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AGE MISSTATEMENT FOR CHILDREN: A PROBLEM FOR INTERPRETING ANTHROPOMETRIC MEASURES IN BANGLADESH

by

Radheshyam Bairagi,
Barry Edmonston, and Awal Dad Khan

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ABSTRACT

This paper reports the level and pattern of age error and the effects of this age error on the use of weight-for-age, height-for-age, and arm circumference-for-age for assessing and screening malnutrition, and for identifying factors of malnutrition of 679 children aged 22 and 59 months in Companyganj, a rural area in Bangladesh. Over-reporting and random error are observed and age error is found correlated with each of the indices. As a result the proportion of children having less than or equal to 60 percent of median weight-for-age is over estimated by 5 percentage points and the proportion of children having less than or equal to 80 percent of median height-for-age is over-estimated by 8 percentage points. Over-estimation or under-estimation for arm circumference-for-age is negligible.

Random error in age and the correlation of age error with the indices result in a loss in sensitivity (proportion of malnutrition correctly identified) for the above cut-off points of 20 percent for weight-for-age and of 17 percent for height-for-age, compared to the situation in the sbsence of age error. For arm circumference-for-age, the loss in sensitivity at the 75 percent cut-off point is 11 percentage points. Although mother's education is not a significant determinant of weight-for-age and height-for-age, age error makes mother's education appear artifactually significant. The effect of age error on the analysis of variance of arm circumference-for-age is negligible. In populations with a substantial proportion of children of unknown or poorly reported age, either efforts need to be made to improve the quality of the age data or anthropometric measures less sensitive to age errors should be used. This paper argues that arm circumference-for-age may be a better alternative than weight-for-age or height-for-age, in the presence of age error.

INTRODUCTION

Malnutrition of individuals or of a population can be assessed clinically, biochemically, or antropometrically. All three methods of measuring the human body provide quantitative or qualitative clues about the nutritional status of the individual. Among these methods, anthropometry has the advantage of being relatively easy to perform and requiring only simple apparatus. Moreover, mild or moderate protein-energy deficiencies in children are difficult to detect by biochemical or clinical examination and have hence been mainly measured in terms of anthropometry (Shakir, 1975). Anthropometric indices are based on physical measurements in which one variable thought to be greatly affected by malnutrition is compared with one less affected. Anthropometric variables change with age, so age plays an important role in anthropometric investigation of the nutritional status of children. Unfortunately, the accuracy of children's reported ages in developing countries is usually unknown. The question therefore arises of the accuracy and limitations of age-dependent anthropometric indices in these countries.

The expected maximum loss in sensitivity (the percent of malnutrition correctly identified) for different levels of age error is most easily calculated with the assumptions that: (a) the expected age error is zero (i.e., the errors are random); (b) index values for malnourished groups and for well-nourished groups are normally distributed, and; (c) index values and age error are uncorrelated (see

Bairagi, 1981 for a statistical presentation of these assumptions). How important are these assumptions for the influence of age error on the sensitivity of anthropometric measures? The limited data available for developing countries show that the ages of less that five years old children are usually overreported (Bairagi, et al., 1982; Caldwell, 1966; Edmonston and Bairagi, 1981). Any bias in age reporting--violating assumption (a)--obviously affects the assessment of nutritional status as measured by an age-dependent index. Assumption (b) is probably suitable in most situations but also depends on the definition of malnutrition. If malnutrition is defined as an value of an index less than some cutoff point, say 60 percent of median weight-for-age in the reference population, then the distribution of index values for malnourished groups and for well-nourished groups will be closer to truncated normal than to the normal distribution. Assumption (c) is a preliminary assumption, but has been found to be invalid in a Bangladeshi sample (Bairagi, et al., 1983), and possibly false in other populations.

Bairagi, et al. (1982) recently demonstrated that bias in age reporting would lead to underestimates of the prevalence of malnutrition and that random error leads to overestimates of malnutrition, where malnutrition was defined as weight-for-age index less than or equal to 60 percent of the standard. There are apparently only two studies--Bairagi, et al.,1982 and Bairagi, et al.,1983--quantifying the effects of age error on anthropometric indicators of nutritional status of children. Both studies discussed some consequences of age error under a

set of assumptions, but did not offer explicit analysis of anthropometric data. They therefore could not clarify the extent to which the three assumptions were not satisfied. This paper will review the level and pattern of age error in a rural area of Bangladesh, investigate the effects of age error on some commonly used age dependent anthropometric indices in assessing and screening malnutrition, and examine the factors related to malnutrition under conditions of age error.

DATA AND METHODS

Data for this study were collected in Companyganj, a rural area of Bangladesh about 160 kilometers southeast of Dhaka (spelled Dacca prior to 1982), the capital of Bangladesh. A detailed description of the study area and the data collections procedures is available elsewhere (Ashraf, et al., 1980; Baraigi, et al., 1983). Only a brief description is given here.

The Christian Commission for Development in Bangladesh (a program of West Germany's Lutheran Church) started the Companyganj Health Project (CHP) in 1974. The project covered an area of 128 square kilometers and had a population of 118,000 in 1975. In order to evaluate the demographic impact of the CHP, birth, deaths, and migration events were recorded from a prospective 10 percent random sample of the households. The demographic surveillance system was active from January 1975 to March 1980.

The CHP area is about average economically for Bangladesh, with a per capita income of about U.S.$120. The education level is more than the Bangladesh average: 66 percent of the fathers and 27 percent of the mothers of the study children can read simple sentences in Bengali. The local populace are somewhat more traditional in comparison with other areas of Bangladesh. The health care facilities of the CHP were generally under-utilized during the period of the project (Chowdhury, et al., 1978). The demographic impact of the health project is now under investigation at the Carolina Population Center, although the impact of the project on children's nutritional status seems to be positive (Bairagi, 1983).

During the second week of September 1981, a team of six students and three faculty members of the Institute of Statistical Research and Training (ISRT), University of Dhaka went to Companyganj for preliminary arrangements for data collection. The questionnaire for age data was then tested in two places and adapted for field use in the Companyganj area. The recruitment and training of the supervisors and the workers, including additional field workers, began during the third week of October 1981. The purpose of the study was discussed, the complete set of equipment was displayed, and the anthropometric measurements were demonstrated. The workers were given intensive training for the collection of the age data and in the use of the various measuring instruments.

Identification of the children (including names, sex, location,

name of the "bari" or household, family number, individual number, father's name, and mother's name) was collected from the initial registration record of the CHP. Some names of the children, as recorded in the birth registration, were found to have changed during the time of the study; however, these name changes were examined and then updated in the birth registration before actual data collection began. After the collection of the reported age from the field, the actual date of birth was noted by a supervisor from the CHP's central vital registration record.

Four teams of field workers collected the data. Each team comprised two trained field workers (one male and one female), a porter to carry the anthropometric equipment, and a local "dai" or midwife. These workers visited each of the sample households and collected data on the age and anthropometric of the children, some socio-economic data on the children's family, and also some data on beliefs, attitudes and practices of child nutrition from the mothers and other members of the households.

Four spring Salter weighing scales were provided by the CHP. These scales were standardized at the beginning for the data collection with several known weights. The scales were calibrated once a week in the CHP office to ensure accurate weighing. Weights were taken to the nearest 100 grams, and height and arm circumference were taken to the nearest 0.1 centimeter.

Data on 679 children, ranging from 22 to 59 months of age, were collected in the field study. These age limits were used because the actual age of children below 22 months was not available. These age limits roughly correspond with ages at which children in developing nations are thought to be particularly nutritionally vulnerable, although children less than 22 months of age may be more vulnerable in some populations.

Age error, defined as actual age known from the birth registration minus the reported age, was calculated in the CHP office by a supervisor. Weight-for-age, height-for-age and arm circumference-for-age (see Waterlow, et al., 1977 for definitions) as a percentage of the National Center for Health Statistics (NCHS) standard were calculated for actual and reported age as well. The Polish standard (Jelliffe, 1966: 220-226) was used for calculating arm circumference-for-age. All the information, including socioeconomic data, for each child were coded, checked and processed at the Bangladesh University of Engineering and Technology's Computer Center in Dhaka.

RESULTS

Table 1 presents age error by actual age. Age is over-reported for each of the completed age groups in Companyganj. This over-reporting tendency for these age groups is also common in other populations (Ewbank, 1981: 49). Random error is apparent from the standard

deviation of the age error and increases with age as expected. Since the standard deviation of age error exceeds the amount of bias (the mean age error), it is clear that many children also have their ages underestimated. Table 1 does not present data on digit preference (i.e., reporting of single year ages), which is a problem described by Bairagi, et al. (1982) for Bangladeshi data.

Table 2 gives the correlation matrix of age error and the actual antropometric indices, and the actual mean and reported mean of the antropometric indices. Age error has a significant negative correlation ($p < 0.05$) with each of the indices, except weight-for-height. The correlation coefficients are highest with weight-for-age and height-for-age, lowest with weight-for-height, and somewhat between with arm circumference-for-age. These correlation coefficients indicate that a child with a higher true anthropometric index value was reported relatively older and a child with a lower true index value was reported relatively younger. Obviously, the correlation coefficients demonstrate misclassification of well-nourished children as malnourished and malnourished children as well-nourished.

Correlation coefficients between the anthropometric indices are positive and significant ($p < 0.05$), with the exception of height-for-age and weight-for-height where the correlation coefficient is negative but not significant. These inter-correlation coefficients are similar to that of other populations (Anderson, 1979; Bairagi, 1981; Brown, et al., 1982). Of course, the magnitude of intercorrelation coefficients for

different populations is not the same since the size of the coefficient is likely to depend on diet and disease patterns as well as on the age of the study population.

Table 3 presents the distribution of children by actual weight-for-age and reported weight-for-age. Fifteen percent of the children are actually severely malnourished (less than or equal to 60 percent of weight-for-age) and 32 percent are greater than 75 percent weight-for-age index. Due to age error these figures appear as 19 percent and 27 percent respectively. Only 80 percent of the severely malnourished children are correctly identified in terms of sensitivity analysis; and of those who are reported as severely malnourished, only 63 percent of them are correctly identified (the positive predictive value in this case). Thus, age error considerably affects both assessment and screening of malnutrition as measured by weight-for-age.

The effects of age error on assessment and screening malnutrition by height-for-age and arm circumference-for-age are given in Tables 4 and 5. The effect for both assessment and screening malnutrition is more severe for height-for-age than for weight-for-age. However, for arm circumference-for-age, the effect on assessment is neglible and on screening is mild.

Table 6 displays the effect of age error on the analysis of variance of nutritional status measured by weight-for-age, height-for-age, and arm circumference-for-age. Three independent

variables are defined for the analysis of variance: annual family income is classified into three groups (0 to 6000, 6001 to 12000, and 12001 and more Bangladeshi taka; there were approximately 20 taka to a U.S. dollar at the time of the survey), mother's education in two groups (illiterate and literate), and children's actual age in three groups (22 to 35, 36 to 47, and 48 to 59 months of age). Income is a significant determinant of the nutritional status of the children as measured by each of the indices; while mother's education is a significant determinant of arm circumference-for-age only. But when the indices created with reported age are used, mother's education appears as a significant variable in each case. This change in the level of significance for weight-for-age and height-for-age is statistically artifactual and is due to the difference in age error between the children of literate and illiterate mothers (a finding discussed in detail in Bairagi, et al., 1983). Both literate and illiterate mothers overreport the age of their children, but illiterate mothers overreport more (Bairagi, et al., 1983).

DISCUSSION

Both systematic and random error are present in children's age data in Companyganj. Age error is correlated with each of the anthropometric indicators of nutritional status of children, with a well-nourished child's age over-reported relatively more. The relationship of age error is strong with weight-for-age and height-for-age, moderate with arm circumference-for-age, and weak with weight-for-height.

Standard deviations of weight-for-age and height-for-age of this population are 10 and 6, which is about the same of other populations (Bairagi, 1981; Waterlow, et al., 1977). The comparison of means between actual and reported weight-for-age ıd between actual and reported height-for-age by the usual t-test thus reveals artifactually significant differences ($p < 0.05$). The same will happen if a comparison is made between the proportion of severely malnourished children measured by the two indices. However, neither the mean nor the proportion of severely malnourished measured by actual and reported arm circumference-for-age is statistically significant. The differences in means between the actual and reported index is mainly due to systematic age error. In addition to the effect of systematic error, random error may have some contribution to the over estimation of the proportion of severely malnourished children (Bairagi, et al., 1982).

The loss in sensitivity (the percent of severely malnourished children correctly classified) and in positive predictive value (percent of severely malnourished children reported as severely malnourished) is extremely high in these data. Both random error and the correlation between random error and anthropometric measurement are responsible for this loss. But since it is unlikely that only random error causes such a large loss in sensitivity (see Bairagi, 1981:113-114 for expected maximum loss is sensitivity for different level of random error), the correlation between age error and anthropometric measurement apparently produces the additional loss in sensitivity.

These Bangladeshi data demonstrate several specific consequences of age error for anthropometric measurements. First, although age error does not have any effect in assessing nutritional status of children by arm circumference-for-age, it has some effect on this index in screening malnutrition. This effect is mainly due to random error. A large age error of a child misclassifies their nutritional status even by arm circumference-for age. Second, age error misleads the conclusions about the contribution of mother's education to the weight-for-age and height-for-age of children in Companyganj. Differences in age reporting error between literate and illiterate mothers produces this artifactual contribution: there is an interaction between the child's anthropometric measurement and mother's literacy on age error.

In summary, age error has a significant effect on the weight-for-age and height-for-age for assessing and screening malnutrition, and for identifying factors of malnutrition in Companyganj. Age error affects arm circumference-for-age in screening only. Age error is unlikely to be unique to Companyganj, and probably displays similar effects in other areas of the developing world. These age errors increase the possibility of misinterpreting the results of two of the most commonly using anthropometric indices, weight-for-age and height-for-age.

Two solutions might be used to deal with these age error problems, though neither are proposed here as yielding perfect results. First, it is helpful to employ an age independent index or an index less sensitive

to age error. Weight-for-height is age independent for instance, but has several limitations: (a) it is a measure of wasting only (Waterlow, 1976) and is not a valid substitute for weight-for-age and height-for-age; (b) its correlation with height-for-age in Companyganj, in Matlab (another rural area of Bangladesh), and in data from several other developing countries is negative (Anderson, 1979; Bairagi, 1981), and; (c) weight-for-height does not appear to a good predictor of childhood mortality in rural Bangladesh (Chen, et al., 1980). Arm circumference-for-age is less sensitive to age error. This index is highly correlated with weight-for-age and height-for-age, and has been found to be a good predictor of childhood mortality in rural Bangladesh (Chen, et al., 1980). In nutritional surveillance in Bangladesh this index could probably be used as a substitute for weight-for-age and height-for-age. Of course, this index will not present all the information expected from weight-for-age and height-for-age measurements. For example, mother's education appears as a significant determinant of arm circumference-for-age in Companyganj, but not of the other two indexes. Usually one expects an value of arm circumference-for-age intermediate between weight-for-age and height-for-age, but its significant relationship with mother's education proves otherwise. It may be an exception in these data, so further work is needed to confirm this result.

Rates of growth in weight and height are likely to be less sensitive to age error and may be used instead of weight-for-age and height-for-age if resources and time permit the collection of weight and

height data at two or more points in time. How many children should be included, at what interval should be measured, and how accurate the measurements should be are all factors that deserve careful consideration in estimating the growth rate of children.

Second, in order to improve the age data it would be better if the field workers are especially trained in the problems and collection of age data. Field workers should be warned not to judge the age of children by their nutritional status. This may not decrease the absolute age error (and might even increase it) but it might help to reduce the correlation between nutritional status and age error. Thre is also evidence that maternal birth histories--which are often collected for demographic information--improve the accuracy of reported ages for children (Becker and Mahmud, 1981).

Nonavailability of actual age in developing countries makes the checking of the quality of reported age difficult. Some consistency checks may be helpful in this regard. In the study reported here, the cutoff points of the weight-for-age, height-for-age, and arm circumference-for-age for the worst 15 percent of children are 60, 75, and 81 and for the worst 40 percent of children are 67, 81, and 86. A comparison of the cutoff points of the weight-for-age and height-for-age with arm circumference-for-age may give an idea about the bias in age data. The correspondence of the cutoff points of the indices may vary in populations and may vary seasonally in a population. In order to generalize further, additional studies are needed.

The correlation between weight-for-age and arm circumference-for-age is found to be high in this study, as in other reported studies. Since weight-for-age is highly sensitive and arm circumference is quite insensitive to age error, fitting a simple linear regression line would give an expected weight-for-age for a given arm circumference-for-age. If the expected weight-for-age differs markedly from the observed weight-for-age, the possibility of error is more likely for one or more of the components of the indicators. Although there is error in the anthropometric measurements themselves, this paper has limited attention to error stemming from age reporting. The age error may be estimated and corrected under the assumption that it is the sole source of error. But if the regression estimation is based on reported weight-for-age and reported arm circumference-for-age, the correction is likely to reduce only the random error and not the bias.

As a final caveat, we would like to emphasis that improvements in age data need to be seen in broader terms of tradeoffs in the positive predictive value of commonly used indicators. What are the losses in positive predictive value with increasing age error? How much age misstatement should a researcher tolerate before switching to an indicator this is less valid in the absence of age error? These are also an issues for further study.

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Table 1. Age Error, in Months, for Children Aged 22 to 59 Months in Companyganj, Bangladesh

Actual Age (years)	Number	Age Error* Mean	Age Error* Standard Deviation	Coefficient of Variation**
2	228	-2.43	7.07	24
3	214	-2.27	9.46	23
4	200	-3.15	10.36	19

* age error equals the acutal age minus the reported age

** coefficient of variation equals the standard deviation divided by age time 100

Table 2. Correlation Coefficients of Age Error, in Months, and the Anthropometric Measures, and Their Mean Actual and Reported Values

Variable		Variable Number				Mean	
Number	Title	1	2	3	4	Actual	Reported
1.	Age Error					-2.5	----
2.	Weight-for-age	-.248*				71.4	69.7
3.	Height-for-age	-.244*	.675*			86.9	85.7
4.	Arm Circumference-for-age	-.109*	.661*	.398*		82.5	82.3
5.	Weight-for-Height	-.046	.602*	-.059	.439*	90.5	----

* statistically significant at the .05 level with a one-tailed t-test

Table 3. Distribution of Children by Actual Weight-for-Age and Reported Weight-for-Age*

Actual	Reported -60	61-75	76-90	91+	Total
-60	80 (80) (63)	18 (18) (5)	2 (2) (1)	0 (0) (0)	100 (15)
61-75	45 (13) (35)	290 (81) (79)	23 (6) (14)	0 (0) (0)	358 (53)
76-90	3 (2) (2)	56 (29) (15)	129 (67) (80)	4 (2) (19)	192 (28)
91+	0 (0) (0)	5 (17) (1)	7 (24) (4)	17 (59) (81)	29 (4)
Total	128 (19)	369 (54)	161 (24)	21 (3)	679 (100)

* figures in parentheses are row and column percentages, respectively

Table 4. Distribution of Children by Actual Height-for-Age and Reported Height-for-Age*

Actual	Reported -80	81-85	86-90	91+	Total
-80	66 (83) (50)	6 (8) (50)	7 (9) (3)	1 (1) (1)	80 (12)
81-85	42 (24) (32)	101 (58) (57)	20 (12) (9)	10 (6) (7)	173 (26)
86-90	20 (8) (15)	55 (22) (31)	157 (61) (72)	24 (9) (16)	256 (38)
91+	5 (3) (4)	16 (9) (9)	34 (20) (20)	115 (68) (77)	170 (25)
Total	133 (20)	178 (26)	218 (32)	150 (22)	679 (100)

* figures in parentheses are row and column percentages respectively

Table 5. Distribution of Children by Actual Arm Circumference-for-Age and Reported Arm Circumference-for-Age*

Actual	Reported -75	76-80	81-90	91+	Total
-75	88 (89) (89)	11 (11) (7)	0 (0) (0)	0 (0) (0)	99 (15)
76-80	11 (7) (11)	134 (83) (80)	19 (9) (4)	1 (1) (2)	161 (24)
81-90	0 (0) (0)	23 (7) (14)	312 (91) (90)	7 (2) (11)	342 (50)
91+	0 (0) (0)	0 (0) (0)	19 (25) (6)	58 (75) (88)	77 (11)
Total	99 (15)	168 (25)	345 (51)	66 (10)	679 (100)

* figures in parentheses are row and column percentages respectively

Table 6. Effects of Age Error on the Analysis of Variance of the Anthropometric Measures

Sources of Variation	Degrees of Freedom	Probability Values					
		Weight-for-Age		Height-for-Age		A.C.-for-Age**	
		Actual	Reported	Actual	Reported	Actual	Reported
Income(I)	2	.000*	.002*	.001*	.014*	.022*	.035*
Mother's Education(E)	1	.177	.029*	.077	.018*	.004*	.001*
Age(A)	2	.706	.647	.001*	.017*	.007*	.016*
Interations							
IxE	2	.819	.445	.748	.391	.155	.177
IxA	4	.691	.911	.702	.846	.719	.627
ExA	2	.940	.651	.408	.354	.863	.782
IxExA	4	.301	.456	.591	.723	.988	.956
Residual	661						

* $p < .05$

** A.C. is abbreviation for arm circumference

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