Estimation of the Provincial Counts of Vitamin A Deficient Children Aged Six Months to Five Years in the Philippines[1]

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This paper aims to present methodologies in estimating the number of Vitamin A deficient children aged six months to five years in the Philippine provinces. Data from the 6th National Nutrition Survey (NNS), specifically, the data on plasma retinol which is used to directly determine Vitamin A deficiency is used to compare direct and model-based methods. The direct estimates obtained was used as the dependent variable while the 2000 Census of Population and Housing and 2002 Field Health Service Information System were used as sources of auxiliary variables in the Poisson regression fitted using robust standard errors which resulted to a model with Pseudo-R^2 of 55.57%. Measures of precision and reliability were also obtained to assess the properties of the estimates for the provincial estimates. In direct estimation technique, 71 provinces have valid estimates but the coefficient of variations are all greater than 20%. On the other hand, valid model-based estimates using Poisson regression were observed for 72 provinces, but the coefficient of variations are at most 10% for 78% of these provinces. The use of Poisson regression based model generated more precise estimates of the number of children with Vitamin A deficiency for the provinces.

Keywords: Small area estimation, Poisson regression model

1. Introduction

Micronutrient malnutrition such as Vitamin A deficiency has been a public health problem in the Philippines. Vitamin A deficiency or VAD is a condition that covers all physiological disturbances caused by low Vitamin A level, including

1 Major results presented in this paper were taken from the unpublished Master's thesis of LPD Abitona under the supervision of ZVJ Albacea.

subclinical and clinical signs and symptoms which is reflected using the plasma retinol level (NSCB, 2008). Based on the 6th National Nutrition Survey, VAD was considered as one of the most common micronutrient deficiencies with a national estimate of 40.1% among children aged six months to five years. This means that from four in every 10 children aged six months to five years suffered from VAD. After five years, the 7th National Nutrition Survey reported that the national prevalence was down to 15.2%. (FNRI, 2009). Thus, there was a reported decrease of the prevalence at the national level. However, there is a need to assess the condition at a lower level of disaggregation or at sub-national level specifically at the provincial level.

The official statistics that are usually generated in the Philippines are at the national and regional levels only since most of the nationwide surveys have consider regions as the domains. The National Nutrition Survey (NNS) provide inputs in policies and programs related to nutrition. For instance, because of the reported high prevalence of VAD, the law known as the Food Fortification Act of 2000 (RA 8976) was enacted. This law provides for the mandatory fortification of staple foods based on standard set by the Department of Health (DOH) and a voluntary fortification of all processed foods or food products under the Sangkap Pinoy Seal Program. Also, the DOH issued Administrative Order 3-A series of 2000 which includes priority targets, mechanics and schedule of supplementation, distribution, handling, and storage of Vitamin A capsules, and implementation of a monitoring system.

On the other hand, the disaggregated statistics could help determine the prevalence of Vitamin A deficient children in the country and could also be used for better implementation of existing programs. It is also considered a better strategy in determining which sub-national locality like a province would need more support. In addition, estimates at the provincial level could provide more reliable information as bases for plans, policies and decisions and as inputs to research studies and development projects especially for the children in the provinces. The information from these estimates can provide policymakers and development program planners an accurate picture of the nutritional status of Filipino children. Accurate evaluation of the hunger and nutrition situation of the Philippines may serve as basis for policy and program recommendations of short and long term solutions to the national problem of nutrition and health. Hence, the obtained estimates are valuable and relevant in assessing the quality of life of the people especially the children.

With this objective, this paper provides alternative methodologies to generate reliable provincial count estimates of Vitamin A deficient children aged six months to five years. The counts obtained from these methodologies could be used to target the rightful beneficiaries of the program that could prevent the prevalence of Vitamin A deficiency.

One approach of generating sub-national level statistics is to obtain it directly from the nationwide survey. However, large standard errors of the estimates may occur because the sample sizes within the subpopulations tend to be very small and some subpopulations may not be sampled at all in the survey. Due to large standard errors, direct survey estimates for small areas are unreliable (Ghosh and Rao, 1994).

An alternative is the use of a model-based approach in small area estimation (SAE). The approach uses models to connect the small areas and obtain estimates with improved precision by 'borrowing strength' through the use of auxiliary variables (Ghosh and Rao, 1994; Rao, 2003). Hence, with the use of some auxiliary information, the estimates can then be improved giving lower standard errors. The traditional indirect techniques of SAE include the demographic, synthetic and composite methods of estimation. Moreover, model-based approach includes the regression-synthetic, empirical best linear unbiased prediction (EBLUP), empirical Bayes (EB), hierarchical Bayes (HB) techniques and the Elbers, Lanjouw and Lanjouw (ELL) method.

Since the goal of the study is to predict the number of Vitamin A deficient children in a small area like a province, a regression model that could handle count data can be chosen. Such prediction can also be handled by using a multiple linear regression. However, the predominance of zeros and small values, and the discrete nature of the dependent variable suggest an alternative estimation other than the least squares method in estimating a linear model with a specification that accounts for these characteristics (Greene, 1990). Thus, to consider these characteristics, the Poisson regression model was used to attain the objective of prediction. Moreover, adjustment could also be incorporated in case there are departures in the assumptions of the Poisson distribution.

2. Methodology

The provincial estimates on the number of Vitamin A deficient children aged six months to five years were computed using two estimation techniques, the direct and model-based estimation techniques. In the direct estimation, the data used to directly determine children suffering from VAD were obtained from the 6th National Nutrition Survey (2003 NNS) of the Food and Nutrition Research Institute of the Department of Science and Technology. Only the data set from the 2003 NNS was used since it is the one that is readily available for independent research use.

The Biochemical Component of the 2003 National Nutrition Survey provides data on the Vitamin A status of Filipino children aged six months to five years. Vitamin A deficiency is measured by observing the plasma retinol level for each surveyed child. The WHO/UNICEF/HKI/ IVACG (1982) as cited by the

Department of Science and Technology- Food and Nutrition Research Institute (DOST-FNRI) provided the guidelines for the interpretation of plasma retinol data as shown in Table 1. A child is regarded as deficient if the child's biochemical assessment for plasma retinol is below the cut- off points.

Table 1. Cut-off points for plasma retinol, 1982 WHO

Level	µg/dL	µmol/ L
Deficient	<10	<0.35
Low	10-19	0.35-0.69
Acceptable	20-49	0.70-1.74
High	≥50	≥1.75

In the model-based estimation, the estimation of the count of Vitamin A deficient children was obtained using Poisson regression model. In the Poisson regression model, the provincial direct estimates served as the dependent variable while the auxiliary information served as the independent variables. Auxiliary information was the data sets coming from the 2000 Census of Population and Housing (CPH) and the 2002 Field Health Information System (FHSIS).

The 2000 Census of Population and Housing (CPH) was conducted by the National Statistics Office (NSO). The census provides information on the size and distribution of total population as well as characteristics of individuals and households, and information on supply, characteristics and facilities of housing units, as well as characteristics of barangays in the Philippines.

Another source of data for the modeling process was the provincial level health-related characteristics from the 2002 Field Health Service Information System (FHSIS) compiled by the Department of Health. FHSIS is administrative in nature and is a nationwide compilation of health indicators collected by city and provincial health offices from health facilities such as district hospitals, rural health units and barangay health stations. The indicators collected reflect the state of health programmes like Maternal and Child Health, Family Planning, the Expanded Programme on Immunization, Nutrition, Dental, Communicable and Non-Communicable Disease Prevention and Control, and Environmental Health. Philippine Health Statistics provides summary statistical data of births and deaths registered and reported in a given year, as well as the notified diseases reported in FHSIS.

Prior to model-based estimation, correlation analysis was done in order to select significant variables associated with VAD. The associations of direct estimated counts of VAD with health and socioeconomic variables were examined by using Pearson correlation analyses. These variables were chosen from the CPH and FHSIS data sets since these data sets generally contain health and socioeconomic variables. The choice of the possible auxiliary variables was also based on some related studies that identified the health and socioeconomic correlates of VAD.

Some of these studies include that of Khandait et al. (2000) where they found that Vitamin A deficiency of children under six years of age in the urban slums of Nagpur, India was associated with illiterate mother and lower socioeconomic status. This is also consistent with the study of Demisse et al. (2009) wherein the prevalence of subclinical Vitamin A deficiency among children was significantly higher among children belonging to illiterate mothers, and children belonging to mothers who had low levels of awareness of Vitamin A compared to children belonging to literate mothers, and children belonging to mothers who had better awareness of Vitamin A.

In addition to awareness on child's nutrition, according to the study of Ziol-Guest et al. (2006), single parents spend a smaller share of their food budget on vegetables and fruits. Plant foods, which are mostly eaten in developing countries, such as dark-green leafy vegetables and deep yellow fruits and vegetables contain Vitamin A in a form of provitamin A carotenoids (Miller et al., 2002). Thus, single parenthood may also affect the consumption of Vitamin A rich foods among children.

Moreover, in the improvement of child's health, increasing the proportion of births assisted by skilled birth attendants during delivery is also considered a central strategy. Association was found to exist between number of skilled birth attendants and economic condition of the household. Thus, household factors related to poverty were shown to be important barriers to skilled birth attendant use (Mayhew, 2008). On the other hand, poverty is also associated with inadequate food intake which in turn leads to poor Vitamin A status in children (Jiang et al., 2008). This implies that the number of skilled birth attendants may indirectly affect Vitamin A deficiency among children which through the child nutrition status.

The Poisson regression model expresses the log of the counts of Vitamin A deficient children as a linear function of a set of predictors. Equivalently, since the Poisson model is expressed in a loglinear function, regression coefficients must be exponentiated to give the incidence ratio rates. Moreover, the predictors or the independent variables must not be correlated with each other. The major assumption of the Poisson model is the equality of the mean and variance. To control for the violation of such assumption, robust standard errors for the parameter estimation was obtained.

To choose the 'best' predictive model, Pearson chi-square goodness-of-fit test was used to check if the model adequately fits the data. Then, with the ‘best’ predictive model, the estimated counts were generated. Assessment of the generated direct and model-based estimates was then conducted. Assessment includes obtaining the standard error and coefficient of variation of each estimate. Estimates with small standard errors and coefficient of variation of at most 10% are considered precise and reliable, respectively.

3. Results and Discussions

3.1 Direct estimation for the provincial counts of Vitamin A deficient children aged six months to five years

The province with the highest estimated count was Cavite with 238 Vitamin A deficient children aged six months to five years per 1000 live births and a standard error of 67 per 1000. On the other hand, the province with the lowest count was Abra with one child per 1000 live births and this estimate has a standard error of one per 1000. Such estimates were consistent with estimated total number of children since Cavite has a large number of children while Abra was one of those provinces with small estimated number of children in the national survey. Both estimates of these two provinces have coefficients of variation greater than 10% which can be described as unreliable.

The distribution of the estimated number of Vitamin A deficient children is presented in Table 2. There were 71 out of 79 provinces considered since the estimates for these provinces provided measures of variability. No measures of variability obtained for the provinces of Ilocos Sur, Benguet, Kalinga, Aurora, and Guimaras since there were no direct estimates for these provinces. Also, for the Provinces of Camiguin and Siquijor, all the sampled children were identified to be Vitamin A deficient and for the Province of Davao Oriental, only one child was considered to be Vitamin A deficient. In this case, there were no measures of variability obtained.

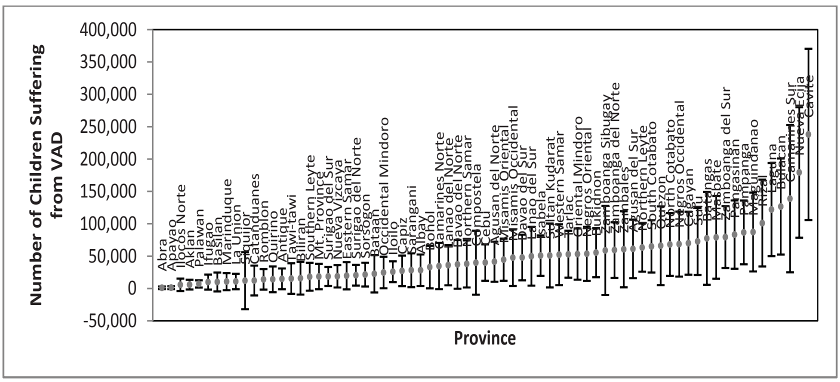
Around half of the number of provinces (49.30% or 35 out of 71) have estimated count of at most 40 per 1000 live births These low estimates indicate lesser serious malnutrition problem in these provinces. On the other hand, around eight percent of the provinces have estimated counts greater than 100,000. That is, only six provinces have extremely high number Vitamin A deficient children aged six months to five years and may be considered to be a serious problem. These provinces were dark shaded in the incidence map (see Appendix Figure 1).

Figure 1 shows the ninety-five percent confidence interval estimates for the provinces. Wide confidence interval estimates obtained for the provinces were due to the large values of standard errors associated with the direct estimates. Moreover, the figure shows that provinces with high direct estimates were mostly associated with relatively wide confidence intervals such as in the provinces of Cavite, Nueva Ecija, Camarines Sur, Bulacan, Laguna and Rizal. Such wide

Table 2. **Distribution of the direct estimates of the provincial count of Vitamin A deficient children aged six months to five years**

Direct Estimates (per 1000 live births)	Frequency	Realative Frequency (%)
At most 10	6	8.45
Greater than 10 up to at most 20	15	21.13
Greater than 20 up to at most 30	8	11.27
Greater than 30 up to at most 40	6	8.45
Greater than 40 up to at most 50	6	8.45
Greater than 50 up to at most 60	9	12.68
Greater than 60 up to at most 70	8	11.27
Greater than 70 up to at most 80	4	5.63
Greater than 80 up to at most 90	3	4.23
Greater than 90 up to at most 100	0	0.00
Greater than 100	6	8.45

Figure 1. **Ninety five percent confidence interval estimates of the provincial count of Vitamin A deficient children aged 6 months to 5 years using direct estimation technique**



confidence intervals indicate that the estimates from these provinces were not accurate. The figure also shows the negative lower bounds of some provinces. The negative lower bounds were generally considered invalid since counts should be positive.

The distribution of the standard errors of the direct estimates is presented in Table 3. The standard errors range from 1 to 67 per 1000. Majority of the provinces (76.06%) have less precise estimates with standard errors of greater than 10,000. Thus, direct estimation technique generated estimates which were mostly less precise. On the other hand, the coefficients of variation of the estimates using direct estimation technique range from 28.36 to 186.56. Such large values of coefficients of variation were due to large values of the standard error of the estimates. Since there were no provincial estimates with coefficients of variation at most 10%, in fact the minimum value was around 28% then it can be said that the direct estimation technique generated estimates which were not reliable.

Table 3. Distribution of the standard errors of direct estimates of provincial count of Vitamin A deficient children aged six months to five years

Standard Error (per 1000)	Frequency	Relative Frequency (%)
At most 2	2	2.82
Greater than 2 up to at most 3	1	1.41
Greater than 3 up to at most 4	1	1.41
Greater than 4 up to at most 5	1	1.41
Greater than 5 up to at most 6	1	1.41
Greater than 6 up to at most 7	2	2.82
Greater than 7 up to at most 8	2	2.82
Greater than 8 up to at most 9	5	7.04
Greater than 9 up to at most 10	2	2.82
Greater than 10	54	76.06

3.2 Model-based estimation for the provincial counts of Vitamin A deficient children aged six months to five years using Poisson Regression Model

The model-based estimates of the provincial counts of Vitamin A deficient children aged six months to five years were generated using the Poisson regression modeling. Table 4 presents the predicting model with Pseudo-R^2 of 55.57%. The three predictors in the model are all significant at 5% level. These predictors are the total number of divorced or separated persons, total number of households headed by a person who is a college graduate or an academic degree holder and total number of untrained "hilot" in the deliveries of babies. All three indicators were measured at the provincial level.

The total number of divorced or separated persons in the province is an indicator that having parents who were divorced and separated contribute to the increase in the number of Vitamin A deficient children in the locality. This increase

Table 4. Estimated regression coefficients of the Poisson regression model for provincial counts of Vitamin A deficient children aged six months to five years

Predictor	Estimated Coefficient	Robust Standard Error
Provincial total number of separated or divorced persons	0.00018	0.00002
Provincial total number of households headed by a person who is a college graduate or an academic degree holder	-0.00007	0.00001
Provincial total number of untrained "hilot" in the deliveries of babies	0.00014	0.00006
Constant	9.99791	0.10081

was observed on cases for families who are not having both parents looking after the children. The condition of the children would be better if both parents are jointly providing sufficient or nutritious food for their children especially if both parents are earning. In addition, the total number of households headed by a person who is a college graduate or an academic degree holder indicates that more parents in the provinces are more knowledgeable or informed about the nutrition of children. On the other hand, the total number of untrained "hilot" in the deliveries of babies indicates that the prevailing type of health personnel in the province is a contributory factor to the increasing number of Vitamin A deficient children. This shows that the prevailing health situation of the province reflects the ways the children in the locality are being taken care of.

Incidence rate ratios or the exponentiated values of each coefficient were obtained and are shown in Table 5. For the two predictors, the provincial number of divorced or separated persons and the provincial total number of untrained " hilot" in the deliveries of babies, the incident rate ratios or the exponentiated

Table 5. Computed incidence rates ratios of Vitamin A deficient children aged six months to five years

Predictor	Estimated Coefficient	e^{β}
Provincial total number of separated or divorced persons	0.00018	1.00018
Provincial total number of households headed by a person who is a college graduate or an academic degree holder	-0.00007	0.99993
Provincial total number of untrained "hilot" in the deliveries of babies	0.00014	1.00014

values of the coefficients were both equal. This means that the counts of Vitamin A deficient children in a province would increase by one with a unit increase in the total count of these predictors. On the other hand, the counts of Vitamin A deficient children in a province would decrease by 0.00007 with an increase in the total count of households headed by a person who is a college graduate.

Using the best predicting model, the estimated numbers of Vitamin A deficient children were then predicted for 79 provinces. The estimates obtained were all positive counts and have positive lower bounds. However, only 72 of these provinces were considered to have valid estimates since the seven provinces have overestimated counts relative to the their projected number of children residing in the province. The seven provinces include Batanes, Mt. Province, Biliran, Guimaras, Apayao, Camiguin and Siquijor.

The province with the highest estimated count was Cavite with 284 Vitamin A deficient children aged six months to five years per 1000 live births and a standard error of 39 per 1000. On the other hand, the province with the lowest count was Benguet with 17 per 1000 live births and a standard error of 2 per 1000. Both estimates (for Benguet, coefficient of variation is 13.04% while for Cavite, coefficient of variation is 13.79%) have coefficients of variation greater than 10% but lower than 20% which can be described as unreliable estimates but still with acceptable measures of reliability.

The distribution of the valid estimated provincial counts of Vitamin A deficient children is presented in Table 6. More than half (63.89% or 46 out of 72) of the provinces have estimated number between 20 to 40 per 1000 live births. These estimates indicate lesser serious malnutrition problem in these provinces. On the other hand, around 7% of the provinces have estimated counts greater

Table 6. Distribution of the model-based estimates of the provincial count of Vitamin A deficient children aged six months to five years

Poisson Regression Estimates (per 1000 live births)	Frequency	Relative Frequency (%)
Greater than 10 up to at most 20	2	2.78
Greater than 20 up to at most 30	22	30.56
Greater than 30 up to at most 40	24	33.33
Greater than 40 up to at most 50	8	11.11
Greater than 50 up to at most 60	6	8.33
Greater than 60 up to at most 70	2	2.78
Greater than 70 up to at most 80	2	2.78
Greater than 80 up to at most 90	1	1.39
Greater than 90 up to at most 100	0	0.00
Greater than 100	5	6.94

than 100 per 1000 live births. That is, only five provinces have extremely high number of Vitamin A deficient children aged six months up to five years and VAD prevalence can be considered to be a serious problem in these provinces which are dark shaded in the incidence map (see Appendix Figure 2).

Table 7 presents the top ten provincial counts of Vitamin A deficient children aged six months to five years. Included in this list are the reliable estimates that are those with coefficients of variation at most 10%. All three main islands were represented in this list.

Table 7. Ten provinces with the highest model-based estimates of the provincial counts of Vitamin A deficient children aged six months to five years

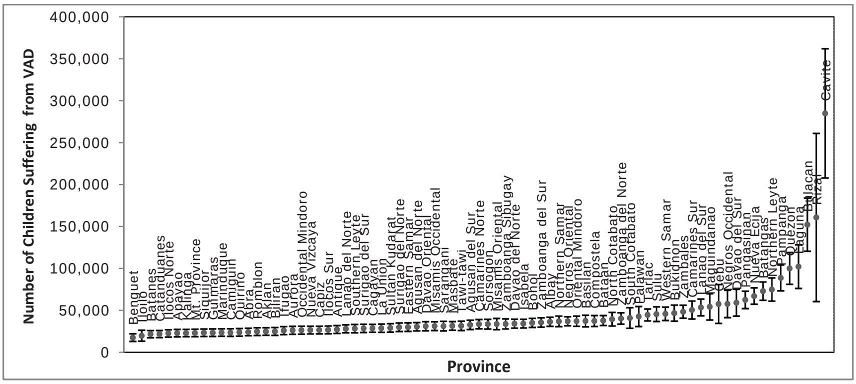
Rank	Province	Model-based Estimate (per 1000 live births)	Coefficient of Variation(%)
1	Quezon	100	9.66
2	Pampanga	89	8.87
3	Northern Leyte	75	9.39
4	Batangas	73	7.65
5	Nueva Ecija	67	7.42
6	Pangasinan	62	8.45
7	Lanao del Sur	53	9.52
8	Zambales	48	8.14
9	Western Samar	46	8.84
10	Sulu	45	9.76

Lanao del Sur and Sulu were included in the top ten and were the provinces of Mindanao, specifically from the ARMM region. According to the official statistics in 2003, ARMM has a high poverty incidence and is considered to be serious in terms of the degree of severity based on the obtained hunger index estimates (Virola and Castro, 2007). Moreover, in terms of other malnutrition reports, ARMM is said to have high prevalence of under height, thin, and underweight children. This is also consistent with the low development index (HDI) obtained by the United Nations Development Programme. The HDI measures the quality of life, life expectancy, education, literacy, per capita income, and standard of living.

Moreover, Table 7 also includes two provinces from Region 8 of Visayas, namely; Northern Leyte and Western Samar. According to the official poverty statistics, Region 8 was also considered to be one of the poorest regions. The rest of the provinces identified in Table 7 are found in Luzon, specifically from the two most populated regions in the country, namely; Southern Tagalog (Region 4A) and Central Luzon (Region 3) region. However, relative to the population of children in such provinces, the estimated number of deficient children is still low. This implies to lesser serious cases of Vitamin A deficiency of these provinces.

Figure 2 shows the ninety-five percent confidence interval estimates for the 79 provinces. Most of the provinces were found to have low estimates and have narrow confidence intervals indicating that the Poisson regression model estimates of the counts from these provinces are accurate. Narrow confidence interval estimates obtained for the provinces was due to the small standard errors associated with the Poisson regression model-based estimates. On the other hand, those provinces with higher estimates have wider confidence intervals. Specifically, it can be observed in the Provinces of Cavite, Rizal, Bulacan and Laguna which were also found to have the most unreliable estimates.

Figure 2. Ninety five percent confidence interval estimates of the provincial count of Vitamin A deficient children aged six months to five years using Poisson regression estimation technique



The distribution of the standard errors of the estimates is presented in Table 8. The standard errors using Poisson regression ranges from 2 to 51 per 1000. Majority of the provinces (76.39%) have the most precise estimates with standard errors of at most 5,000. This means that model-based approach mostly generated precise estimates.

Table 9 shows that the model-based approach using the Poisson regression model generated around 78% of the estimates which are considered reliable. There are only 16 out of the 72 estimates which are unreliable but still 14 of them have measures of reliability that are still acceptable, that is, their coefficients of variation range between 10% and 20%. The highest coefficient of variation is 31.81% was obtained for the estimate of the Province of Rizal.

3.3 Comparison of direct and poisson regression estimation techniques

There were 71 provinces considered to have valid estimates under direct estimation while there were 72 provinces with valid estimates under model-based estimation. Figure 3 shows the box-and-whiskers plots of the estimates of the

Table 8. Distribution of the standard errors of model-based estimates of provincial count of Vitamin A deficient children aged six months to five years

Standarrd Error	Frequency	Relative Frequency (%)
Greater than 2 up to at most 3	39	54.17
Greater than 3 up to at most 4	11	15.28
Greater than 4 up to at most 5	5	6.94
Greater than 5 up to at most 6	4	5.56
Greater than 6 up to at most 7	2	2.78
Greater than 7 up to at most 8	3	4.17
Greater than 8 up to at most 9	2	2.78
Greater than 9 up to at most 10	1	1.39
Greater than 10	5	6.94

Table 9. Distribution of the coefficients of variation of model-based estimates of the provincial count of Vitamin A deficient children aged six months to five years

Coefficient of Variation (%)	Frequency	Relative Frequency (%)
≤10.00	56	77.78
10.01-20.00	14	19.44
>20.00	2	2.78

provincial counts using direct and Poisson regression model-based estimation techniques. The Province of Cavite is observed to have the highest count of Vitamin A deficient children for both direct and Poisson regression model-based estimation techniques, with values 238 and 285 (per 1000 live births), respectively. However, these estimates for Cavite were not reliable. There were other provinces with extremely high model-based estimates but were generally lower than direct estimates. Moreover, 75% of the model-based estimates generated were at most 46,371 while 75% of the direct estimates were at most 65,096. Thus, the Poisson regression model-based estimation technique mostly generated lower estimates than the direct estimation technique. When the rankings of the model-based estimates were correlated with those of the direct estimates, a strong association (Spearman rank correlation coefficient of 0.786) was observed. Likewise, the incidence maps depicting the estimate counts from the two estimation techniques do not differ much with the Poisson regression model-based approach showing less number of provinces where VAD can be considered a serious health situation (see Appendix Figures 1 and 2).

Figure 3. **Comparison of the box-and-whiskers plots of provincial estimated counts of Vitamin A deficient children aged six months to five years**

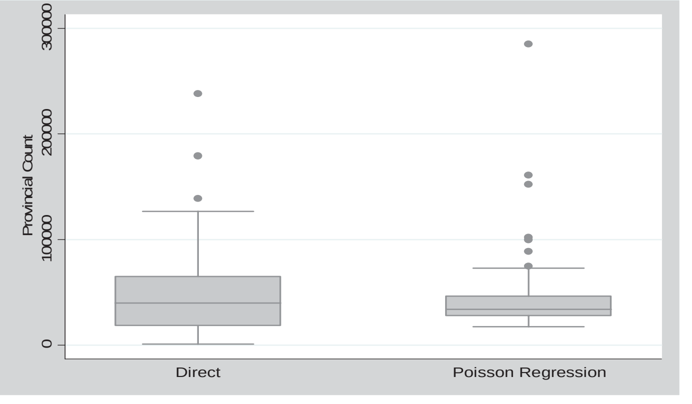


Figure 4 shows the box-and-whiskers plots of the standard errors of the estimates using two estimation techniques. High standard errors were observed for the estimates of Cavite (67 per 1000), Camarines Sur (58 per 1000) and Nueva Ecija (51 per 1000) generated by direct estimation. Extreme values of standard errors were also observed in the model-based approach. However, generally the values are lower compared to those of the direct estimates. Majority of the Poisson regression model-based estimates were more precise than the direct estimates since 75% of the standard errors were at most 5 per 1000. This indicates that model-based technique produced more precise estimates than the direct estimation technique.

Figure 4. **Comparison of the box-and-whiskers plots of standard errors of the estimated counts of Vitamin A deficient children aged six months to five years**

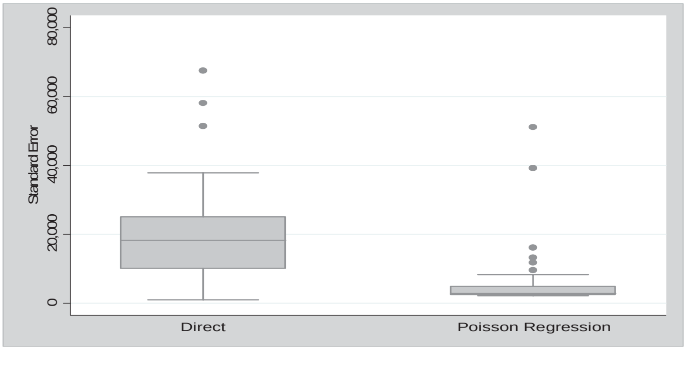
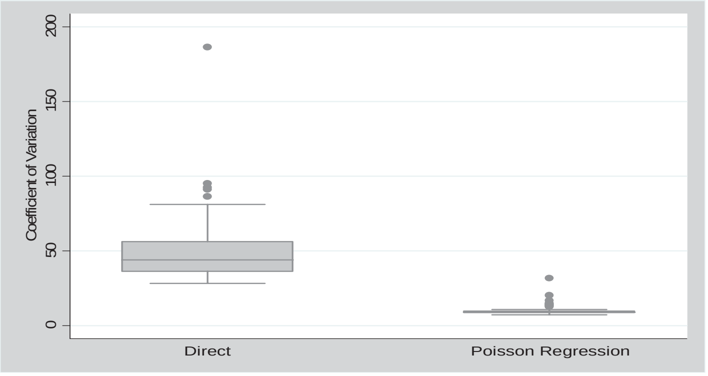


Figure 5 shows the box-and-whiskers plots of the coefficients of variation of the valid estimates using the two estimation techniques. All provinces with direct estimates have coefficients of variation greater than 20%. Thus, estimates generated under this technique were unreliable. On the other hand, model-based estimation technique generated only two provincial estimates with coefficients of variation greater than 20% and these estimates are for Cebu and Rizal. Majority (77.78% or 56 out of 72 provinces) of the model-based estimates have coefficients of variation at most 10%.

Figure 5. Comparison of the box-and-whiskers plots of coefficients of variation of the estimated counts of Vitamin A deficient children aged six months to five years



4. Conclusions

Since prevalence of VAD is considered to be a national problem, government and private sectors are must engage continuously and give urgent attention to the implementation of programs that can improve the conditions of the affected children. For such reason, estimation on smaller domains such as the provincial level is appropriate so that programs to solve VAD can be properly implemented. This paper provided an alternative methodology to have estimates for the count of VAD at provincial level using model-based approach, specifically the Poisson regression model. Estimates generated using this technique was evaluated in terms of their precision, accuracy and reliability as measured by the estimate's standard error, confidence interval and coefficient of variation, respectively.

In the direct estimation, only 71 out of 79 provinces were considered to have valid estimates, which range from one (Abra) to 238 (Cavite) Vitamin A deficient children aged six months up to 5 years, per 1000 live births and majority of the provinces (75%) have estimates of at most 65 per 1000 live births. Also, the standard errors of the estimates range from one to 67 per 1000. Most of the provinces (76.06%) have less precise estimates with standard errors of greater than 10,000. Moreover, the coefficients of variation range from 28.36% to 186.56%. These values indicate that there were no reliable direct estimates obtained.

The obtained Poisson regression model has a Pseudo-R^2 of 55.57%. Only 72 provinces have valid estimates which range from 17 (Benguet) to 285 (Cavite) per 1000 live births. Also, the standard errors of the estimates range from 2 to 51 per 1000 and majority of the provinces (76.39%) have precise estimates with standard errors of at most 5,000. Moreover, in terms of reliability, 77.78% of the coefficients of variation obtained were at most 10%, implying more reliable provincial estimates were generated.

Based on the results of this study, the use of Poisson regression model in model-based approach is said to have generated the better set of estimates of the provincial count of Vitamin A deficient children aged six months to five years that can be used for targeting purposes by the government in implementing some of its nutrition programs.

References

ABITONA, L.P.D., 2011, Provincial Level Estimation of the Proportion of Vitamin A Deficient Children Aged 6 Months to 5 Years in the Philippines, Master's Thesis, University of the Philippines Los Baños.

DEMISSIE, T., A. ALI, Y. MEKONNEN, J. HAIDER, and M. UMETA, 2009, Demographic and Health-related Risk Factors of Subclinical Vitamin A Deficiency in Ethiopia. *Journal of Health Population Nutrition* 27(5):666-673.

DEPARTMENT OF HEALTH, 2006, 2002 FHSIS Annual Report, Retrieved on Sept 24, 2011 from http://www.doh.gov.ph/kp/statistics/fhsis2002.html

FOOD AND NUTRITION RESEARCH INSTITUTE (FNRI), 2003, Biochemical Facts and Figures. Retrieved on July 8, 2011 from http://fnri.dost.gov.ph/files/fnri%20files/nns/factsandfigures2003/biochemical.pdf

FOOD AND NUTRITION RESEARCH INSTITUTE (FNRI), 2009, 7th National Nutrition Survey Results. Retrived on October 18, 2011 from http://www.fnri.dost.gov.ph/images/stories/7thNNS/biochemical/biochemical_vad.pdf.

GHOSH, M. and J.N.K. RAO, 1994, Small area estimation: an appraisal, *Statistical Science*, 9(1): 55-93.

GREENE, W.H., 1990, *Econometric Analysis,* USA: McMillan Publishing House, Inc., 783pp

JIANG, J.X., L.M. LIN, G.L. LIAN, and T. GREINER, 2008, Vitamin A deficiency and child feeding in Beijing and Guizhou, China, *USA World J Pediatr*, 4(1): 20-25

KHANDAIT, D.W., N.D. VASUDEO, S.P. ZODPEY, and D.T. KUMBHALKAR, 2000, Risk Factors for Subclinical Vitamin A Deficiency in Children Under the Age of 6 Years, *Journal of Tropical Pediatrics*, 46(4): 239–241

MAYHEW, M., P.M. HANSEN, D.H. PETERS, A. EDWARD, L.P. SINGH, V. DWIVEDI, A. MASHKBOR, and G. BUMHAM, 2008, Determinants of Skilled Birth Attendant Utilization in Afghanistan: A Cross-Sectional Study, *American Journal of Public Health*, 98(10): 1849–1856.

MILLER, M. J. HUMPHREY, E. JOHNSON, E. MARINDA, R. BROOKMEYER, J. KATZ, 2002, Why Do Children Become Vitamin A Deficient?, *The Journal of Nutrition*, 132: 2867S-2880S

NATIONAL COORDINATION BOARD (NSCB), 2008, Glossary of Terms. Retrieved on May 13, 2009 from http://www.nscb.gov.ph/glossary /inc.asp

RAO, J. N. K, 2003, *Small Area Estimation*, New Jersey, USA: John Wiley and Sons, Inc., Hobooken, 313pp.

VIROLA, R.A. and L.V. CASTRO, 2007, Meeting the Challenge for Official Statistics on Hunger in the Philippines, Retrieved on December 27, 2011 from http://www.nscb.gov.ph/ncs/10thNCS/papers/invitedpapers/ips01/ips01-02.pdf

ZIOL-GUEST K.M., T. DELEIRE, and A. KALIL, 2006, The Allocation of Food Expenditure in Married- and Single-Parent Families, *The Journal of Consumer Affairs*, 40(2): 347-371

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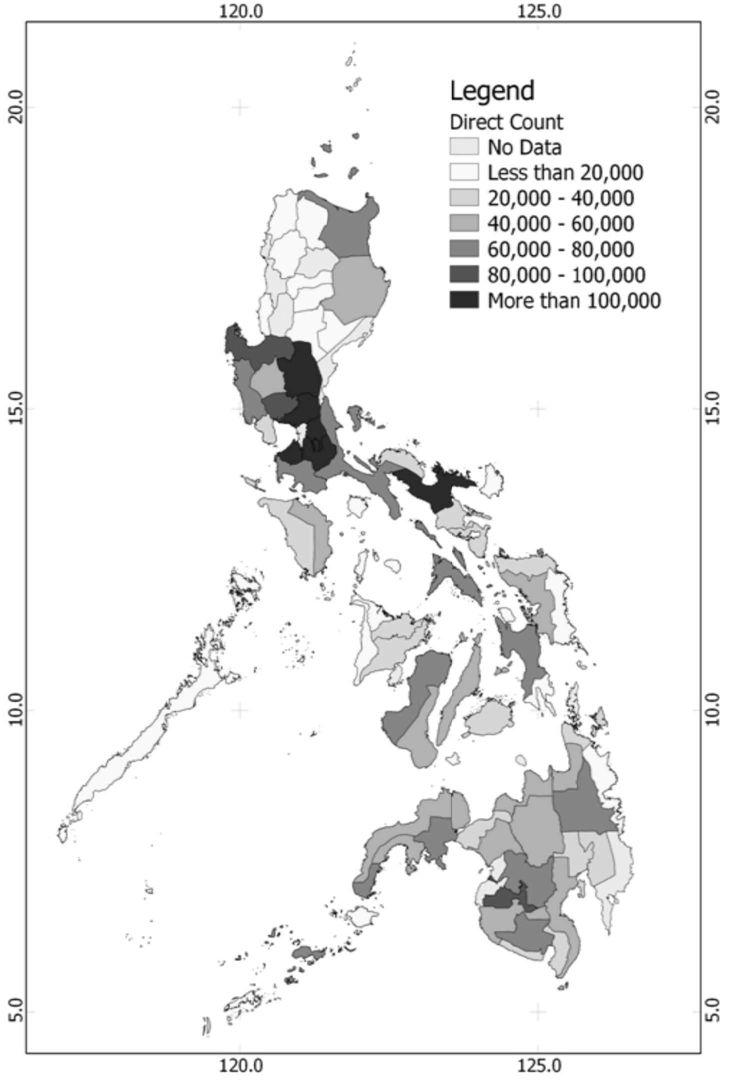
Appendix Figure 1. Incidence map of VAD children aged six months to five years based on the direct estimates obtained using the 2003 NNS



Appendix Figure 2. Incidence map of VAD children aged six months to five years based on the model-based estimates