight and stunting prevalence. The calculation of standard errors is necessary to evaluate the reliability of the estimates. When the standard errors are too large, the estimates are not useful as it is impossible to rank communes accurately. While the method allows us to derive estimates at any level of aggregation, the standard errors tend to be larger at lower levels of aggregation, where population size may be small. The standard errors associated with the estimates presented here are taken into account in the maps presented with the discussion of results in Section 4.

Map 1. Percentage of stunted children under 5



Map 2. Percentage of underweight children under 5



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3. Data

CDHS data

The CDHS was designed to collect health and demographic information for the Cambodian population, with a particular focus on women of childbearing age and young children. The cluster sample covered 12,236 households across the country. Survey estimates were produced for 12 individual provinces, (Banteay Mean Chey, Kampong Cham, Kampong Chhnang, Kampong Speu, Kampong Thom, Kandal, Koh Kong, Phnom Penh, Prey Veng, Pursat, Svay Rieng and Takeo) and for the following five groups of provinces: i) Battambang and Krong Pailin, ii) Kampot, Krong Preah Sihanouk and Krong Keb, iii) Kracheh, Preah Vihear and Stueng Treng, iv) Mondul Kiri and Rotanak Kiri, and v) Otdar Mean Chey and Siem Reap.

In addition to detailed information about each household, its members, and housing characteristics, one half of these households were systematically selected to participate in the anthropometric data collection. All children under 60 months of age in the sub-sampled households were weighed and measured. After excluding children for whom information on height or weight was missing or implausible, 3,596 observations were used for this analysis.

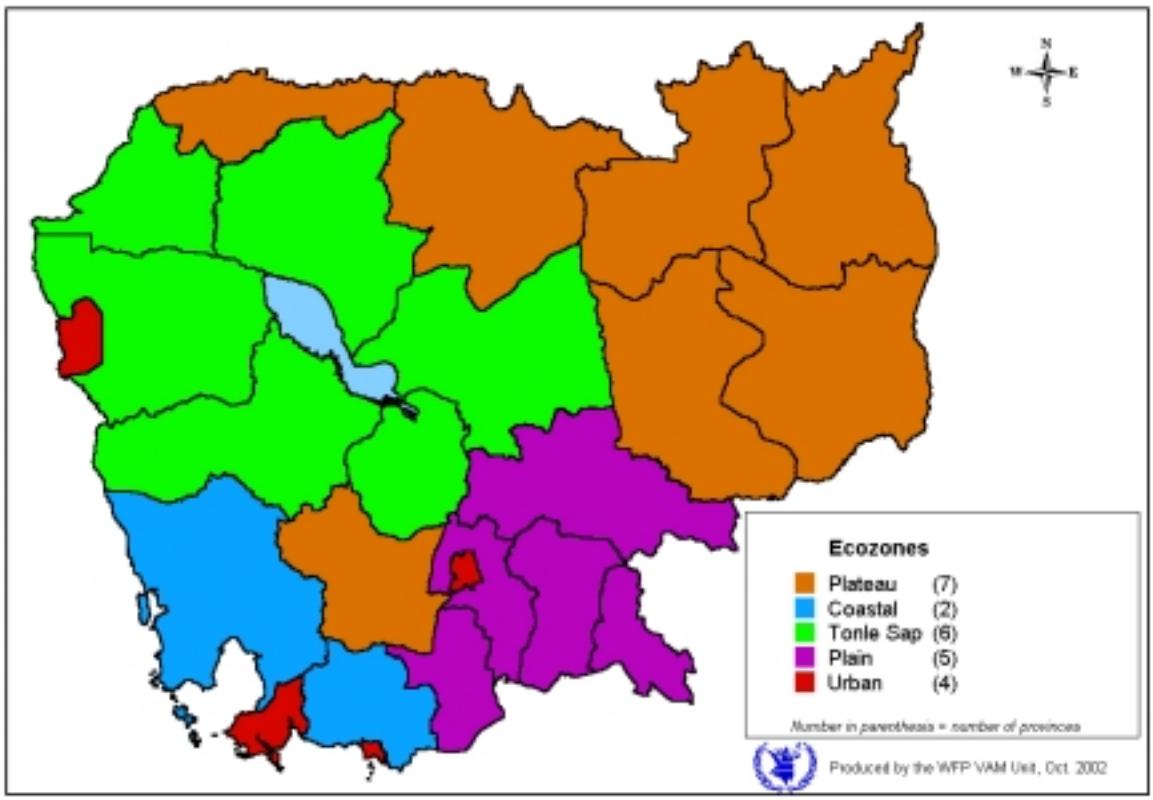
Since height and weight increase as the child gets older, the measurements must be standardized so that they can be compared across different ages. The z-score is a conventional measure for this purpose. However, because of the technical requirements of the methodology, the outcome variable had to be non-negative and continuous. Consumption measures always take on non-negative values, therefore a transformation of z-scores that would produce non-negative measures of height and weight was needed. The z-scores were standardized using the distribution of height and weight of 24 month-old females in a healthy population as the reference. Each child's original height-for-age z-score was converted to the height of a 24 month old girl with the same z-score. Weight-for-age z-scores were treated in the same manner. This allowed the outcome variables to remain positive as they represented height in centimeters or weight in kilograms. This approach avoids the methodological problems arising from the use of the original z-scores, which have both positive and negative values. This transformation has been previously applied to z-scores to measure health inequality (Pradhan, Sahn and Younger, 2002).

Table 1. Number of children under 5 by ecozone[3]

Province	Ecozones					Total
	Urban	Plain Rural	Tonle Sap Rural	Coastal Rural	Plateau Rural	
Banteay Mean Chey	31	0	149	0	0	180
Baatambang	24	0	155	0	0	179
Kampong Chaam	2	189	0	0	0	191
Kampong Chhnang	25	0	254	0	0	279
Kampong Speu	10	0	0	0	237	247
Kampong Thom	25	0	151	0	0	176
Kampot	3	0	0	128	0	131
Kandal	6	179	0	0	0	185
Koh Kong	38	0	0	200	0	238
Kracheh	42	0	0	0	103	145
Mondol Kiri	29	0	0	0	59	88
Phnom Penh	136	0	0	0	0	136
Preah Vihear	18	0	0	0	65	83
Prey Veng	9	151	0	0	0	160
Pursat	26	0	236	0	0	262
Rotanak Kiri	22	0	0	0	179	201
Siem Reap	23	0	191	0	0	214
Krong Preah Sihanouk	57	0	0	0	0	57
Stueng Treng	18	0	0	0	36	54
Svay Rieng	6	147	0	0	0	153
Takeo	4	181	0	0	0	185
Otdar Mean Chey	9	0	0	0	21	30
Krong Keb	11	0	0	0	0	11
Krong Pailin	11	0	0	0	0	11
Total	585	847	1,136	328	700	3,596

[3] Unweighted number of cases.

Map 3. Ecozones of Cambodia



Cambodian National Population Census

The second data source was the Cambodian National Population Census, the first population census to be conducted in Cambodia since 1962. The census covered all persons staying in Cambodia, including foreigners, at the reference time of midnight of March 3, 1998. The 1998 census in Cambodia gathered information to allow a count of the population, as well as detailed information on housing characteristics. Additionally, the census included detailed information on each usual household member and visitors present on the reference night, including the relationship to the head of household, sex, age, marital status, migration, literacy, education and employment. The census also contained questions on fertility of females aged 15 and over, and infant mortality.

GIS data

A set of geographic indicators was also used in this analysis. Because Cambodia has a rich collection of geographic data, indicators on a range of characteristics could be generated. These indicators included distance calculations, land use and land cover information, climate indicators, vegetation, agricultural production and flooding. A number of data sets from various sources were compiled into a GIS and these indicators were generated for all villages and communes in Cambodia. Very coarse resolution data was summarized at the commune level, while high resolution data was attributed to individual villages. Distances from villages to roads, other towns, health facilities, and

major rivers were calculated from the center of the villages. Indicators based on satellite data with varying temporal resolutions included land use within the commune (agricultural, urban, forested, etc.), a vegetation greenness indicator to proxy agricultural productivity, and the degree to which the area was lit by nighttime lights as a proxy of urbanization. Relatively stable indicators including soil quality, elevation, and various 30-year average climate variables were derived from other composite data sets.

4. Results

After the predictions for stunting and underweight were estimated for each child in the census, these estimates were aggregated to the commune level for the 1,616 communes in Cambodia[4]. To evaluate the reliability of the estimates, the provincial level CDHS prevalence of stunting and underweight were compared to the predicted provincial level estimates using the census, DHS and GIS variables. Table 2 summarizes these results. For four of the eco-zones, the differences are within two standard errors of the CDHS estimates, suggesting that the predicted estimates are reliable[5]. However, the estimated prevalence of stunting for Tonle Sap is outside the standard error bounds of the CDHS estimate. Further research will attempt to determine why the model for this stratum does not appear to adequately explain stunting.

The following maps show the commune level estimates as compared to the national averages for stunting and underweight. For each commune, the difference between the commune level estimate and the national average is divided by the standard error of the estimate for that commune. The resulting z-scores are classified as follows: greater than two standard deviations above the mean is significantly above average, between zero and two is above average, between zero and negative two is below average, and lower than negative two is significantly below average. Commune level estimates and standard errors are provided in Appendix 2.

Stunting

The red areas in Map 4 indicate levels of stunting that are significantly above the national average of 45%. Concentrations of significantly high levels of stunting are spread throughout Cambodia. In the densely populated parts of the country surrounding Phnom Penh, the provinces of Kandal, Prey Veng, Svay Rieng, Kampong Cham, and Kampong Chhnang all exhibit large areas of significantly high prevalence of stunting. Most of the communes in Kampot province, also densely populated, show significantly high rates of stunting. In other parts of the country which are less populated and generally more forested such as Preah Vihear, Stueng Treng, and Rotanak Kiri in the north, and Koh Kong on the Gulf of Thailand, there are also concentrations of high rates of stunting. Areas that have significantly low prevalence of stunting include Phnom Penh, Mondol Kiri, and Eastern Battambang. Communes around Tonle Sap Lake in Pursat and Kampong Thom provinces also have significantly low stunting rates. There appears to be an east-west band across the middle of the country where children are less

[4] At the time of the 1998 Census there were 1,616 communes in Cambodia. Since then, some new communes have been created but estimates were not generated for these.

[5] An evaluation of the estimated standard errors can be found in Appendix 1.

stunted.

Table 2. Stratum level comparison of estimates

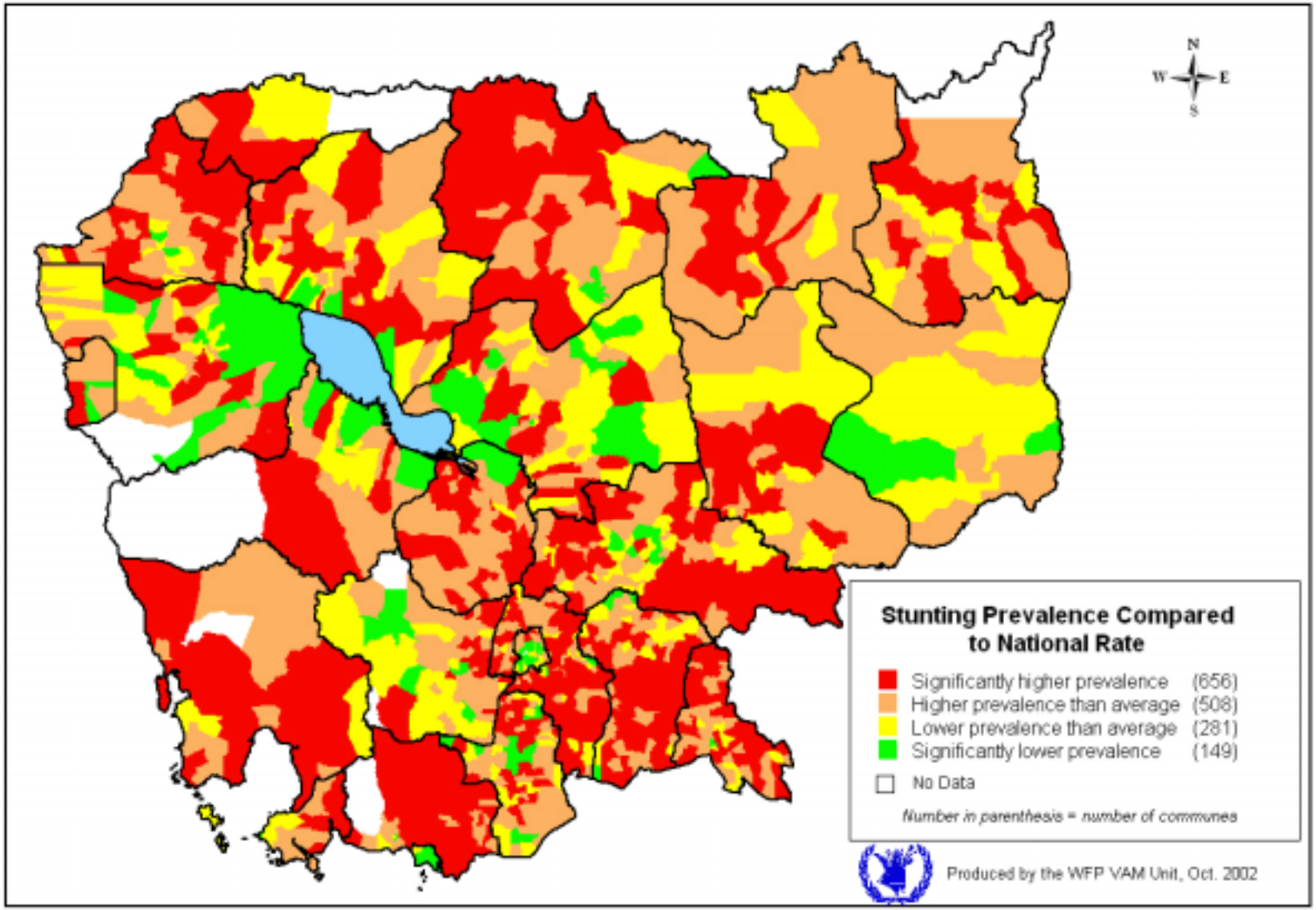
Measure/Stratum		DHS Only		DHS + census	
Stunting	Urban	37.9	(3.2)	43.1	(0.7)
	Plain	47.6	(2.8)	49.9	(0.5)
	Tonle Sap	42.9	(2.0)	47.3	(0.6)
	Coastal	47.2	(4.7)	53.1	(0.9)
	Plateau	47.1	(2.8)	47.6	(0.9)
Underweight	Urban	39.6	(2.8)	39.5	(1.2)
	Plain	47.8	(2.4)	44.5	(3.5)
	Tonlesap	45.8	(2.1)	42.1	(3.7)
	Coastal	39.0	(4.8)	38.9	(1.9)
	Plateau	46.4	(3.1)	50.5	(3.0)

Note: All the figures are percentages and figures in brackets are standard errors. The standard errors for DHS Only take into account clustering, expansion factors and intra-household correlation. The urban estimates for DHS include all children in Phnom Penh, and in all other urban areas of the country.

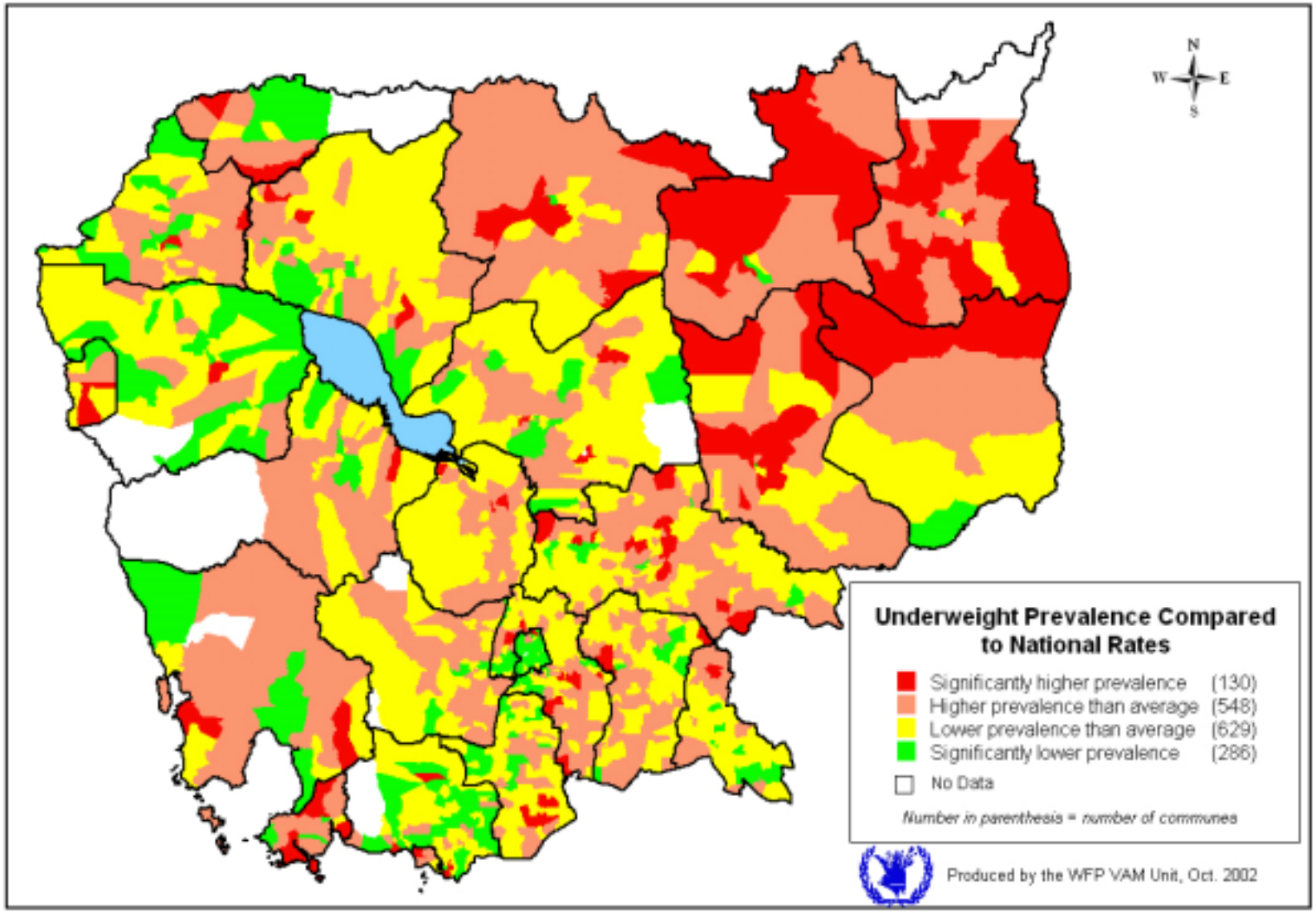
Underweight

The red areas in Map 5 represent the communes where the prevalence of underweight children is significantly above the national average of 45%. Unlike the prevalence of stunting, the concentration of significantly underweight children is clearly clustered in the northeastern part of the country. Most of the communes in the provinces of Stueng Treng, Rotanak Kiri, Kracheh, and much of Preah Vihear exhibit significantly higher than average rates of underweight children. However, the population density in these areas is quite low. Some concentrations of significantly low rates also appear in more densely populated areas in the south, particularly Kampong Cham and Kandal; and in Koh Kong. -is this a mistake? Areas of significantly lower underweight prevalence include communes around Lake Tonle Sap in Battambang, Siem Reap and Pursat. Otdar Mean Chey and Banteay Mean Chey in the north also exhibit significantly low underweight prevalence, as well as parts of Kampot in the south, and Phnom Penh.

Map 4. Commune-Level Stunting Rates Compared to National Rates



Map 5. Commune-Level Underweight Rates Compared to National Rates



5. Discussion

Previous estimates of the prevalence of child malnutrition from the CDHS were only available at the province level. Such estimates are useful to target interventions in areas with a high prevalence of malnutrition throughout the province, such as the northeastern provinces. However, provincial estimates often mask great disparities in the prevalence of malnutrition within the province. Targeting based on such estimates will likely fail to capture many malnourished children.

The uses and inferences that can be drawn from these results are many. Some possible directions for further study are as follows:

Understanding the determinants of malnutrition to better inform program planners. The power of these maps can be multiplied when they are combined with others to explain relationships among outcomes. For example, where high rates of malnutrition overlap with high poverty rates it might be assumed that there is insufficient access to food. An overlay of stunting prevalence with women's education as a proxy for child care may be a first step towards understanding and distinguishing areas of high malnutrition along with their causes. Such exploratory maps may be followed with a multivariate analysis of the underlying and immediate causes of malnutrition. The conclusions drawn from such integration of maps and follow-on analysis can inform program planners so that interventions can be designed and targeted more effectively.

Validating the commune level estimates. Because of the exploratory nature of this study, it would be valuable to try to validate these estimates from external data sources. This could be done using another dataset (population survey, or perhaps facility based surveillance data) or through a ground-truthing study. Validation is especially important if these maps were to be used individually to target resources.

Updating the map of malnutrition. Another direction for further research is to develop methods of updating these maps when new survey data becomes available. Currently, efforts are being made to develop such methods to update poverty maps for other countries. Such updating would be desirable for the nutrition estimates in the near future. In the mean time, these maps should be used in combination with other data sources whenever possible, especially when important programmatic decisions are at stake. As the methodology evolves, the quality and reliability of results are expected to improve.

Dissemination of the malnutrition maps for wider use. A number of ongoing national level initiatives could benefit from these estimates, including:

- Millennium Development Goals: The first goal is the reduction of hunger and poverty. A key indicator for monitoring hunger is the proportion of children underweight. Government and donor interventions to reach the goal might in part be targeted on the basis of the estimates presented in this study.

- Cambodia Nutrition Investment Plan: Developed by the Ministry of Planning in

conjunction with other Ministries and donors, this plan aims to address malnutrition in Cambodia.

- World Bank Poverty Reduction Strategy Paper and Asian Development Bank's Socio Economic Development Plan: These two documents form the overarching development goals and actions of the Government of Cambodia. Including maps of the prevalence of malnutrition in these papers would help ensure that the issue receives attention from decision makers.

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Appendix 1. Estimated standard errors for stratum level estimates.

The level of accuracy of the commune-level estimates varies. Table 1 provides summary statistics on the standard errors. The first column, Mean S.E., is the simple average of the standard errors for each ecozone. Standard errors are generally low for the estimates of stunting. The median of the standard errors is presented in the second column, Median S.E. The third column, S.E. Ratio, is the average of the ratio of the standard error to the point estimate. The fourth, # Commune, is the number of communes in the stratum. The standard errors are low enough for the results to be useful as proxies, but are high for a number of communes, especially for the estimates of prevalence of underweight. In particular, the estimates of prevalence of underweight for the Plain, Tonlesap and Plateau strata have relatively high levels of standard error.

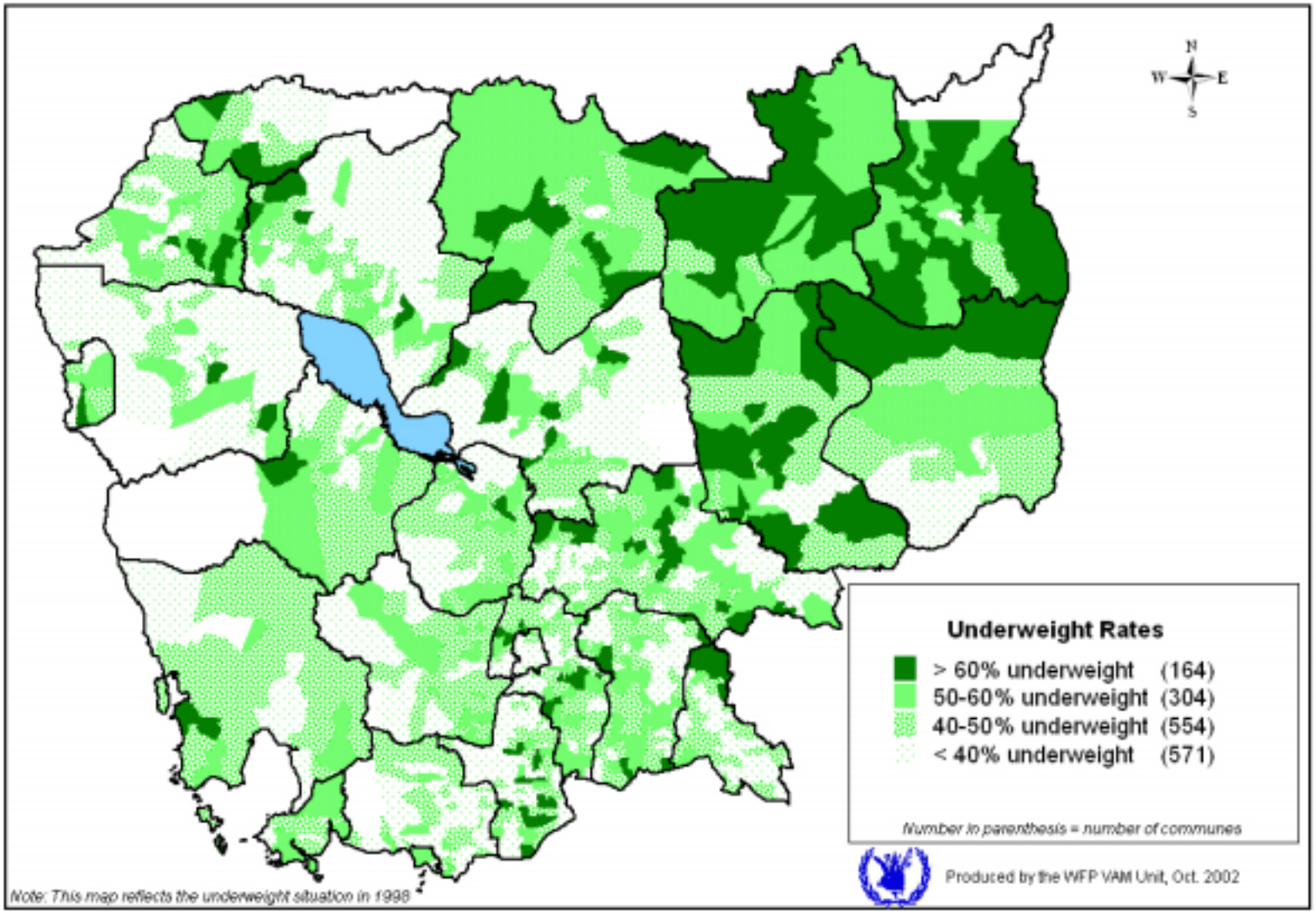
It should be noted that a relatively high level of standard error may not matter for the purpose of targeting if the point estimates are high enough. A commune with the point estimate of 95% and standard error of 15% for prevalence of stunting would be far worse than other communes. On the other hand, even if the ratio of the standard error to the point estimates is high, it does not matter when the absolute value of the standard error is low. If the point estimate and standard error were 0.1% for prevalence of underweight, then the commune should not be targeted for intervention.

Table 1. Summary Statistics: Standard errors for commune-level estimates

Measure/Stratum		Mean S.E.	Median S.E.	S.E. Ratio	# Commune
Stunting	Urban	2.38	2.17	5.51	235
	Plain	2.21	2.36	4.90	591
	Tonlesap	3.08	2.38	6.69	389
	Coastal	2.64	2.30	5.04	116
	Plateau	3.17	2.94	6.68	262
Underweight	Urban	3.35	3.21	8.24	235
	Plain	8.31	7.95	20.33	591
	Tonlesap	9.10	7.44	28.24	389
	Coastal	3.82	3.59	10.46	116
	Plateau	7.46	7.14	1.44	262

Note: All figures except for # Commune are expressed as percentages.

Annex 2. a. Commune-Level Estimate of Underweight Rates



Annex 2. b. Commune-Level Estimate of Stunting Rates