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Rose Imee Zhella G. Amar and Zita V.J. Albacea, Ph.D.

For additional information, please contact:

Author's name : Rose Imee Zhella G. Amar
Designation : Instructor
Affiliation : Institute of Statistics, U.P. at Los Baños
Address : College, Los Baños, Laguna
Tel. no. : (049) 536-2381
E-mail : arz911@yahoo.com

Co-author's name : Zita V.J. Albacea
Designation : Associate Professor
Affiliation : Institute of Statistics, U.P. at Los Baños
Address : College, Los Baños, Laguna
Tel. no. : (049) 536-2381
E-mail : zvjalbacea@yahoo.com

Barangay Level Estimation of the Proportion of Underweight Filipino Children Aged 0–5 Years¹

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Rose Imee Zhella G. Amar and Zita V.J. Albacea, Ph. D.²

ABSTRACT

This paper addresses estimation of the proportion of underweight children aged 0 – 5 years at the barangay level, applying direct and indirect estimation techniques. Using the 2001 Updating of the National Nutrition Survey, the direct estimation technique resulted to proportions which range from 0 to 0.74, with mean square errors (ranging from 0.0008 to 0.0249) and coefficients of variation (all above 10%, some exceeding 100%) indicating the estimates as unreliable. One of the indirect estimation techniques, the regression-synthetic estimator of the proportion, a weighted least squares model with an adjusted- R^2 of 27.01% was constructed with the following predictors: barangay-level proportions of households headed by a person with no spouse, with at least one member aged less than 1 year, headed by a person who completed 6th grade, housing units with outer walls made of strong materials, and whether or not there are from 1 to less than 10 restaurants, and provincial ratio of number of trained birth attendants (locally known as “hilot”) to population. Estimates of the barangay-level proportion range from 0.05 to 0.49 with small mean square errors (from 0.000046 to 0.0011) and coefficients of variation (almost 96% are less than 10%). The other indirect estimation technique used was the empirical best linear unbiased prediction (EBLUP) technique, a weighted combination of the direct and regression-synthetic estimators. The estimated proportions range from 0.07 to 0.50. The corresponding mean square errors ranging from 0.0007 to 0.0024 and coefficients of variation (ranging from 9.47% to 58.58%) were smaller than those of the direct but not of the regression-synthetic estimates. Thus, the ‘best’ set of estimates was obtained using the regression-synthetic estimator since this provided the most precise, accurate, and reliable estimates among the three techniques.

Keywords: *small area estimation, malnutrition, proportion of underweight*

I. INTRODUCTION

The nutritional status of individuals is an important gauge of a country’s development. Monitoring it reflects an assessment of the quality of life of the individuals and their standard of living. In particular, the nutritional status of children is of utmost importance.

Nutrition, a basic human need, remains unmet for vast numbers of children, who are unable to achieve their full genetic development potential (de Onis et al. 1993). Four malnutrition problems affect young children, one of which is protein-energy malnutrition, wherein there is a lack of energy and protein which results in growth retardation. Prevalence of this form of malnutrition can be assessed through anthropometric measurements such as

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²Instructor and Associate Professor of Statistics, respectively, Institute of Statistics, University of the Philippines at Los Baños, Laguna.

height and weight. From these, the weight-for-age, height-for-age, and weight-for-height indices are computed and compared with the USA's National Center for Health Statistics (NCHS)/World Health Organization (WHO) standards. A child is considered underweight, underheight (or short) or thin if his weight-for-age, height-for-age, or weight-for-height index, respectively, is below the median of the NCHS reference population less 2 standard deviations.

De Onis et al. (1993) describes the weight-for-age index as representing a convenient synthesis of the assessment of both linear growth and body proportion. Hence, a child being underweight can be seen as an indication of insufficient or unbalanced diet, the inadequacy to sustain linear growth and body proportion. Internationally, the prevalence or the proportion of underweight children (under five years of age) is one of the indicators listed to assess attainment of the first of the Millennium Development Goals, which is to eradicate extreme poverty and hunger as stated in the Millennium Declaration (September, 2000). The indicator helps address the second target, which is to halve, between 1990 and 2015, the proportion of people who suffer from hunger.

So far, trends in the proportion or prevalence of underweight among 0 – 5 year-old children show no consistent upward or downward movement from 1989-90, 1992, 1993, 1996, 1998, and 2001. Based on initial results of the 2003 6th National Nutrition Survey (NNS), 27.6 % of children under five years of age are underweight. (<http://fnri.dost.gov.ph/nns/6thnns.pdf>). The surveys are conducted at the national and sub-national levels by the leading agency in food and nutrition research in the country, the Food and Nutrition Institute (FNRI) under the Department of Science and Technology (DOST). In 1996 and 1998 FNRI's surveys yielded provincial level estimates in response to the clamor of local government units and planners for estimates that are more relevant to local planning (Cerdeña et al. 2001). However, in the more recent surveys, aside from national and regional estimates, provincial estimates for only some selected provinces were obtained due to limited budget allocated to the project.

Since much of the decision-making process involves sub-national levels, such as at the barangay, provincial or municipal level, the need for sub-national level estimates cannot be ignored. Small area statistics are desired for better implementation, monitoring and evaluation of projects and to determine which areas need more government support. However, conduct of surveys at sub-national levels is costly and time-consuming. Also, the approach of using direct estimates is unreliable mainly because sample sizes in small areas are seldom large enough to provide adequate precision (Ghosh and Rao, 1994). Because of this, it becomes necessary to employ indirect estimators that borrow data from related areas to increase the effective sample size and thus increase the precision. This estimation may

be done using explicit or implicit modeling through the use of census and/or administrative data (Rao, 2000).

This paper focuses on obtaining barangay-level estimates for the proportion of underweight children aged 0 – 5 years, specifically in estimating the proportion of underweight children aged 0 - 5 years at the barangay level using direct and indirect methods; assessment of these estimates; comparison of the different methods for obtaining the estimates and recommendation of the method which provides the ‘best’ set of estimates.

II. METHODOLOGY

The data set used in this study is the 2001 Updating of the Nutritional Status of 0–10 year-old Filipino Children at the Regional Level (2001 Updating) of the Food and Nutrition Research Institute (FNRI). This survey employed a stratified two-stage sampling design covering 16 regions with 96 survey areas (79 provinces and 17 cities/municipalities) of the country. In each province, barangays were grouped according to size into different strata. Barangays and individuals were the primary and secondary sampling units, respectively. A total of 10,634 children aged 0 – 5 years were sampled.

Related variables were also determined from the 2000 Census of Population and Housing (CPH). The census provides information on the total population (its size, distribution, and characteristics of individuals and households), housing units (supply, characteristics, and facilities), as well as characteristics of barangays in the Philippines. Likewise, information on the following were also considered for possible auxiliary variables: provincial level health-related characteristics from the 2000 Field Health Service Information System (FHSIS) of the Department of Health, year 2000 enrollment information of the Department of Education, and income class of the provinces and municipalities.

To determine whether a child is underweight, the computed value of the weight-for-age index is compared with the USA’s National Center for Health Statistics (NCHS)/World Health Organization (WHO) Standards. A child is deemed underweight if his or her weight-for-age measure is below the median weightfor-age minus 2 standard deviations of the NCHS reference population.

The direct estimate of the proportion of underweight children aged 0 – 5 years \hat{p}_i was computed as the ratio of the estimates of the total number of underweight children aged 0 – 5 years and total number of children aged 0 – 5 years in the i^{th} barangay. Assessment of this estimator was done based on estimates of bias, mean square error (mse), and coefficient of variation. Acceptable or valid estimates are those with small values of these

measures. Based on the coefficient of variation, the bias of an estimator may be safely regarded as negligible if the computed coefficient is below ten percent (Cochran, 1977).

For the first indirect estimation technique, a regression-synthetic estimator was determined. Predicted values, \hat{p}_i , obtained using a weighted least-squares estimator served as the regression-synthetic estimator of p_i . The weighted least squares estimator was obtained by regressing \hat{p}_i on the auxiliary variables with weights the inverse of the total variance. Estimates of the mean square error and coefficient of variation were obtained to evaluate the estimated proportions. Also, the coefficient of multiple determination or R^2 and the adjusted R^2 were examined to assess the adequacy of the model used in predicting the barangay-level proportion of underweight children aged 0 – 5 years. Additional assessment and validation of the model was also done including ensuring satisfaction of the assumptions required for regression analysis and studying the adequacy of the model based on the coefficient of determination.

With appropriate weighting, the regression-synthetic estimate was then combined with the direct estimate to come up with the empirical best linear unbiased prediction (EBLUP) estimate, \hat{p}_i^H . In barangays with no direct estimates, the EBLUP estimator was based solely on the regression-synthetic estimator using information from the selected predictor variables associated with those areas. Estimates of the mean square error and coefficient of variation were computed for the barangays with both direct and regression-synthetic estimates.

The direct and indirect estimates of the barangay-level proportion of underweight children aged 0 – 5 years were compared based on their statistical properties. The set of estimates which can be considered the most accurate, precise and reliable was determined as 'best'.

III. RESULTS AND DISCUSSION

The "2001 Updating of the Nutritional Status of Filipino Children" indicates that 30.6% of Filipino children aged 0 – 5 years are underweight. From the 585 barangays surveyed, it was observed that direct estimates of the proportion of underweight Filipino children aged 0 – 5 years varied greatly, with values from 0 to 0.74, of which about 50% are from above 0.2 to 0.4.

For the regression-synthetic estimator, a multiple linear regression model with 6 predictors was determined based on data on the 575 barangays with measures of reliability and over 400 matching auxiliary variables. In choosing the model, the classical assumptions

of the linear regression analysis were verified. The identified predictors and its corresponding estimated coefficients for a weighted least squares regression model are presented in Table 1.

Table 1. Predictors used in the weighted least squares estimator of the barangay-level proportion of underweight children aged 0– 5 years.

PREDICTOR	COEF-FICIENT	STANDARD ERROR	p-VALUE
barangay proportion of housing units with outer walls made of strong materials	-0.133	0.023	0.000
barangay proportion of households headed by a person with no spouse	-0.550	0.093	0.000
barangay proportion of households with at least one member aged less than 1 year	0.475	0.141	0.001
barangay proportion of households headed by a person who completed 6 th grade	0.149	0.052	0.004
whether or not there are from 1 to less than 10 restaurants in the barangay	-0.037	0.012	0.002
provincial ratio of the number of trained birth attendants (locally known as <i>hilot</i>) to the population	31.532	10.496	0.003
(intercept)	0.365	0.034	0.000

For this model, the coefficient of determination, R^2 is 27.70% with an adjusted R^2 of 27.01%. This means that about 27% of the total variation in the proportion of underweight children aged 0 – 5 years in a barangay is explained by the predictors of the model. All the auxiliary variables were significant predictors at the 1% level of significance.

Based on the model, the average proportion of underweight children aged 0 – 5 years at the barangay level is 0.365. The predictors with negative coefficients contribute to a decrease in the number of underweight children aged 0 – 5 years in the barangay.

Based on the weighted least squares estimator, the predicted proportions ranged from 0.05 to 0.49. Over 80% of these proportions are from above 0.2 to 0.4.

Using the EBLUP estimation technique, the values ranged from 0.07 to 0.5. Of the 575 estimates, about 78% fall in the range from above 0.3 to 0.4.

In comparison, the regression-synthetic and EBLUP estimates had ranges narrower than that of the direct estimates. Of the three, the regression-synthetic estimates are grouped within the shortest range (see Figure 1).

For the 577 barangays with non-zero direct estimates, the estimated bias ranged from -0.0121 to 0.0075, with a majority within the range from above -0.002 to 0.002. Only 6.07% of the estimates have biases from above 0.002 to 0.008, while 9.01% of the biases were at most -0.002. The values of the bias estimates are small. On the average, the estimated proportions differed from the true value by no more than an estimated absolute value of 0.0121.

A big difference is observed in the distribution of the mean square errors of the three techniques. Based on the distribution, only 3 direct estimates have mean square errors that are most 0.002 while all regression-synthetic estimates have mean square errors of at most 0.002. Furthermore, for the EBLUP estimates, all the mean square errors are at most 0.004 whereas for the direct estimates, only about 3% of the mean square errors are at most 0.004. As shown in Figure 2, the differences between the direct and indirect estimates are very visible. The observations for the indirect estimates are found only on the first two categories unlike the direct estimates which have only very few mean square errors in the first two categories and are distributed over a wide range.

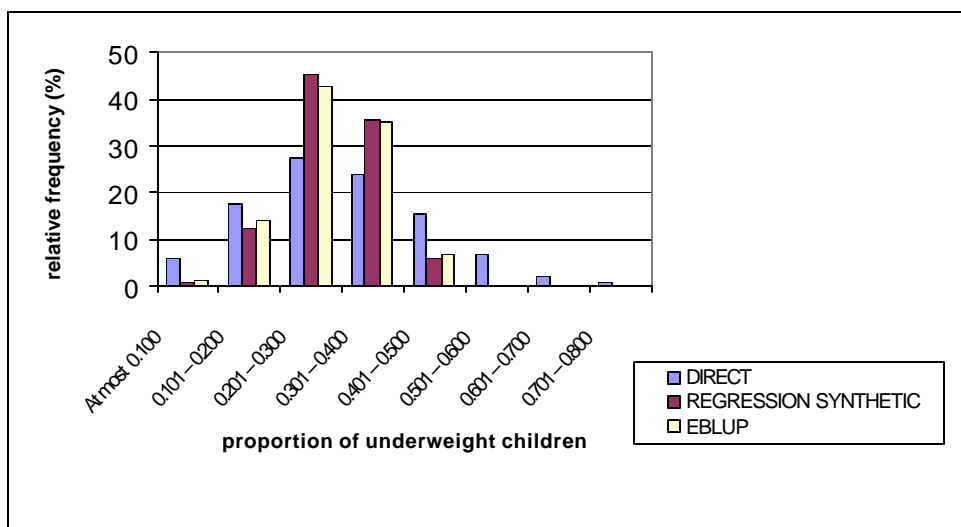


Figure 1. Estimates of the barangay-level proportion of underweight children aged 0 – 5 years using direct and indirect estimation techniques.

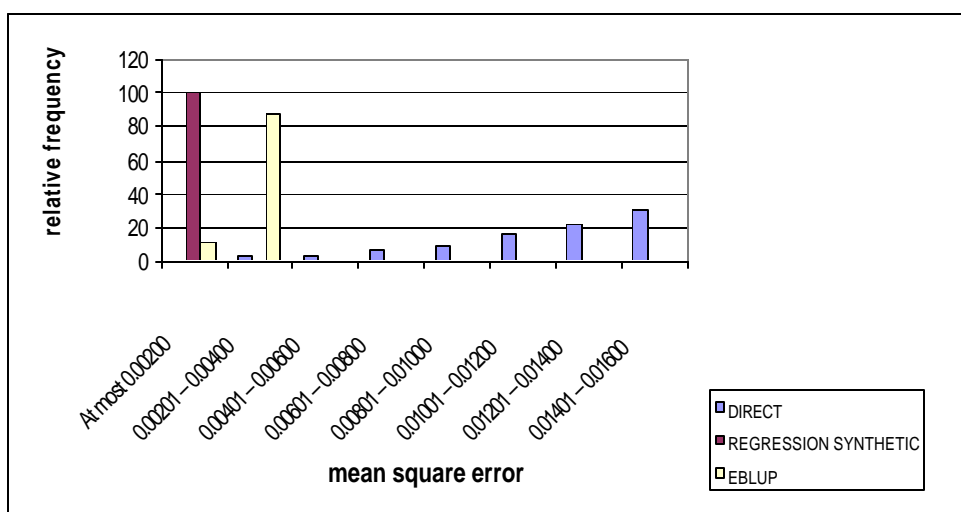


Figure 2. Mean square errors of the estimates of the barangay-level proportion of underweight children aged 0 – 5 years using direct and indirect estimation techniques.

Lastly, for the coefficients of variation, the differences between the direct and indirect estimates are also clearly seen. For the direct estimates, the values are all above 10%, ranging from 14.44% to 103.36%. The indirect estimates, on the other hand, are distributed over about half the range of the direct estimates. Between the two indirect estimates, the regression-synthetic estimation gave the most number of reliable estimates, about 96% of the coefficients are at most 10%. For the EBLUP estimates, only 3 are at most 10% but about 75% is in the range from 10% to 20%. The differences are most noticeable in the graph (Figure 3). The EBLUP estimates are more evidently distributed over many categories than the regression-synthetic estimates.

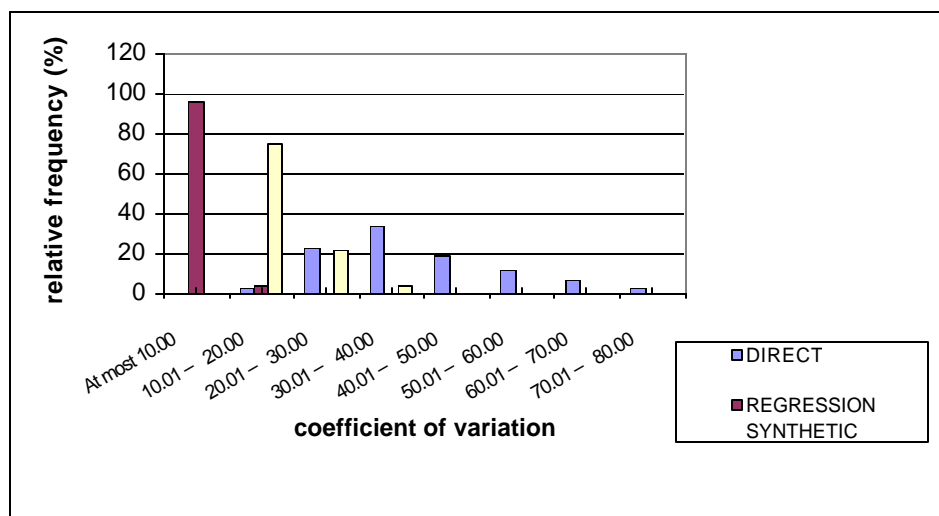


Figure 3. Coefficient of variation of the estimates of the barangay-level proportion of underweight children aged 0 – 5 years using direct and indirect estimation techniques.

As part of the assessment of the three estimation techniques used, the top 20 barangays in terms of the proportion of underweight children aged 0 – 5 years were looked into. Only three barangays were common on the three lists: the barangays Imelda and Laoangan in Northern Samar and Looc in Masbate. Of the top 20 barangays determined using the direct estimation technique, there were a total of 10 barangays which were also found in the top 20 barangays based on EBLUP estimates; whereas 12 out of 20 barangays topping the list based on regression-synthetic estimates were also listed in the 20 based on EBLUP estimates. Hence there were more common barangays between the EBLUP and regression-synthetic estimates than the direct and EBLUP or direct and regression-synthetic estimates.

Among the three estimation techniques, the regression-synthetic estimator was the technique which gave the 'best' set of estimates to determine the top 20 barangays, since

the mean square errors of its set of estimates are the smallest and the coefficients of variation are all less than 10%.

IV. CONCLUSION

Estimates of the proportion of underweight children aged 0 – 5 years for the barangays with survey data ranged from 0 to 0.74. Based on the statistical properties, none of the estimates can be considered reliable. For the regression-synthetic estimator based on the weighted least squares regression model, the estimated proportions ranged from 0.05 to 0.49. The model-based estimation gave reliable results since the mean square errors were very small (from 0.000046 to 0.0011) and almost 96% of the coefficients of variation were at most 10%. However, only about 27% of the variation in the proportion of underweight children aged 0 – 5 years is explained by the set of predictors mentioned above. For the EBLUP estimates, the values range from 0.07 to 0.50. The mean square errors had small values; however, only three of the estimates have coefficients of variation at most 10%.

The “best” set of estimates were obtained using the regression-synthetic estimator since the mean square errors of its set of estimates are the smallest and almost all its coefficients of variation are less than 10%. However, care should be taken in using this technique since it is greatly restricted by the model used for prediction.

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