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ALTERNATIVE NUTRITION/HEALTH INTERVENTION EFFECTS AND COST-EFFECTIVENESS

PART II

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An Overview of Part II

This report is a follow-up on additional analysis of the study reported in [1]. We strongly encourage the reader to review the original report, and hence for brevity, make references to the study without details.

The report has two primary sections. Our original report essentially restricted itself to using percent of standard weight for age (PSWT) as the measure of nutritional status. The focus then was on statistical analysis and cost-effectiveness of the nutrition/health interventions. Section I of this report is concerned with further investigations of the statistical analysis and a look at interaction effects between the nutrition/health interventions. It is our hope that Section I will enable researchers to make better use of statistical analyses and to better judge when various statistical procedures are appropriate or inappropriate for their needs. Of course the main goal of both of these reports is to compare the interventions in terms of cost and effectiveness to the child.

Section II is possibly the most interesting part of the report. In this section we investigate intervention differences using some nutrition indices other than PSWT. These indices are selected from an investigation of nutrition indices reported separately in [2]. Again, we encourage the reader to also review that report for more complete understanding of the justifications for these new indices. While all of the indices used are reasonable, the conclusions drawn using the various indices are sometimes different. This is seen by comparing the cost-effectiveness results between the selected nutrition indices.

Hence, the researcher must be concerned about which index is more appropriate before making decisions about which interventions are best in terms of cost and effectiveness.

Though we have stated that this report depends heavily on [1], we will very briefly outline the basic study. The study was longitudinal and was concerned with the primary nutritional/health interventions of education to the mother, childhood immunizations, supplementary food (in the form of nutripaks), sanitation, and all combinations of these along with a control. Eighteen communities were included in the study. A baseline study was completed on each subject child and family before age five (5) months. Interventions began at age 5 months and lasted for one year with a one-year follow-up. Measurements were taken bi-monthly during the 12 month intervention period and quarterly during the follow-up period.

SECTION I

COMPLETION OF ANALYSIS AND EVALUATION BASED UPON THE NUTRITION INDEX PERCENT OF STANDARD WEIGHT FOR AGE (PSWT)

1.1 INTRODUCTION

Due to the fact that the study measured many variables and generated a large data set, we investigated some variables not considered in the original report and investigated further different kinds of statistical analyses. Section 1.2 considers the effect of some new variables incorporated into the model used for adjusted means of the interventions. In Section 1.3 we consider several ways of using descriptive statistical analysis where problems such as statistical outliers and lack of normality may exist. In the original report we stated that statistical interactions existed between intervention combinations. We investigate these interactions in Section 1.4.

1.2 INVESTIGATION OF ADDITIONAL VARIABLES FOR MODELS USED TO COMPUTE INTERVENTION ADJUSTED MEANS

The models utilized in the original report selected covariates from the set of variables of initial height, initial PSWT, mother's education, father's education, family income, number of children in the family, and mother's age. We have since investigated numerous other variables and only four seemed to be potentially useful in the analysis. These were sex of the child, type of infant feeding, seasonal variation, and mix ratio of water to formula for bottle fed infants. Only two of the variables (sex and type of infant feeding) were of statistical importance

in terms of the models used for computing adjusted intervention means. Unadjusted averages for sex and type of infant feeding are given in Table 1.1 by intervention number. As indicated in Table 1.1, there is a significant difference in average percent of standard weight between males and females. Typically, males were about five percentage points higher on the average than females of the same age. During the early months, type of infant feeding seems important with breast feeding best, then mixed feeding followed by bottle feeding. Interestingly, the opposite seems to be true during latter months. This might be explained by a possible lack of sufficient nutrition from the mother's milk alone and possibly by different approaches for introducing supplementary foods. Figure 1.1 shows the correlations for each of the variables used in our regression model by age. As can be seen from the figures the relationship between the variables and PSWT differ over age. The correlation for initial percent of standard weight (PSWT) decreases over time while initial height increases with time. The change in effect of type of infant feeding over time is again seen in Figure 1.1. Finally, we should point out that adding the variables for sex and type of feeding to the originally used model made little difference in the adjusted means reported in [1].

We could not detect any significant differences between mixing ratios of water to formula for bottle fed infants. However, the sample sizes were not very large, and hence we would hesitate to conclude that no real difference exists.

After investigating seasonal differences we could not detect clear trends. There is at least a suggestion that average percent of standard

TABLE 1.1

DIFFERENCES IN PSWT BETWEEN SEXES AND TYPE OF INFANT FEEDING

a. Percent Standard Weight by Sex

	Intervention Number (age in mos.)								Follow-up Number (age in mos.)			
	0 2 (mos.)	1 5 (mos.)	2 7 (mos.)	3 9 (mos.)	4 11 (mos.)	5 13 (mos.)	6 15 (mos.)	7 17 (mos.)	1 20 (mos.)	2 23 (mos.)	3 26 (mos.)	4 29 (mos.)
Male	104.6	103.0	98.0	91.7	87.9	86.2	85.0	85.3	84.6	85.0	85.8	86.7
Female	96.1	94.6	89.7	84.9	82.0	80.6	80.1	80.2	80.6	81.0	81.8	82.4

b. Percent Standard Weight by Type Infant Feeding

	Intervention Number (age in mos.)								Follow-up Number (age in mos.)			
	0 2 (mos.)	1 5 (mos.)	2 7 (mos.)	3 9 (mos.)	4 11 (mos.)	5 13 (mos.)	6 15 (mos.)	7 17 (mos.)	1 20 (mos.)	2 23 (mos.)	3 26 (mos.)	4 29 (mos.)
Breast	102.6	100.9	94.9	88.5	84.0	82.6	81.6	81.8	81.8	82.1	84.0	82.9
Mixed	101.1	99.0	93.9	88.6	85.4	83.9	82.8	83.0	82.8	83.0	83.1	85.2
Bottle	92.7	92.3	90.2	86.3	85.1	83.2	83.7	83.7	83.3	84.1	84.5	86.4

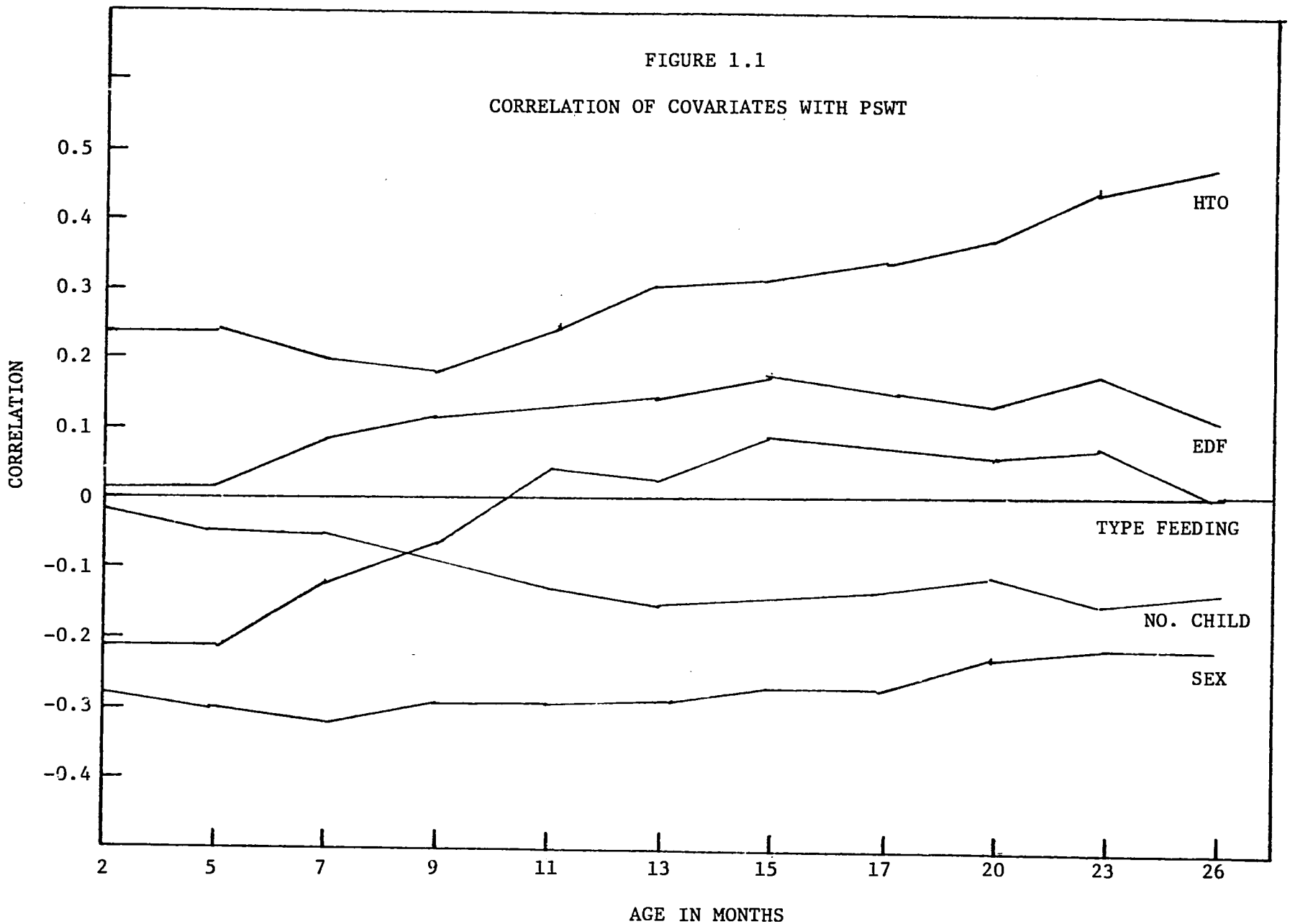


FIGURE 1.1
CORRELATION OF COVARIATES WITH PSWT
CORRELATION
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
HTO
EDF
TYPE FEEDING
NO. CHILD
SEX
2
5
7
9
11
13
15
17
20
23
26
AGE IN MONTHS

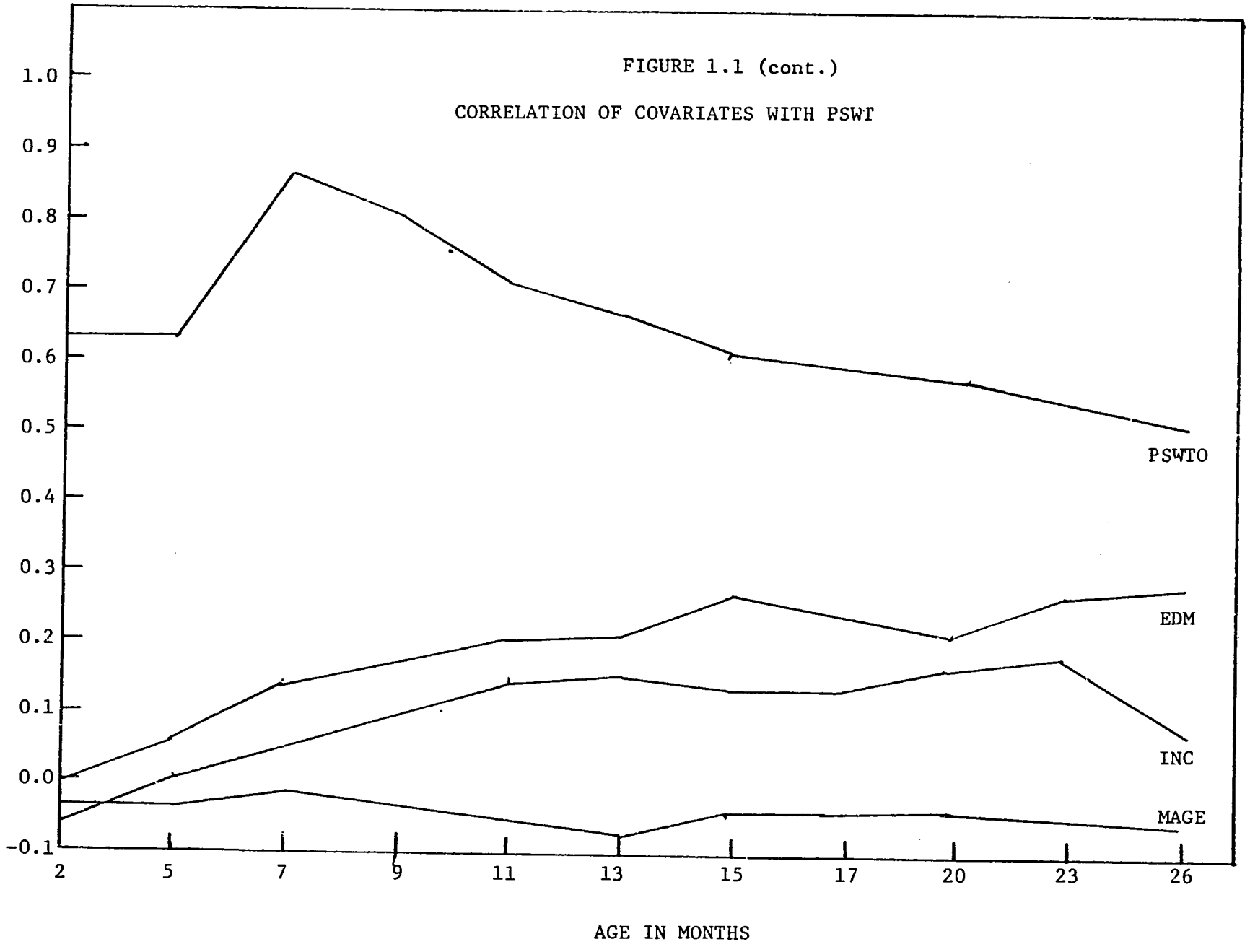


FIGURE 1.1 (cont.)

CORRELATION OF COVARIATES WITH PSWT

weights were somewhat lower between April and July than for the rest of the calendar year. Table 1.2 shows the average percent of standard weight for interviews taken in the respective calendar month by interview number and for all interventions combined.

1.3 INVESTIGATION OF VARIOUS STATISTICS CONSIDERED FOR THE ANALYSIS

Since the primary statistical concern in this study was to estimate intervention effects and to determine when significant differences existed, we did a lot of exploratory data analysis to investigate the validity of statistical assumptions needed in our analysis. For example, is it reasonable to assume normality in performing tests of significance and is the mean (average) a good measure of central tendency as opposed to the median, etc.? Do the data seem reasonably symmetric or are they skewed with possible outlier values?

The estimator used in our earlier report was a modified form of the analysis of covariance adjusted mean. We concluded early that various socioeconomic variables should be taken into account in our analysis. This is the reason covariate models were developed using the covariates described in the previous section. Our modified estimator of the average intervention effect was

$$\bar{\bar{Y}}_i + \bar{r}_{ij},$$

where $\bar{\bar{Y}}_i$ denotes the unadjusted average for all observation at interview i and $\bar{r}_{ij}$ denotes the average of the residuals for the observations in the jth intervention at interview i. The residuals are the difference between the observed value and the predicted value given by the covariate regression model.

TABLE 1.2

SEASONAL UNADJUSTED AVERAGES OF PSWT FOR
COMBINED TREATMENTS BY MONTH

Interview Number	Month of Interview/(Sample Size) JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	99.92 (28)	99.53 (46)	98.26 (114)	93.25 (36)	94.05 (38)	94.18 (40)	100.06 (24)	100.52 (49)	99.23 (35)	101.32 (63)	101.80 (39)	101.83 (37)
2	96.51 (42)	93.79 (37)	93.77 (37)	90.[illegible]8 (38)	93.39 (104)	91.25 (41)	92.48 (38)	89.17 (39)	97.31 (22)	93.85 (50)	93.97 (38)	97.86 (61)
3	90.96 (40)	91.45 (61)	89.00 (43)	88.31 (31)	85.79 (31)	85.45 (46)	87.61 (103)	86.26 (44)	84.98 (33)	86.25 (46)	90.54 (29)	91.96 (43)
4	84.64 (29)	87.46 (46)	87.25 (45)	86.62 (49)	83.92 (38)	84.64 (45)	82.54 (24)	83.58 (46)	84.36 (91)	85.87 (50)	82.86 (49)	84.33 (35)
5	83.35 (45)	81.53 (37)	83.74 (29)	85.07 (46)	84.60 (32)	83.92 (59)	80.72 (43)	80.92 (33)	83.72 (33)	84.22 (51)	84.93 (99)	81.03 (39)
6	83.19 (99)	83.03 (38)	81.18 (48)	80.01 (34)	80.14 (23)	81.84 (52)	85.24 (30)	82.29 (58)	83.12 (41)	82.29 (40)	83.99 (41)	83.29 (38)
7	85.04 (31)	83.20 (44)	83.31 (97)	80.43 (31)	81.42 (33)	80.87 (42)	79.00 (21)	81.68 (43)	85.13 (33)	83.16 (61)	82.80 (41)	84.71 (36)
11	83.82 (61)	83.67 (32)	83.11 (57)	83.21 (34)	80.71 (21)	81.18 (67)	82.01 (41)	81.71 (40)	80.89 (43)	81.32 (22)	83.30 (28)	84.23 (30)
12	81.32 (23)	84.89 (24)	85.44 (26)	82.66 (52)	80.50 (14)	82.03 (21)	84.42 (17)	81.45 (21)	82.93 (60)	84.21 (41)	83.20 (41)	81.44 (37)
13	85.41 (39)	84.98 (35)	82.38 (35)	80.95 (21)	77.24 (6)	86.90 (8)	84.05 (25)	81.26 (9)	83.11 (21)	85.00 (18)	82.50 (25)	84.57 (52)
14	85.85 (15)	81.64 (25)	85.28 (53)	84.85 (41)	85.83 (20)	83.04 (12)	82.53 (7)	76.33 (3)	84.14 (8)	85.93 (28)	84.74 (11)	83.97 (13)

Intervention effects were estimated for the entire study using each of the estimators given below, where i denotes interview number and j denotes intervention number.

i) $\bar{\bar{Y}}_{ij}$, the simple average using all data,

ii) $\bar{\bar{Y}}_i + \bar{r}_{ij}$, the covariate adjusted mean using all data,

iii) $\bar{\bar{Y}}_i + r_{ij(md)}$, the covariate adjusted median using all data,

iv) $\bar{\bar{Y}}_i + \bar{r}_{ij}$ (without outliers), the covariate adjusted mean after statistical outlier observations are deleted,

v) $\bar{\bar{Y}}_i + \bar{r}_{ij}$ $(80 \leq \text{PSWTO} \leq 120)$, the covariate adjusted mean when the data were restricted to baseline percent of standard weight between 80% and 120%,

vi) $\bar{\bar{Y}}_i + \bar{r}_{ij(md)}$ $(80 \leq \text{PSWTP} \leq 120)$, the covariate adjusted median when the data were restricted to baseline percent of standard weight between 80% and 120%,

and

vii) $\bar{\bar{M}}_i + r_{ij(md)}$, a covariate adjusted median using the median of the unadjusted observations $(\bar{\bar{M}})$ instead of the mean $(\bar{\bar{Y}})$.

Part of our investigation can be illustrated with the figures which follow. Each of these figures show five (5) kinds of exploratory data analysis. Moments, tests on the mean, and tests for normality are given in the first part. The second part shows quantiles, range, interquartile range, and mode. The part labeled stem leaf is a histogram with frequencies. The boxplot shows the 25%, 50%, and 75% points and indentifies statistical outliers with zeros. Finally, the normal probability plot is shown. For this plot, a straight line suggests that normality is a reasonable assumption.

FIGURE 1.2. EXPLORATORY DATA ANALYSIS

MOMENTS

N	61	SUM WGTS	61
MEAN	0.657933	SUM	40.1339
STD DEV	6.9503	VARIANCE	48.3066
SKEWNESS	-0.118721	KURTOSIS	0.0870905
USS	2924.8	CSS	2898.4
CV	1056.38	STD MEAN	0.889894
T:MEAN=0	0.739338	PROB>|T|	0.462584
D:NORMAL	0.0679881	PROB>D	>0.15

QUANTILES(DEF=4)

100%	MAX	16.0392	99%	16.0392
75%	Q3	4.70707	95%	13.0378
50%	MED	1.22979	90%	9.72183
25%	Q1	-3.36489	10%	-8.48062
0%	MIN	-15.3084	5%	-13.5226
			1%	-15.3084
RANGE		31.3475		
Q3-Q1		8.07196		
MODE		-15.3084		

```
STEM LEAF                          #          BOXPLOT
  16 00                            2             |
  14                                             |
  12 2                             1             |
  10 63                            2             |
   8 799                           3             |
   6 15249                         5             |
   4 233591                        6          +-----+
   2 455549                        6          |     |
   0 191256668                     9          *--+--*
  -0 93211                         5          |     |
  -2 61007421                      8          +-----+
  -4 6232                          4             |
  -6 4665                          4             |
  -8 37                            2             |
 -10                                             |
 -12 62                            2             |
 -14 31                            2             |
     ----+----+----+----+
```

NORMAL PROBABILITY PLOT

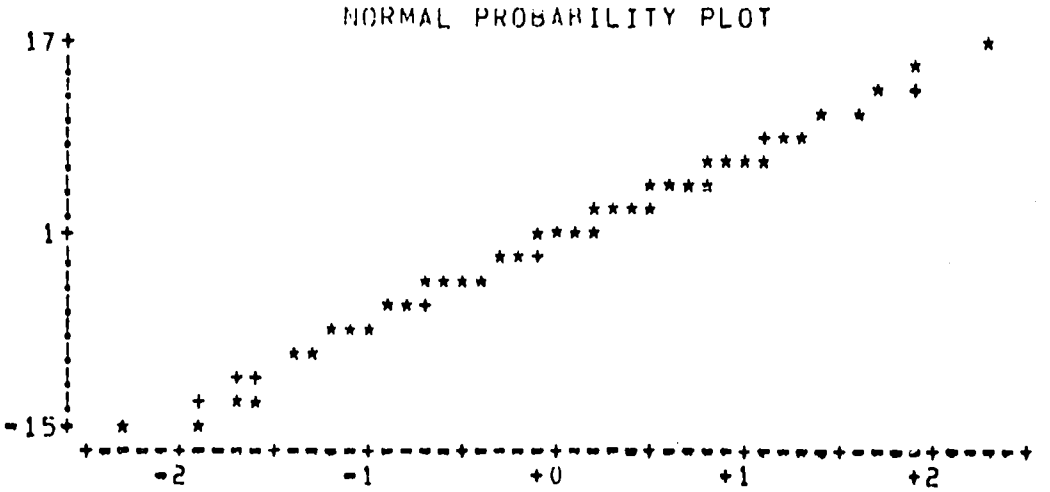


FIGURE 1.3. EXPLORATORY DATA ANALYSIS

MOMENTS

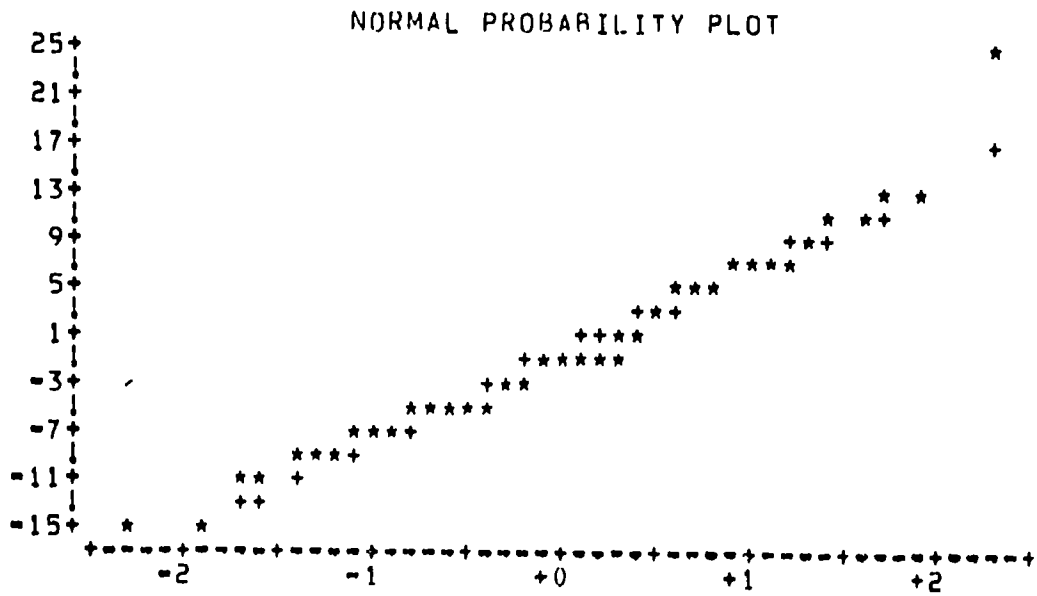
N	60	SUM WGTS	60
MEAN	-0.495108	SUM	-29.7065
STD DEV	7.27911	VARIANCE	52.9855
SKEWNESS	0.646612	KURTOSIS	0.968818
USS	3140.85	CSS	3126.14
CV	-1470.21	STD MEAN	0.939729
T:MEAN=0	-0.526862	PROB>|T|	0.600265
D:NORMAL	0.102328	PROB>D	0.118

QUANTILES(DEF=4)

100%	MAX	24.062	99%	24.062
75%	Q3	4.58307	95%	11.9817
50%	MED	-1.26083	90%	9.48955
25%	Q1	-5.59636	10%	-8.30195
0%	MIN	-14.7139	5%	-11.3055
			1%	-14.7139
RANGE		38.7759		
Q3-Q1		10.1794		
MODE		-14.7139		

```
STEM LEAF                          #             BOXPLOT
  24 1                             1                0
  22
  20
  18
  16
  14
  12 02                            2                |
  10 49                            2                |
   8 07                            2                |
   6 019359                        6                |
   4 1462                          4             +-----+
   2 537                           3             |     |
   0 559                           3             |     |
  -0 98832176532                  11             *--+--*
  -2 938                           3             |     |
  -4 8711832100                   10             +-----+
  -6 65170                         5                |
  -8 6310                          4                |
 -10 31                            2                |
 -12                                                |
 -14 75                           2                |
     ----+----+----+----+
```

NORMAL PROBABILITY PLOT



Figures 1.2 and 1.3 show some analysis of the residuals, r_{ij}. From Figure 1.2 we see that the normality assumption is reasonable (i.e. normal plot is almost a straight line and test for normality is not significant). However, the mean residual is 0.66 and the median residual is 1.23. Hence, the two estimators differ by 1.23-0.66 = 0.57. The boxplot suggests no statistical outliers in the data set. In Figure 1.3, the normality assumption is not as strongly documented and there is clearly a statistical outlier identified in the data set. Removing the outlier causes the mean residual to change from -0.50 to -0.91, which is not very different from the median residual.

Another method of treating outliers is to restrict the data set at the outset. We also analysed the data by deleting all children from the analysis whose percent of standard weight for age at baseline was less than 80% or greater than 120%. This essentially restricted the data to "normal" children at the baseline stage. Other exploratory data analyses were also performed but will not be reported as they did not lead to useful results.

We will now make some broad recommendations for analysis of data such as these. Not all recommendations will apply to every data set but may alert the researcher to possible problems which need attention in the analysis and interpretation.

1. Extra care should be taken, with pilot studies, etc., to make sure the data are collected as accurately as possible.
2. Generally the data should be put through a major editing process to remove recording errors, obvious mistakes, etc. This is very important since the quality of the analysis is very dependent upon the quality of the data.

3. Exploratory data analysis should be performed in an attempt to identify factors affecting the variables of interest; investigate the data for outliers, symmetry, etc. which will help identify which statistics are reasonable.
4. When the primary measurements are affected by other variables (such as socioeconomic variables), methods to adjust the data to eliminate (or at least reduce) these effects must be sought. If enough data are available, simple cross tabulation may be sufficient. Usually some type of covariate analysis works well if assumptions needed are reasonably met.
5. The researcher usually feels more comfortable if various reasonable approaches to the analysis lead to the same (or similar) results. If this is not the case then extra care must be taken to investigate the most valid approach.
6. Finally, there is no substitute for professional judgment in the interpretation of the statistical analysis. This stage is best handled in a team fashion with the generic discipline professional and the statistician. This team approach has been invaluable in this study.

1.4 INTERVENTION INTERACTION ANALYSIS

We reported in our earlier report that statistical interaction existed for intervention combinations. Hence, one must be careful in interpreting intervention effects when in combination with each other. It also makes comparisons with single (primary) interventions difficult.

Table 1.3 helps in our investigation of the interaction effects. These can be confusing without careful consideration. We will also see that

in some cases the interaction effect differs over time. This simply implies that interventions have different effects at different ages of children, as might be expected. We will first explain the tables and then offer some interpretations.

Consider the 2 x 2 table in the first column and first row of Table 1.3. For interview number 3 (age 9 months) and the common intervention education (E), we have

		F	$\bar{F}$	
E	I	87.7	88.7	-1.0
	$\bar{I}$	90.3	88.3	+2.0
		-2.6	0.4	

- - - - - - - - - - - - - - - - - - - -

-3.0

A bar above a symbol means absence of the intervention, and hence, the entries in the tables represent the adjusted means for the following intervention combinations.

EIF = 87.7

EI = 88.7

EF = 90.3

E = 88.3

The row and column numbers are obtained by subtracting the respective entries from the upper left entry. The entry below the dotted line (-3.0) is the difference between the first and second column entries (-2.6 and 0.4). Hence, the number -3.0 represents the estimate of how much greater the food effect is for immunized children than for non-immunized children. Stating another way, food is 3.0 percentage points less value to immunized children than it is to non-immunized children. Thus one could conclude that food is more important for children not

TABLE 1.3

INTERVENTION INTERACTION EFFECTS

Intervention Combination	Interview Number (age in mos.) 3			5			7			Follow-up Number 1			3		
		F	$\overline{F}$		F	$\overline{F}$		F	$\overline{F}$		F	$\overline{F}$		F	$\overline{F}$
E	I	87.7	88.7	-1.0	82.5	83.9	-1.4	81.8	84.3	-2.5	82.1	85.1	-3.0	83.0	86.9	-4.0
	$\overline{I}$	90.3	88.3	+2.0	85.1	84.4	+0.7	83.2	83.2	0.0	82.7	82.7	0.0	82.9	82.6	+0.3
		-2.6	0.4		-2.6	-0.5		-1.4	1.1		-0.7	2.4		0.1	4.3	
		-3.0			-2.1			-2.5			-3.1			-4.2		
		F	$\overline{F}$		F	$\overline{F}$		F	$\overline{F}$		F	$\overline{F}$		F	$\overline{F}$	
E	S	87.4	87.4	0.0	82.4	83.1	-0.7	82.4	81.4	+0.9	82.0	82.4	-0.4	82.5	84.8	-2.3
	$\overline{S}$	88.3	88.3	0.0	85.1	84.4	+0.7	83.2	83.2	0.0	82.7	82.7	0.0	82.9	82.6	+0.3
		-1.0	-1.0		-2.7	-1.4		-0.8	-1.8		-0.7	-0.4		-0.4	2.2	
		0.0			-1.3			+1.0			-0.3			-2.6		
		I	$\overline{I}$		I	$\overline{I}$		I	$\overline{I}$		I	$\overline{I}$		I	$\overline{I}$	
E	S	88.4	87.4	+1.0	82.0	83.1	-1.1	81.6	81.4	+0.1	81.4	82.4	-1.0	83.7	84.8	-1.2
	$\overline{S}$	88.7	88.3	+0.3	83.9	84.4	-0.5	84.3	83.2	+1.1	85.1	82.7	+2.4	86.9	82.6	+4.3
		-0.3	-1.0		-1.9	-1.4		-2.7	-1.8		-3.7	-0.4		-3.3	2.2	
		0.7			-0.5			-0.9			-3.3			-5.5		

TABLE 1.3 (cont.)

INTERVENTION INTERACTION EFFECTS

Intervention Combination	Interview Number (age in mos.) 3			5			7			Follow-up Number 1			3		
		I	$\overline{I}$		I	$\overline{I}$		I	$\overline{I}$		I	$\overline{I}$		I	$\overline{I}$
E/F	S	88.2	87.3	+0.9	83.0	82.4	+0.7	82.6	82.4	+0.3	81.8	82.1	-0.2	83.4	83.0	+0.4
	$\overline{S}$	87.7	90.3	-2.5	82.5	85.1	-2.6	81.8	83.2	-1.4	82.1	82.7	-0.7	83.0	82.9	+0.1
		-0.5	-3.0		0.6	-2.7		0.8	-0.8		-0.2	-0.7		0.4	0.1	
		2.5			3.3			1.6			0.5			0.3		
		F	$\overline{F}$		F	$\overline{F}$		F	$\overline{F}$		F	$\overline{F}$		F	$\overline{F}$	
E/I	S	88.2	88.4	-0.2	83.4	82.0	+1.1	82.6	81.6	+1.1	81.8	81.4	+0.4	83.4	83.7	-0.3
	$\overline{S}$	87.7	88.7	-0.9	82.5	83.9	-1.4	81.8	84.3	-2.5	82.1	85.1	-3.0	83.0	86.9	-4.0
		0.5	-0.3		0.6	-1.9		0.8	-2.7		-0.2	-3.7		0.4	-3.3	
		0.8			2.5			3.5			3.5			3.7		
		F	$\overline{F}$		F	$\overline{F}$		F	$\overline{F}$		F	$\overline{F}$		F	$\overline{F}$	
E/S	I	88.2	88.4	-0.2	83.0	82.0	+1.1	82.6	81.6	+1.1	81.8	81.4	+0.4	83.4	83.7	-0.3
	$\overline{I}$	87.3	87.4	0.0	82.4	83.1	-0.7	82.4	81.4	+0.9	82.0	82.4	-0.4	82.5	84.8	-2.3
		0.9	1.0		0.7	-1.1		0.3	0.1		-0.1	-1.0		0.9	-1.2	
		-0.1			1.8			0.2			0.9			2.1		

immunized than it is for immunized children. All of the other 2 x 2 tables for various intervention combinations are interpreted in the same way.

The first part of Table 1.3 shows interaction effects, in the presence of education (E), for food vs. immunization, food vs. sanitation, and immunization vs. sanitation. In the case of food versus immunization, we see that the difference increases with age to -4.2 at follow-up 3 (age 26 months). For food versus sanitation, the pattern is not consistent. This should be expected from the results on the primary interventions where sanitation seemed to hinder growth for a period of time and then showed an excellent growth rate during the follow-up period. Here again, the data suggests that during the follow-up food is of less value with sanitation than without sanitation. For immunization versus sanitation, the pattern is consistent and suggests that immunization is not as important to the children with sanitation as it is to the children without sanitation.

The patterns are somewhat different in the second part of Table 3. In the presence of education (E) <u>and</u> food (F), immunization seems more effective with sanitation than without sanitation, with a decreasing difference as the children get older. In the presence of education (E) <u>and</u> immunization (I), the interactions suggest that food effect is greater with sanitation than without sanitation with the difference increasing with age. Finally, in the presence of education (E) <u>and</u> sanitation (S), there is a slight suggestion that food effect is greater with immunization than without immunization.

In summary these results are interesting and on the surface may appear contradictory. However, one must remember that here we are considering the <u>effect</u> of an intervention in the presence or absence of

another intervention. This does not necessarily tell us which intervention combination is best. However, given that one or more interventions will be administered, the interactions help us to estimate the effect of adding another intervention with or without a further intervention. Briefly, the interactions suggest the following:

1. In the presence of education (E) alone, the effect of food is less with immunization than without. The opposite is true in the presence of education (E) and sanitation.
2. In the presence of education (E) alone, the effect of food is less with sanitation (S) than without sanitation ($\bar{S}$). The opposite is true in the presence of education (E) and immunization (I).
3. In the presence of education (E) alone, the effect of immunization (I) is less with sanitation (S) than without. Again, the opposite is true in the presence of education (E) and sanitation.

1.5 SUMMARY OF SECTION I

After throughly investigating data analysis used in [1] along with other types of analysis, we feel comfortable with the earlier results given. We have seen that it is absolutely necessary to adjust data for extraneous factors which influence the results in order to adequately evaluate nutrition interventions. We believe the summary of results given in [1] are valid, at least if one accepts the index of PSWT as proper to measure intervention impact. In addition, we have looked at estimates of interaction effects and found reasonable results which basically suggest that intervention combinations are not as effective as

the sum of the respective single interventions given alone (i.e. interventions are not additive).

We also wish to emphasize that the average percent of standard weight for age for all interventions was higher than is typically seen for children not in intervention programs. Hence, all interventions were effective in various degrees. However, costs are different which leads to some different results in terms of cost-effectiveness.

All of the results in our original report and Section I of this report used percent of standard weight for age (PSWT) as the nutritional status index. In interpreting the results the reader should use whatever caution he deems necessary with respect to possible limitations of this single index. In the following part of the report (Section II), we will consider the interventions using other very reasonable nutrition indices.

SECTION II

COMPARISON OF INTERVENTION ANALYSIS BASED UPON SOME NEW INDICES FOR NUTRITIONAL STATUS

2.1 INTRODUCTION

In this section we will be primarily concerned with comparing cost-effectiveness of interventions using alternative nutrition indices. All of the cost-effectiveness analysis in [1] utilized percent of standard weight for age (PSWT) as the index to measure nutritional status. We will see that reasonable alternative indices sometimes yield different results. Hence, before one can comfortably evaluate alternative nutrition interventions, we must understand what an index really measures and then agree that the measurements truly reflect intervention effects.

In [2], several (fourteen) nutrition indices were suggested and evaluated. In addition to some of the more commonly used indices, this study gave some new nutrition indices which are based upon a correct mathematical relationship between physical body measurements. We refer the reader to that report for derivations and mathematical justifications. In this report we have selected five new indices from [2] so that the cost-effectiveness using these indices can be compared with the analysis in [1]. We believe that the results should raise some fundamental questions about which index (or indices) are most appropriate to use in nutrition evaluation.

2.2 DEFINITION OF NUTRITION INDICES

The analysis here will compare results using the nutrition indices given below. We will use the same notation as that in [2] so that cross

referencing will not be difficult. The formulae for the indices use the notational abbreviations of ht, wt, ch, and hd for observed height, weight, chest circumference, and head circumference, respectively. A subscript zero denotes the standard value for age of the respective measurement. Thus, for example, wt/wt_o denotes the observed weight divided by the standard weight for age.

1. Percent of standard weight for age

$$V_1 = (wt/wt_o) \times 100 \quad .$$

2. Percent of standard weight for age relative to percent of standard height for age.

$$V_2 = \frac{(wt/wt_o)}{(ht/ht_o)} \times 100 \quad .$$

3. Proper physical relation between percent of standard weight and percent of standard height.

$$V_3 = \frac{(wt/wt_o)}{(ht/ht_o)^3} \times 100 \quad .$$

4. Proper physical relation between percent of standard weight and estimated convex surface area of body using chest and height measurements.

$$V_4 = \frac{(wt/wt_o)}{\left[\frac{(ch)(ht)}{(ch_o)(ht_o)}\right]^{3/2}} \times 100 \quad .$$

5. Proper physical relation between percent of standard weight and estimated convex surface area of body using head and height measurements.

$$V_5 = \frac{(wt/wt_o)}{\left[\frac{(hd)(ht)}{(ch_o)(ht_o)}\right]^{3/2}} \times 100$$

6. Proper physical relation between percent of standard height and estimated convex surface area of body using chest and height measurements.

$$V_9 = \frac{\left[\frac{(ch)(ht)}{(ch_o)(ht_o)}\right]}{\left(\frac{ht}{ht_o}\right)^2} \times 100$$

We note that V_1 is the index used throughout [1]. Hence, we will duplicate some results from that report for convenience of comparisons here.

2.3 ADJUSTED INTERVENTION MEANS FOR SELECTED NUTRITION INDICES

The adjusted means by intervention and interview number are given in Tables 2.1 - 2.6 for each of the nutrition indices defined above. Table 2.7 gives the approximate standard errors of the means so that the reader can determine when interventions are statistically significantly different. We note from Table 2.7 that the standard errors for V_1 - V_5 are approximately the same size. However, the standard errors for V_9 are about one-half as large as the others. For the primary interventions of C, E, EI, EF, and ES, the adjusted means for each index are graphed in Figures 2.1 - 2.6 for ease of comparison.

The results seen in the graphs show some similarities but also some rather striking differences. All of the indices suggest education <u>and</u> food (EF) is best during the intervention period while supplementary food is given out. However, the difference in favor of supplementary food is much more dramatic for indices V_3 and V_5. Throughout, V_2 is essentially a compromise between V_1 and V_3. Of all the indices, V_9 gives the smallest intervention differences but we note from Table 2.7 that V_9 also has the smallest standard error. In comparing V_1, V_3, and V_5, one big difference

is seen. The intervention EI is strongly suggested as best during the follow-up period for index V_1. Indices V_3 and V_5 strongly suggest that EF remains best even during the follow-up period. We had some difficulty attempting to explain the suggested excellent behavior of EI in [1]. The new indices refute the behavior of EI as suggested by V_1 (percent of standard weight for age).

All of the indices suggest an actual loss due to ES during at least part of the intervention period and then a rather dramatic recovery during the follow-up. Our attempts to explain this phenomena remain the same as reported in [1].

Even though the new indices suggest an even better performance for education <u>and</u> supplemental food, the other interventions also show gains during at least part of the study period. Since the intervention costs are different it is still important to consider the cost-effectiveness as suggested by the alternative nutrition indices.

TABLE 2.1

AVERAGE PERCENT OF STANDARD WEIGHT OF SUBJECTS: ADJUSTED MEANS

Intervention	Baseline	Interview Number/(age in months)							Follow-up Number (Age in mos.)			
	0	1 (5)	2 (7)	3 (9)	4 (11)	5 (13)	6 (14)	7 (17)	1 (20)	2 (23)	3 (26)	4 (29)
Control	100.96	100.77	93.00	87.29	83.68	82.75	82.48	83.34	82.35	82.84	83.08	80.43
Education	102.35	97.72	94.58	88.18	85.69	84.18	82.64	82.90	82.59	81.39	82.53	84.76
Education/ Immunization	99.69	97.55	93.75	88.73	85.65	84.00	84.30	84.55	85.03	84.39	86.46	84.30
Education/ Suppl. Food	101.47	99.32	94.52	90.15	87.08	84.91	83.58	82.99	82.66	83.54	82.53	84.61
Education/ Sanitation	101.76	97.21	94.28	87.31	84.47	83.04	82.15	81.30	81.94	82.32	84.92	85.55
Education/ Immunization/ Food	99.57	99.98	93.62	87.81	83.96	82.53	80.84	81.82	81.86	83.55	83.07	84.87
Education/ Food/ Sanitation	98.05	99.01	91.53	87.22	83.63	82.25	81.94	82.27	82.22	82.92	82.62	84.11
Education/ Immunization/ Sanitation	100.12	98.75	94.52	88.60	84.70	82.32	82.36	81.84	81.78	82.01	81.23	85.28
Education/ Immunization/ Food/ Sanitation	97.74	97.48	93.22	88.44	84.57	83.42	81.95	83.05	82.42	83.07	83.89	85.25

TABLE 2.2

ADJUSTED MEANS USING INDEX V_2

Intervention	Interview Number 1	2	3	4	5	6	7	Follow-up 1	2	3	4
Control	98.98	93.24	87.67	85.48	85.45	87.25	87.95	88.00	89.18	90.73	87.90
Education	97.42	93.34	88.23	87.36	87.72	86.63	86.99	88.11	88.24	89.13	91.51
Education/ Immunization	97.63	94.43	90.04	88.06	86.67	87.50	88.28	89.88	89.46	92.10	90.74
Education/ Suppl. Food	98.65	94.43	91.03	89.61	88.70	87.96	88.05	88.82	90.33	89.99	92.30
Education/ Sanitation	95.49	91.70	86.24	84.97	85.25	85.14	85.37	86.93	88.26	91.49	91.67
Education/ Immunization/ Food	100.98	96.63	91.59	87.77	86.34	84.29	86.18	87.95	90.11	90.32	90.87
Education/ Food/ Sanitation	97.43	92.08	88.71	86.61	85.43	86.29	87.38	88.38	89.61	90.49	91.51
Education/ Immunization/ Sanitation	99.53	95.17	90.43	86.78	84.80	85.40	85.35	85.70	87.42	89.63	91.50
Education/ Immunization/ Food/ Sanitation	99.73	94.29	90.54	86.70	86.24	84.90	86.47	87.18	88.39	89.04	91.49

TABLE 2.3

ADJUSTED MEANS USING INDEX V_3

Intervention	Interview Number 1	2	3	4	5	6	7	Follow-up 1	2	3	4
Control	96.77	93.50	90.26	88.46	89.91	94.01	96.47	99.74	103.30	105.40	104.28
Education	98.81	94.64	91.45	92.66	93.03	95.40	95.94	100.47	103.06	103.44	107.88
Education/ Immunization	95.94	94.90	91.51	92.21	92.03	94.88	96.81	101.21	101.09	105.09	103.97
Education/ Suppl. Food	99.96	96.65	95.18	96.20	96.69	97.16	98.92	102.25	105.85	106.26	108.12
Education/ Sanitation	96.53	94.30	90.27	90.39	92.86	93.87	95.28	99.02	101.73	106.45	106.45
Education/ Immunization/ Food	99.45	95.83	93.89	92.55	92.71	90.66	95.42	101.71	105.16	105.25	106.14
Education/ Food/ Sanitation	96.28	94.30	91.68	91.61	91.43	94.66	96.80	100.39	102.64	105.72	106.59
Education/ Immunization/ Sanitation	99.29	95.27	92.89	90.64	90.70	93.18	94.20	97.17	101.09	107.14	109.75
Education/ Immunization/ Food/ Sanitation	99.94	94.98	93.61	92.21	93.65	93.48	96.77	101.63	105.00	103.74	107.74

TABLE 2.4

ADJUSTED MEANS USING INDEX V_4

Intervention	Interview Number 1	2	3	4	5	6	7	Follow-up 1	2	3	4
Control	92.46	96.02	93.39	93.13	93.77	95.89	97.06	97.88	99.44	100.68	100.61
Education	94.56	96.53	94.80	94.07	95.69	94.38	95.94	98.75	98.45	99.55	102.58
Education/ Immunization	92.10	94.49	93.76	94.89	93.05	95.84	97.24	98.93	98.34	100.99	99.80
Education/ Suppl. Food	95.21	96.26	96.16	96.42	96.43	96.36	98.08	98.72	101.60	100.60	102.86
Education/ Sanitation	94.34	96.72	93.05	92.37	93.86	94.76	95.59	97.77	98.73	101.17	100.97
Education/ Immunization/ Food	92.75	93.25	94.97	95.10	95.86	94.79	96.79	98.89	102.08	104.27	102.05
Education/ Food/ Sanitation	93.08	94.44	92.69	92.10	93.32	95.13	96.66	97.95	98.46	99.65	99.74
Education/ Immunization/ Sanitation	93.80	94.13	94.53	92.32	92.86	94.96	94.42	96.91	97.85	102.43	102.06
Education/ Immunization/ Food/ Sanitation	94.02	95.26	95.71	93.96	94.51	94.58	96.23	98.56	100.50	99.37	103.85

TABLE 2.5

ADJUSTED MEANS USING INDEX V_5

Intervention	Interview Number 1	2	3	4	5	6	7	Follow-up 1	2	3	4
Control	101.38	97.14	93.14	91.14	92.06	94.68	95.92	97.17	98.65	99.41	97.64
Education	101.51	98.00	93.69	94.01	96.19	94.33	94.70	97.72	98.49	98.56	101.06
Education/ Immunization	100.38	98.61	94.84	94.42	93.27	94.62	95.93	98.62	98.34	100.91	100.39
Education/ Suppl. Food	102.57	98.67	96.42	96.24	96.68	96.32	96.76	98.33	101.26	100.73	102.39
Education/ Sanitation	100.02	96.99	92.58	91.92	92.80	93.28	93.72	96.57	98.25	101.67	101.44
Education/ Immunization/ Food	101.53	99.58	96.14	93.55	92.89	91.11	93.66	97.18	99.54	99.08	99.42
Education/ Food/ Sanitation	100.69	97.44	94.56	93.53	92.89	94.43	95.91	97.66	99.65	101.14	101.29
Education/ Immunization/ Sanitation	102.00	98.76	96.09	92.91	91.61	93.06	93.21	94.42	97.62	101.85	103.55
Education/ Immunization/ Food/ Sanitation	103.20	98.65	96.57	94.00	93.86	93.26	95.41	97.37	99.43	98.94	102.20

TABLE 2.6

ADJUSTED MEANS USING INDEX V_9

Intervention	Interview Number 1	2	3	4	5	6	7	Follow-up 1	2	3	4
Control	103.20	98.16	97.61	96.64	97.36	98.67	99.63	101.31	102.63	103.06	102.23
Education	102.91	98.66	97.78	98.93	100.59	100.67	100.05	101.14	102.75	102.57	103.10
Education/ Immunization	102.53	100.27	98.32	98.01	99.14	99.19	99.[illegible]	101.50	101.74	102.68	103.51
Education/ Suppl. Food	103.11	100.26	99.20	99.87	100.08	100.56	100.52	102.25	102.68	103.77	103.60
Education/ Sanitation	101.67	98.36	97.97	98.57	99.15	99.33	99.78	100.91	102.12	103.33	103.56
Education/ Immunization/ Food	104.77	101.82	99.21	98.14	97.77	97.37	99.04	101.90	101.93	101.39	102.35
Education/ Food/ Sanitation	102.41	99.71	99.22	99.69	98.56	99.58	100.25	101.72	102.83	103.98	104.43
Education/ Immunization/ Sanitation	103.90	100.77	98.86	98.65	98.41	98.66	99.74	99.95	102.26	103.00	104.98
Education/ Immunization/ Food/ Sanitation	104.19	99.82	98.67	98.81	99.28	99.25	100.37	102.07	102.96	102.63	102.14

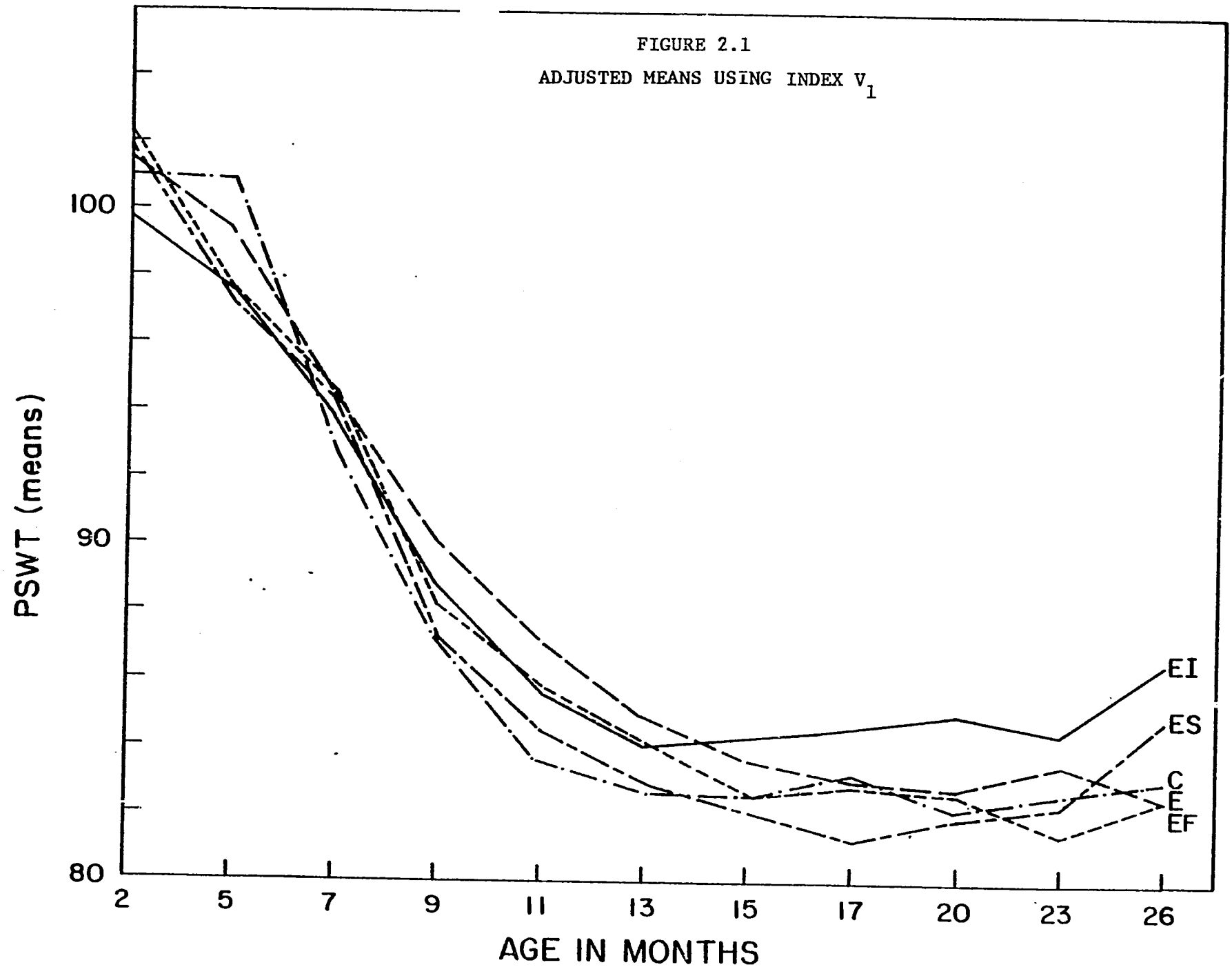
TABLE 2.7

STANDARD ERROR OF MEANS
FOR NUTRITION ESTIMATORS

Interview Number (age in months)	Nutrition Estimator					
	V_1	V_2	V_3	V_4	V_5	V_9
1 (5)	1.30	1.18	1.37	1.01	1.15	0.64
2 (7)	0.85	1.14	1.21	0.88	1.08	0.59
3 (9)	0.86	1.04	1.11	0.86	1.04	0.50
4 (11)	0.88	0.95	1.10	0.82	0.95	0.51
5 (13)	0.94	0.98	1.16	0.90	1.05	0.59
6 (15)	0.90	0.88	1.05	0.84	0.89	0.49
7 (17)	0.94	0.92	1.07	0.83	0.92	0.49
F-1 (20)	0.95	0.97	1.30	0.89	0.99	0.54
F-2 (23)	1.00	1.09	1.36	0.92	1.15	0.60
F-3 (26)	1.20	1.23	1.65	1.48	1.33	0.80
F-4 (29)	1.70	1.44	1.74	1.44	1.59	0.87

FIGURE 2.1

ADJUSTED MEANS USING INDEX V_1



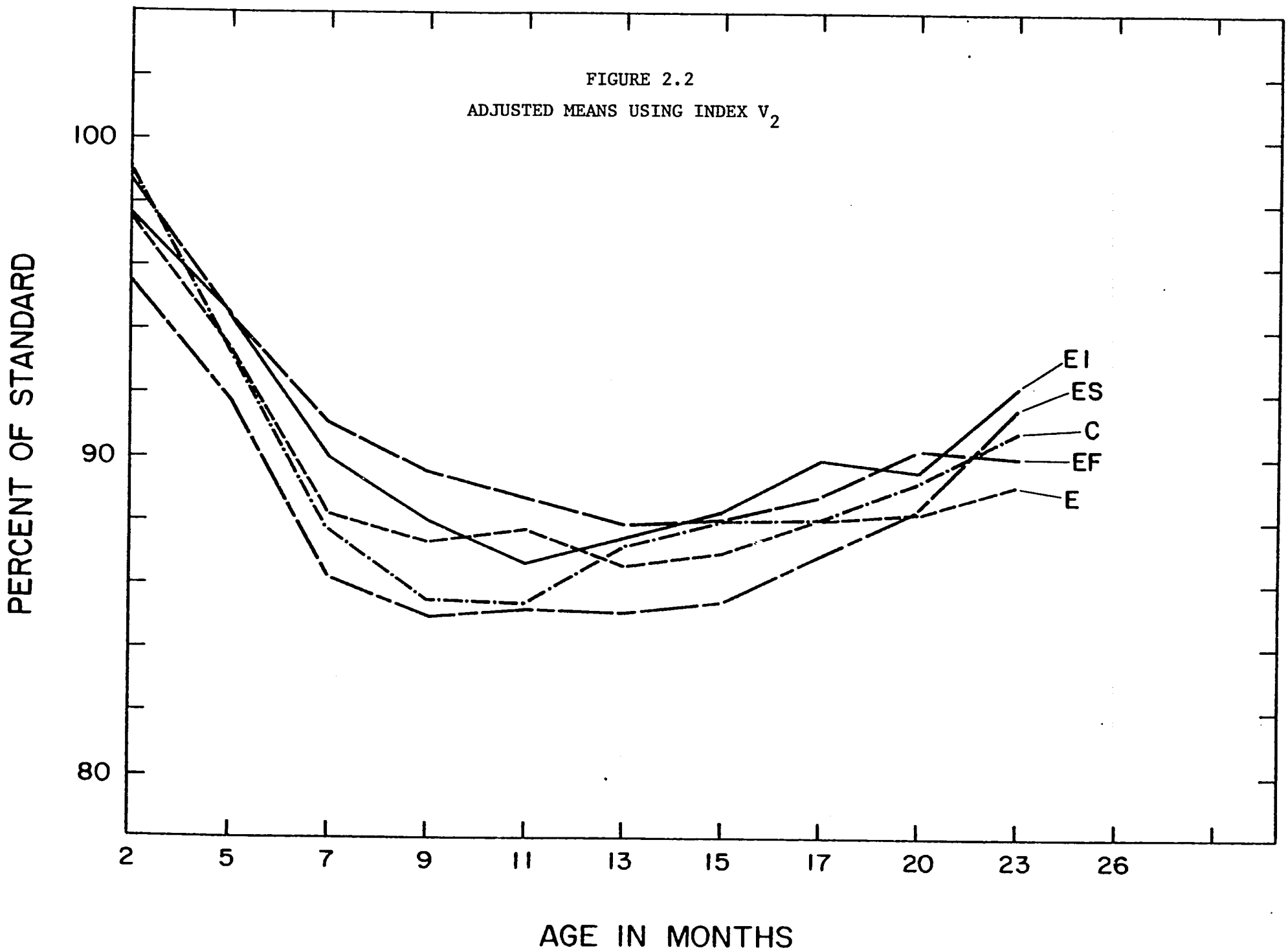


FIGURE 2.2

ADJUSTED MEANS USING INDEX V_2

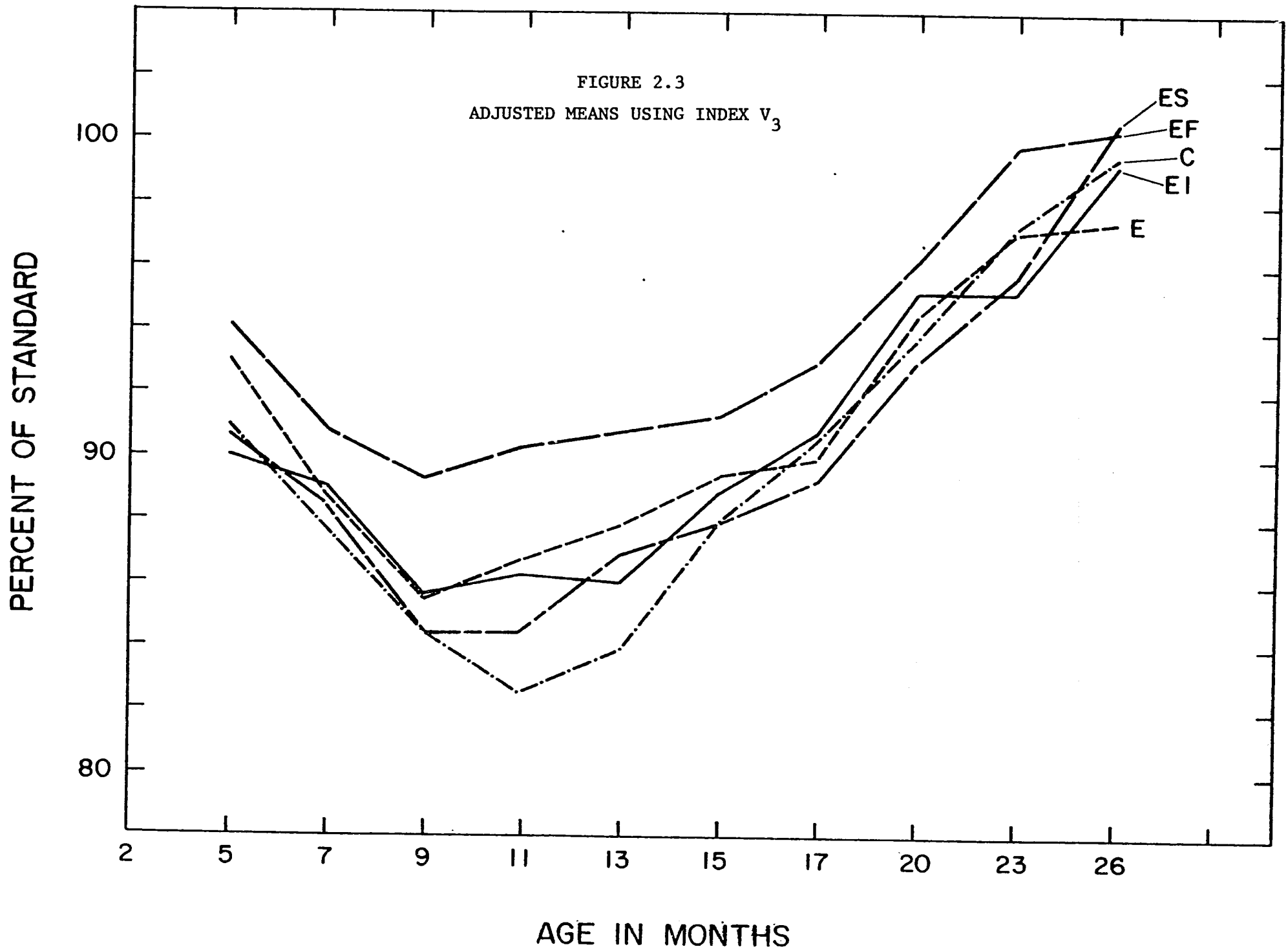


FIGURE 2.3

ADJUSTED MEANS USING INDEX V_3

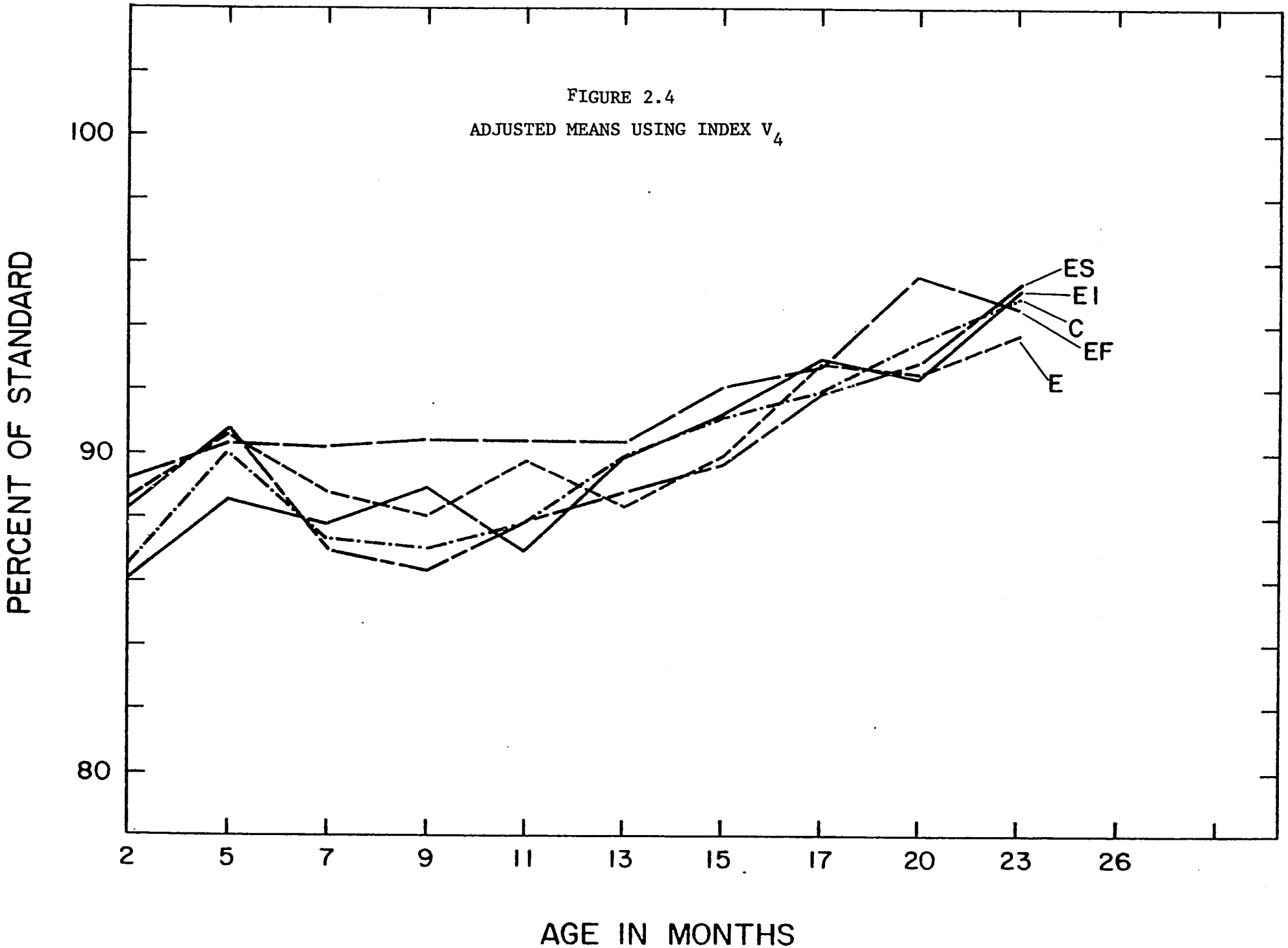


FIGURE 2.4

ADJUSTED MEANS USING INDEX V_4

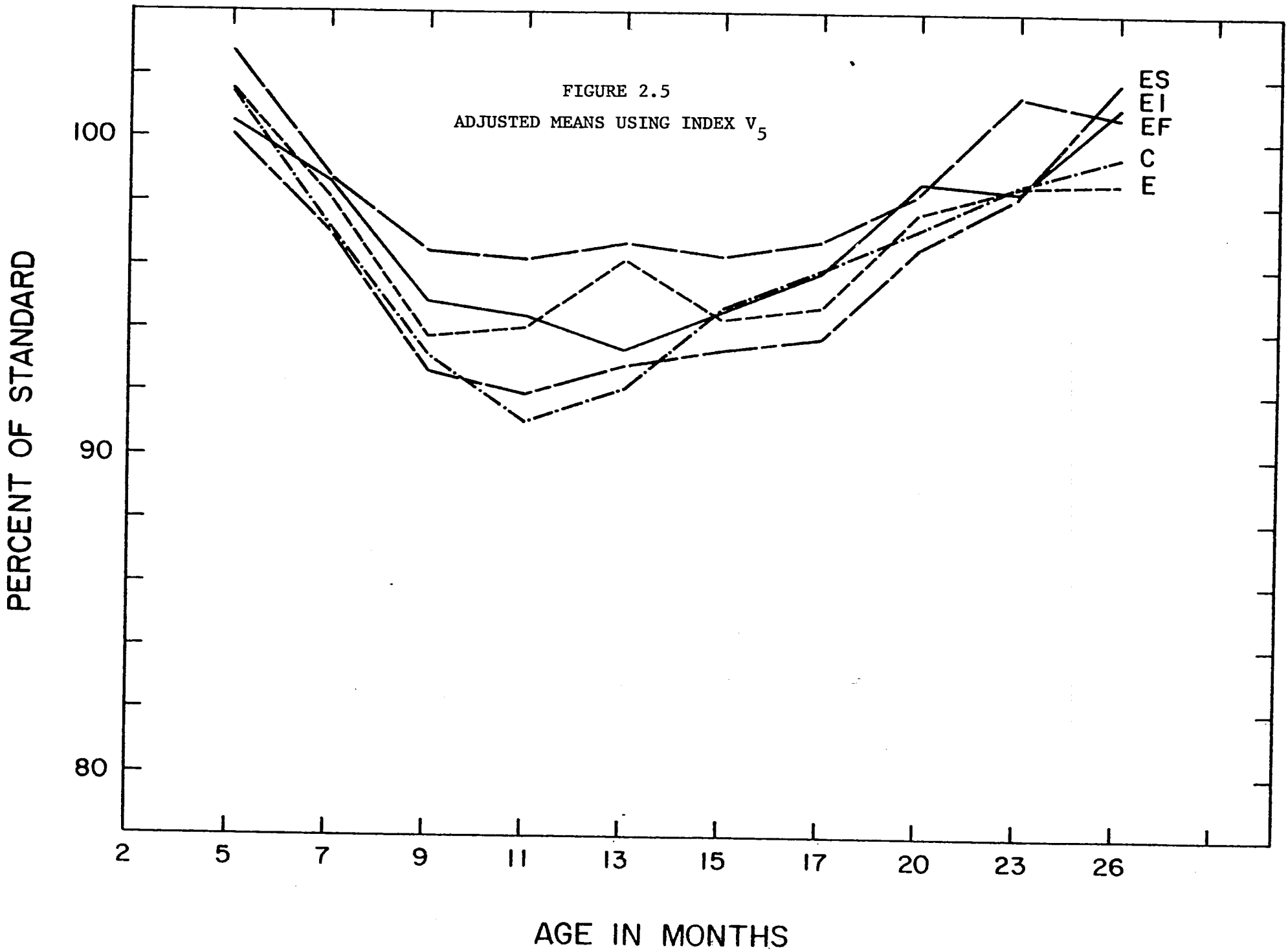


FIGURE 2.5

ADJUSTED MEANS USING INDEX V_5

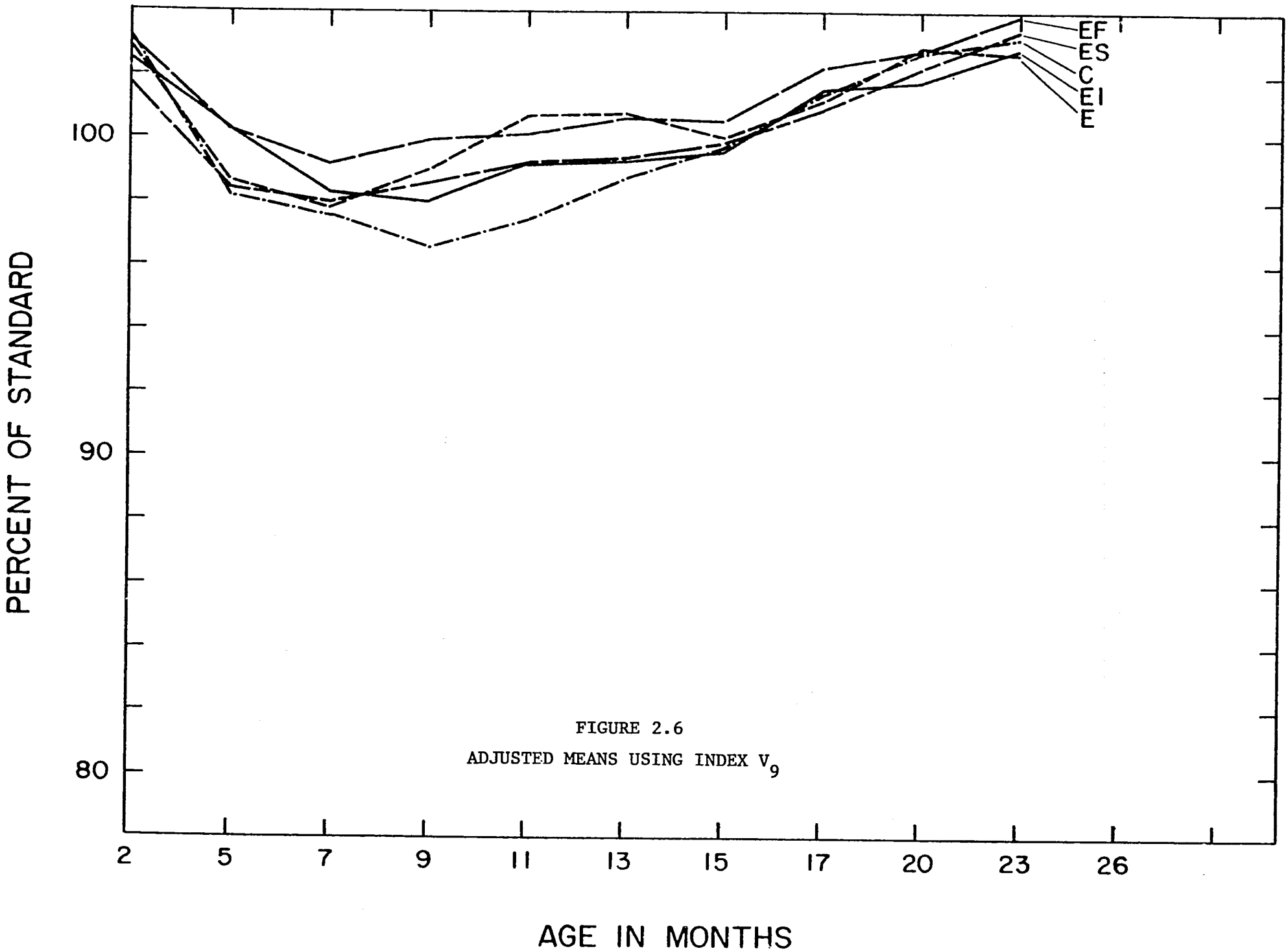


FIGURE 2.6

ADJUSTED MEANS USING INDEX V_9

2.4 COST-EFFECTIVENESS OF INTERVENTIONS AS MEASURED BY SELECTED NUTRITION INDICES

The cost analysis was performed the same way as that given in [1] (refer to Chapter 6) for each nutrition index. The cost-effectiveness index is given by

$$(g_{it}/c_{it}) \times 100, \; i = 1, 2, \ldots, 8; \; t = 1, 2, \ldots,$$

where g_{it} denotes the gain due to intervention i at time t, and c_{it} denotes the total cummulative cost for intervention i at time t.

The cost function values for the respective nutrition indices are given in Table 2.8 - 2.13. The tables give the cost function values for the single interventions (E,I,F,S) and the intervention combinations (EI, EF, ES, EIF, EFS, EIS, and EIFS). The values in the tables are to be interpreted as the higher the number the greater the cost-effectiveness. Of course a negative value results from losses instead of gains.

Cost-effectiveness graphs for the primary interventions (E, EI, EF, and ES) are given in Figures 2.7 - 2.12. During the intervention period (5-17 months), all of the indices suggest that education (E) is the most cost-effective. Indices V_1 and V_2 (especially V_1) show EI to be more cost-effective during the follow-up period. All indices suggest that ES is quite cost-effective during the latter part of the follow-up period but very poor during various parts of the actual intervention period. Food is expensive and this is reflected in the cost analysis. However, EF looks relatively good during the intervention period and indices V_3 and V_5 suggests that supplementary food is cost-effective even during the follow-up.

The cost effectiveness for each of the interventions and the various indices can be evaluated using Tables 2.8 - 2.13. Clearly E, EF, EI, and ES are generally the most cost-effective of the intervention combinations for all indices. During the intervention period alone (5 - 17 months), education (E) alone is clearly the most cost-effective of all interventions considered based upon the cost function utilized in our anlaysis.

TABLE 2.8

COST FUNCTIONS USING V_1

Intervention	Interview Number 3	4	5	7	Follow-up Number 1	2	3
Education	6.2	8.4	5.5	-1.4	1.0	-5.3	-2.4
Immunization	2.5	-0.1	-0.5	2.9	5.4	6.3	8.2
Food	3.3	1.6	0.6	0.0	0.0	1.2	0.1
Sanitation	-20.0	-20.5	-17.9	-17.9	-3.1	8.6	25.1
Education/ Immunization	4.4	2.7	1.7	1.3	3.8	1.9	4.2
Education/ Food	4.0	3.1	1.6	-0.2	0.2	0.3	-0.2
Education/ Sanitation	0.4	2.6	0.9	-5.3	0.0	-1.8	4.6
Education/ Immunization/ Food	0.8	0.2	0.0	-0.7	0.0	0.1	0.2
Education/Food/ Sanitation	2.6	0.0	-0.3	-0.6	-0.1	0.0	-0.3
Education/ Immunization/ Sanitation	3.5	0.0	-0.4	-1.9	-0.7	-1.1	-1.6
Education/ Immunization/Food/ Sanitation	0.7	0.5	0.4	-0.1	0.1	0.1	0.3

TABLE 2.9

COST FUNCTIONS USING V_2

Intervention	Interview Number					Follow-up Number		
	3	4	5	6	7	1	2	3
Education	3.1	7.83	8.11	-2.14	-3.31	.38	-3.24	-5.52
Immunization	11.31	1.46	-2.19	1.81	2.69	3.69	2.54	6.19
Food	4.75	2.62	.87	.95	.63	.37	1.08	.44
Sanitation	-39.8	-39.83	-35.29	-18.63	-18.00	-11.80	.20	23.60
Education/ Immunization	6.97	3.58	1.61	.32	.43	2.44	.36	1.78
Education/ Food	4.36	3.75	2.30	.42	.05	.37	.52	- .33
Education/ Sanitation	-6.22	-1.70	- .57	-5.70	-6.79	-2.74	-2.36	1.96
Education/ Immunization/ Food	4.22	1.45	.47	-1.36	- .73	- .02	.34	- .15
Education/Food/ Sanitation	1.27	.97	- .01	- .54	- .28	.16	.19	- .10
Education/ Immunization/ Sanitation	7.08	1.67	- .78	-2.18	-3.02	-2.64	-2.02	-1.26
Education/ Immunization/Food/ Sanitation	2.93	.74	.40	-1.04	- .58	- .29	- .28	- .60

TABLE 2.10

COST FUNCTIONS USING V_3

Intervention	Interview Number 3	4	5	6	7	Follow-up Number 1	2	3
Education	6.61	17.5	11.14	4.96	-1.83	2.52	- .83	-6.76
Immunization	.38	- .94	-2.08	-1.08	1.81	1.54	-4.10	3.44
Food	6.32	4.12	3.24	1.26	1.76	.92	1.44	1.45
Sanitation	-23.6	-37.83	-2.43	-19.13	-7.33	-14.50	-13.30	30.10
Education/ Immunization	3.68	5.21	2.79	1.13	.44	1.91	- 2.87	- .40
Education/ Food	6.39	7.04	4.81	1.86	1.25	1.13	1.14	.39
Education/ Sanitation	.04	6.43	8.43	- .38	-3.13	-1.85	-4.03	2.69
Education/ Immunization/ Food	3.90	2.59	1.48	-1.54	- .43	.73	.69	- .06
Education/Food/ Sanitation	1.73	2.72	1.03	.37	.16	.28	- .28	.14
Education/ Immunization/ Sanitation	6.74	2.79	.95	- .98	-2.64	-2.95	-2.54	2.00
Education/ Immunization/Food/ Sanitation	3.42	2.29	1.91	- .24	.12	.67	.60	- .59

TABLE 2.11

COST FUNCTIONS USING V_4

Intervention	Interview Number 3	4	5	6	7	Follow-up Number 1	2	3
Education	7.83	3.92	6.86	-5.39	-3.86	3.00	-3.41	-3.90
Immunization	-6.50	1.71	-5.50	3.04	2.71	.38	- .23	3.00
Food	2.31	2.73	.65	1.41	1.28	- .02	1.62	.54
Sanitation	-35.00	-28.33	-26.14	4.75	-3.89	-9.80	2.80	16.20
Education/ Immunization	1.09	2.44	- .95	- .06	.23	1.36	-1.43	.40
Education/ Food	3.60	2.99	1.89	.28	.52	.38	.97	- .04
Education/ Sanitation	-1.48	-2.53	.26	-3.05	-3.87	- .28	-1.82	1.26
Education/ Immunization/ Food	1.70	1.25	1.11	- .51	-.11	.37	.97	1.32
Education/Food/ Sanitation	- .85	- .89	- .30	- .43	-.20	.03	- .42	- .44
Education/ Immunization/ Sanitation	2.92	-1.04	-1.10	-1.09	-3.07	-1.11	-1.83	2.01
Education/ Immunization/Food/ Sanitation	2.37	.51	.38	- .58	- .33	.24	.38	- .47

TABLE 2.12

COST FUNCTIONS USING V_5

Intervention	Interview Number					Follow-up Number		
	3	4	5	6	7	1	2	3
Education	3.06	11.96	14.75	-1.25	-4.21	1.90	- .55	-2.93
Immunization	7.19	.85	-6.08	.60	2.56	1.88	- .31	4.90
Food	4.63	2.59	.08	1.42	1.23	.31	1.43	1.12
Sanitation	-22.20	-34.83	-48.43	-13.13	-10.89	-11.50	-2.40	31.10
Education/ Immunization	5.00	4.56	1.59	- .08	.01	1.88	- .40	1.95
Education/ Food	4.26	4.64	3.28	.97	.43	.52	1.17	.59
Education/ Sanitation	-2.43	2.60	2.11	-3.78	-5.79	-1.54	-1.03	5.79
Education/ Immunization/ Food	3.23	1.53	.44	-1.65	- .93	.00	.33	- .12
Education/Food/ Sanitation	1.73	2.06	.56	- .14	- .00	.21	.43	.75
Education/ Immunization/ Sanitation	7.56	2.27	- .54	-1.91	-3.15	-3.16	-1.18	2.80
Education/ Immunization/Food/ Sanitation	3.50	1.74	.92	- .63	- .20	.07	.28	- .17

TABLE 2.13

COST FUNCTIONS USING V_9

Intervention	Interview Number 3	4	5	6	7	Follow-up Number 1	2	3
Education	.94	9.54	11.54	7.1[illegible]	1.45	- .59	.41	-1.69
Immunization	3.38	-1.92	-3.02	-3.08	- .98	.75	-2.10	.23
Food	2.41	1.09	- .45	- .08	.28	.57	- .04	.62
Sanitation	3.80	-6.00	-20.57	-16.75	-3.00	-2.30	-6.30	7.60
Education/ Immunization	2.09	1.90	2.34	.68	- .06	.25	-1.16	- .49
Education/ Food	2.06	2.94	1.93	1.12	.45	.42	.02	.32
Education/ Sanitation	1.57	6.43	5.11	1.78	.39	-1.03	-1.31	.69
Education/ Immunization/ Food	1.72	.95	.22	- .60	- .24	.22	- .26	- .62
Education/Food/ Sanitation	1.96	2.63	.81	.51	.30	.18	.09	.40
Education/ Immunization/ Sanitation	3.21	2.58	1.27	- .01	.13	-1.56	- .43	- .07
Education/ Immunization/Food/ Sanitation	1.08	1.32	.98	.26	.29	.27	.12	- .15

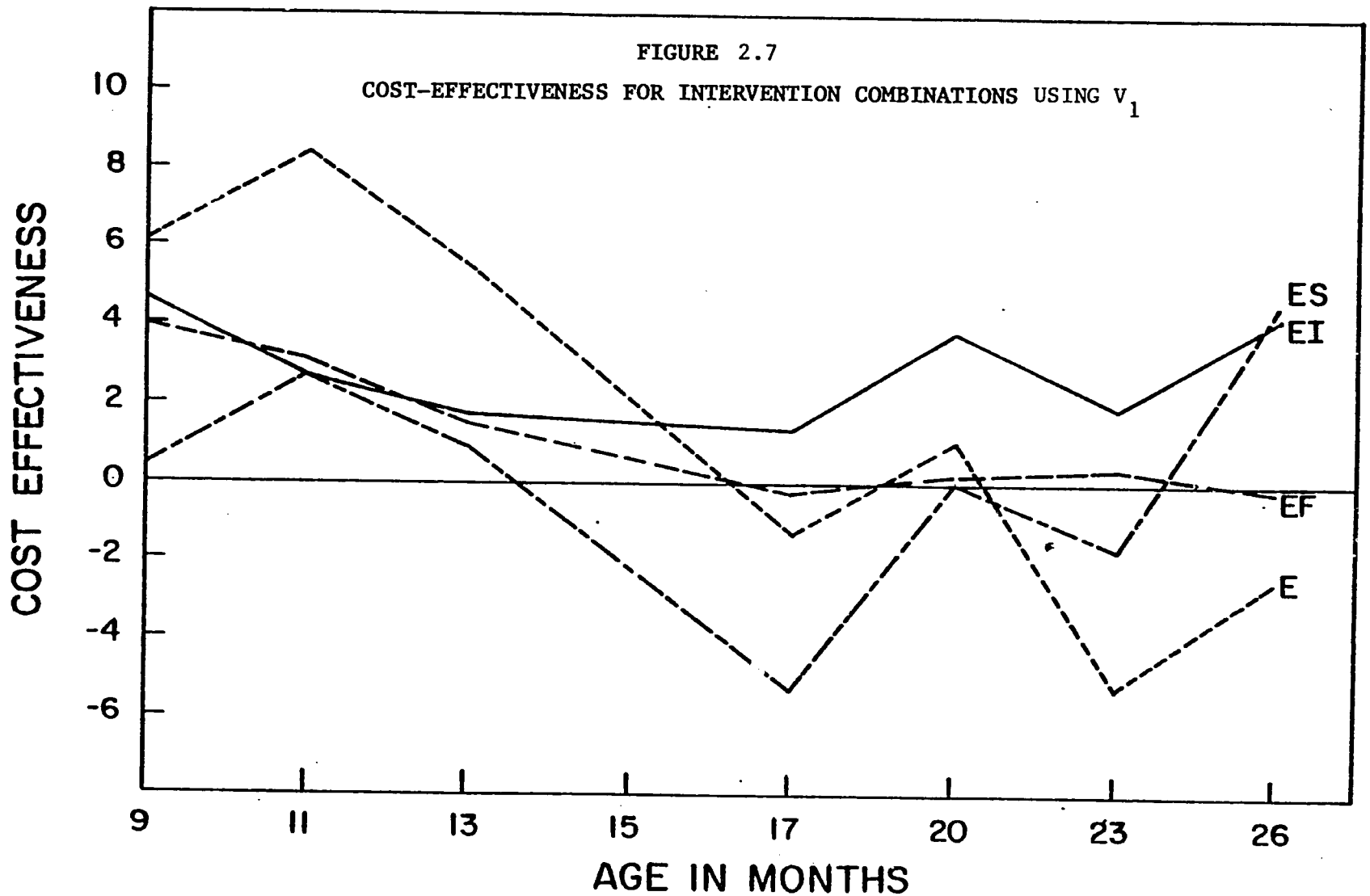


FIGURE 2.7

COST-EFFECTIVENESS FOR INTERVENTION COMBINATIONS USING V_1

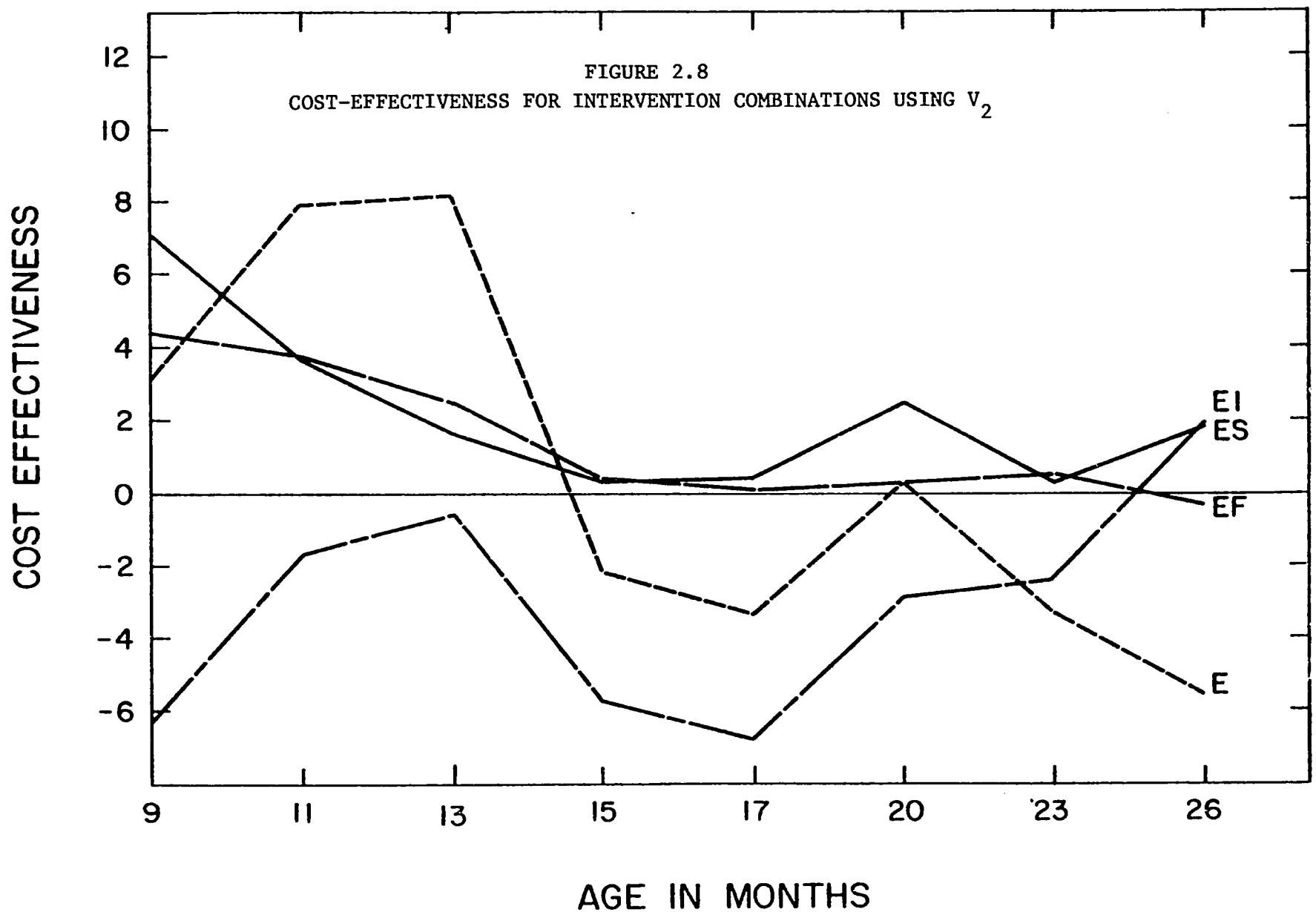


FIGURE 2.8
COST-EFFECTIVENESS FOR INTERVENTION COMBINATIONS USING V_2

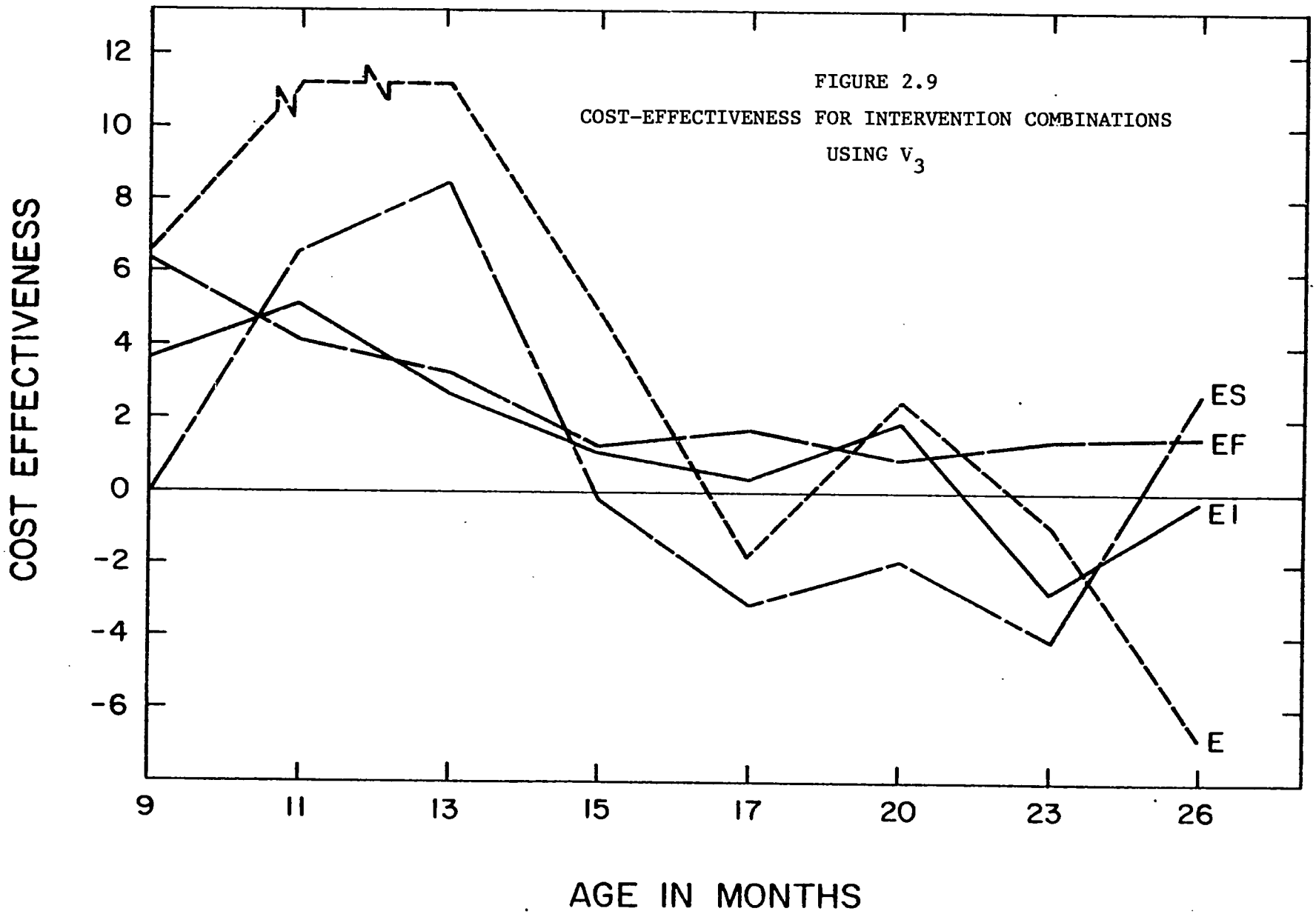


FIGURE 2.9
COST-EFFECTIVENESS FOR INTERVENTION COMBINATIONS
USING V_3

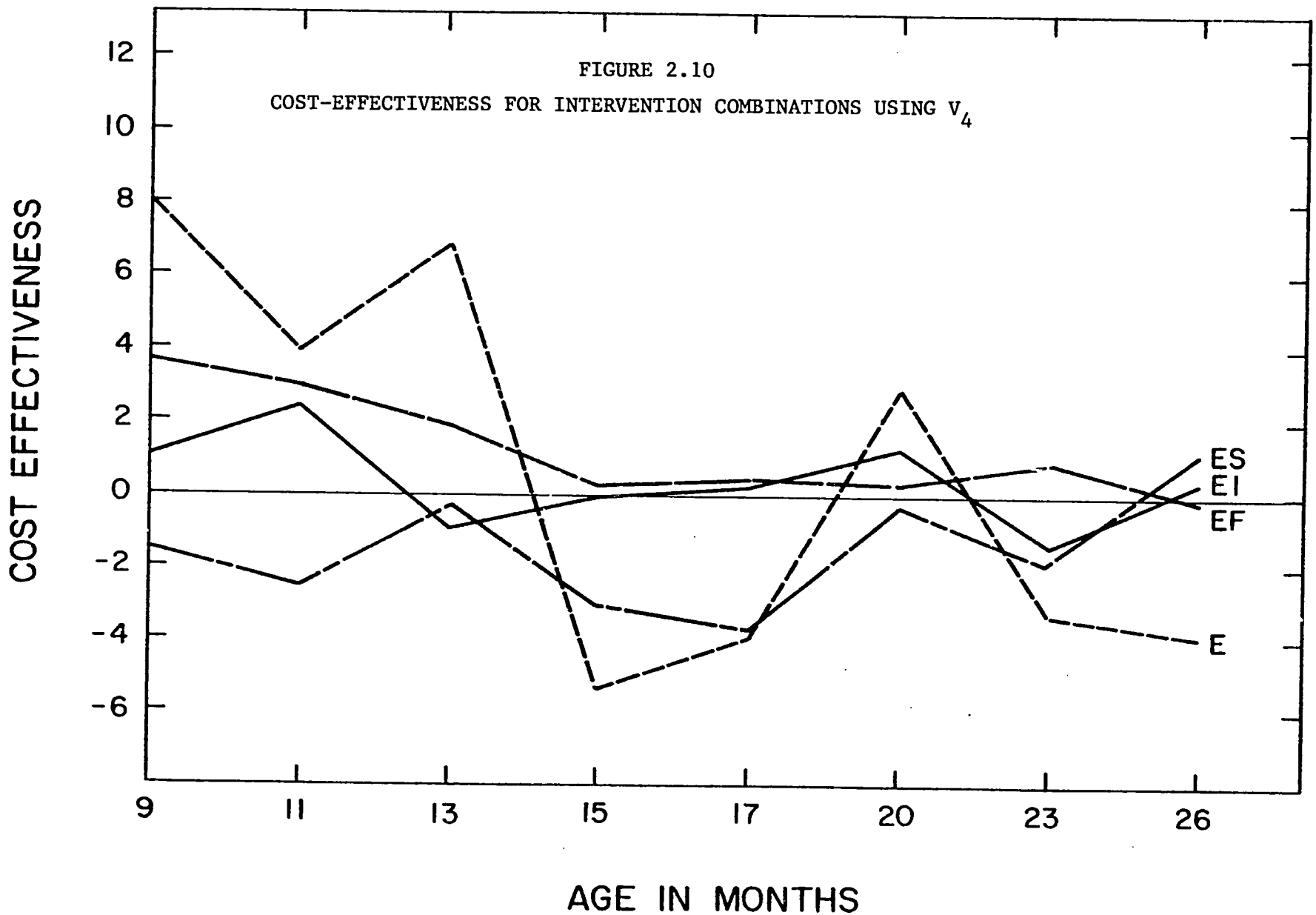


FIGURE 2.10

COST-EFFECTIVENESS FOR INTERVENTION COMBINATIONS USING V_4

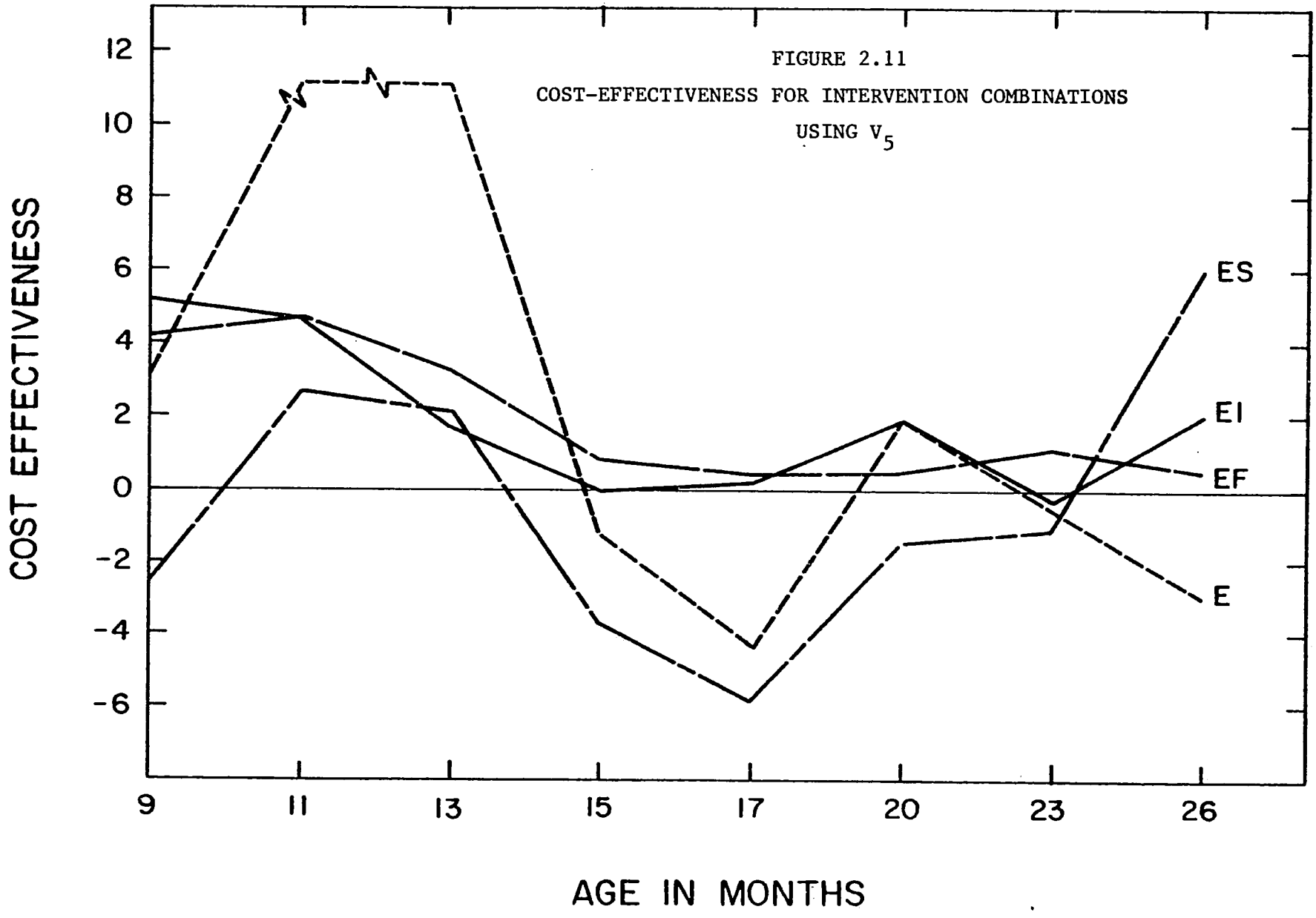


FIGURE 2.11

COST-EFFECTIVENESS FOR INTERVENTION COMBINATIONS USING V_5

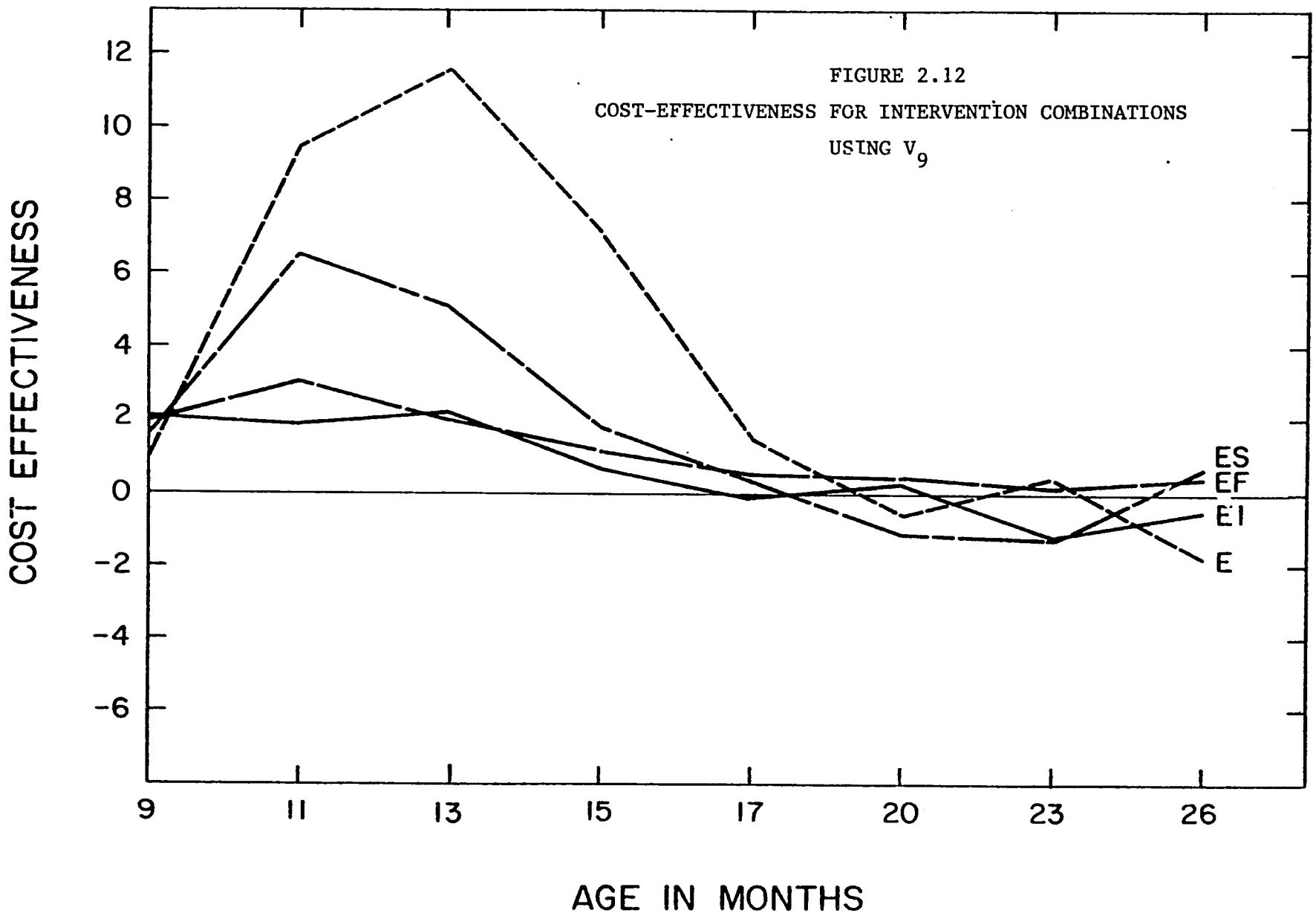


FIGURE 2.12
COST-EFFECTIVENESS FOR INTERVENTION COMBINATIONS
USING V_9

2.5 SUMMARY OF SECTION II

In Section II we have seen that the results using various nutrition indices sometimes differ. Deciding which index best measures nutritional status is not trivial. Philosophically it would be difficult to argue that utilizing more information is not as good. The only problem is in deciding whether the additional information is properly utilized in the sense of properly measuring the variable of interest. The new indices used in Section II have mathematical justification in terms of proper body proportions.

The most likely debatible item is whether (for young children) weight alone, as opposed to weight relative to height or body structure, best measures nutritional status. We believe that to evaluate programs one should utilize this additional information. Even if a child is short due to malnutrition at the beginning of an intervention program, we believe the intervention effect is better measured with the additional information used in the new indices. We note that the results in the cost-effectiveness analysis support our intuitive feelings better than V_1 (PSWT). For example, supplementary food looks better relative to immunization for the new indices than it does using V_1. At the moment we like the behavior of V_3 and V_5 but the final judgment is left to the experienced professional to decide which index best measures the variables deemed most important in their evaluation. Our most important recommendation is that, for each study or evaluation, the researcher should give careful thought to what should be measured and how to best achieve the measurement.

REFERENCES

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[2] Arnold, J. C. An investigation of some new nutrition indices based upon body structure. Report on contract AID/ASIA, C-1136, November, 1981.