A PRELIMINARY SIMULATION MODEL OF FACTORS AFFECTING THE NUTRITIONAL AND HEALTH STATUS OF CHILDREN IN LOW-INCOME FAMILIES

by

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Chairman, Departmental Committee on Graduate Students of the Department of Mechanical Engineering

ABSTRACT

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The objective of this study was to explore the possibilities of employing a detailed simulation model to aid nutrition planners in consideration of the design of nutrition and health programs for children in developing countries. We recognized that limitations on time and the scarcity of data would prevent us from developing a model that is both complete and accurate, or from applying it to a real community. However, we believe that this preliminary exercise has met our original objectives of exploring the possible benefits, limitations, and problems associated with the development of detailed simulation models for nutrition planners.

The first step was to construct a longitudinal analysis of the children of one cohort under status quo conditions, relating their nutritional status at six-month intervals to preceding events in their development from conception through the vulnerable weaning period. The second step was to expand the model to include the influences of a mother and child nutrition and health program on the development of the children. We assume that a program for pregnant mothers leads to higher birth weights, while a program for malnourished children increases the probability of recuperation; both programs are assumed to provide education to the mothers on proper feeding of children.

The model is constructed as a tree (or network) of branches representing various possible paths that children may follow from the time of conception to the end of the weaning period. Each branch leads either to a specific state of nutrition and/or health or to death, or to a critical stage where the influences of a nutrition and health program may occur (e.g., a stage at which it is possible for children to receive supplementary food). A probability is assigned to each branch, and the magnitude of the probabilities along a particular path determine the number of children that will follow that path.

By considering different cohorts born at evenly-spaced intervals, we obtain a description of the nutritional status of children in a community throughout a given period of time. These results enable us to construct a cross-sectional description of the children in terms of the aggregated parameters used in nutrition surveys. The analysis is illustrated by applying it to a hypothetical community.

Various suggestions for future work are discussed, the most important one being that the modelling effort should be accompanied by a simultaneous effort to perform surveys that will provide the data needed for determining the structure and parameters of the model.

Thesis Supervisor: Robert E. Stickney

Title: Professor of Mechanical Engineering

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TO MY FAMILY

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1. Introduction

The planning of national nutrition programs in developing countries has received increasing attention over the last few years.[1,2] As most planning processes, they can benefit from the insights provided by the use of models and other quantitative techniques. However, the application of these techniques to nutrition planning is not easy because it involves the consideration of a number of very diverse and complex factors (nutritional status, health, personal beliefs, food acceptabilities, among them).

This thesis is a preliminary work that focuses its attention upon the development of a model of the response of the nutritional status of pre-school aged children to a mother and child nutrition and health program. A methodology is suggested that encompasses the advantages of both longitudinal and cross-sectional types of studies. In spite of the limitations in time that prevented us from applying the model to the study of a real situation, a hypothetical situation was simulated to illustrate its use.

We believe that this exercise points out the very important need for data-gathering experiments to be carried out in conjunction with the model designing task. Only with the combination of these efforts will it be possible to achieve any significant guidance from models of the detailed nature considered here.

2. Preliminary Considerations and Motivations for a Simulation Model of the Evolution of Malnutrition in Pre-school Children of Low-income Families

The traditional use of cross-sectional studies for evaluation of the nutritional status of a community has failed to provide deep insights about the interactions among factors that determine the evolution of malnutrition. On the other hand, recent longitudinal studies (e.g., see ref. 3) have demonstrated their capacity to enrich the scientific understanding of those factors that affect the development of a particular child. In this way, they provide a better means to explore the changes that a certain policy would introduce into the child's development.

Motivated by the potentials of the longitudinal methodology, we first attempted to design a simulation model that would account for the principal factors that influence the development of an individual child from conception through the pre-school age period. The idea was to describe the evolution of a child as a probabilistic process in which at each step in time there is a changing set of probabilities of the child suffering from insufficient food, diarrhea, measles, etc. The values of the probability set would depend upon the complete range of previous events in the history of the child and his siblings, mother and father (e.g., income, education, etc.). The evolution of that child would then be a sequential trajectory of probabilistic events up to either the terminal age of the study (e.g., age five) or up to the prior death of the child. This probabilistic description would be based upon a set of exhaustive categories that would include the circumstances of all children of that community. The final picture would be a tree-type structure (with probabilities in all its branches) of the possible paths and outcomes of any child's evolution through the period of study. By selecting the initial conditions of a child at random from the relevant categories, the complete evolution of the child could be followed in detail. With the aid of a computer representation of the model, we could consider a sufficiently large sample of children that would enable us to perform a statistical analysis leading to estimations of the values of interest (e.g., total number of malnourished children, death rate, etc.). The model could be calibrated by adjusting the probabilities so as to reproduce the present situation in a particular community. Then, computer "experiments" could be performed to observe variations in the final results produced by choosing a specific policy for combating malnutrition. The decision maker would have then been provided with a useful and rich tool for exploring his assumptions and policies.

We quickly discovered the limitations of this detailed approach. The richness of its behavioral content was counterbalanced by the enormous amount of information that would have been needed to implement it. On the other hand, the complexities involved in the fine-grain design of the model and in its size would have surpassed our time limitations. Therefore, we decided to design a less detailed model which considered groups of children rather than individuals. This model was still sufficiently detailed that the lack of time and data prevented us from applying it to a real community. A hypothetical application was developed, however, to illustrate the potential benefits - as well as the problems - of simulation models of this type. We believed that this rather abstract exercise was a worthwhile complement to the concurrent attempt by another member[4] of our group to develop the opposite type of model, i.e., one simplified to the extent that it may be applied more easily to a real case.

The structure of our model describes the evolution of a given cohort of children in a hypothetical community where a mother and child nutrition and health program, (hereafter abbreviated as N&H Program) is implemented. This program is assumed to provide both health care and a food supplement to the malnourished children. Among the main factors to be considered by the model are:

(a) the direct and indirect influence of the mother's nutritional and health status on the child's birth weight;

(b) the consequences of having proper (or improper) food during the weaning period; and

(c) the influence of a food supplement on malnourished children under different circumstances.

From this structure it would be easy to calculate the number of children of that cohort that are malnourished at the end of consecutive predetermined periods. This type of information would be of special interest in a fundamental study; however, from the viewpoint of a nutrition planner, the main points of interest are the total number of malnourished children in a particular range of ages (the "target group") at yearly intervals in the future. Therefore, we have chosen to develop a methodology that is able to encompass both the longitudinal and cross-sectional views of reality.

As the first step, we will concentrate on the description of the evolution of cohorts. To facilitate the reader's understanding we devote Section 3 to the simplest case of a cohort under circumstances where no N&H program exists (which we will call the "Status Quo model"). Subsequently, in Section 4, we consider the evolution of a cohort in the case of an N&H program (called the "N&H model"), and finally we deal with the evolution of a series of consecutive cohorts under the N&H program and develop a cross-sectional evaluation of their trajectory. In each of these sections a hypothetical situation is developed as an illustration.

We should point out that each cohort was followed for only 18 months because the required computations increase extremely rapidly with the length of the period. We recognize that 18 months is not sufficiently long to cover the entire vulnerable period, but it seemed to be a reasonable simplification at this stage of development.

3. The Status Quo Model

The goal of this section is to provide quantitative analysis for estimating the evolution of children of one cohort under the status quo situation (i.e., no N&H program). Figures 1a to 1e constitute the flow diagram of the model. (At this point, the reader is recommended to ignore the values of the probablities given to the branches in these figures). We start with the number of children conceived in the particular cohort (called "Rate of conception") and the first division of the model is based on its main hypothesis that the evolution of children is originally conditioned on the past history of the mother, i.e., her nutritional and health status during pregnancy, which creates the initial two groups of children, those whose mothers' status during pregnancy is satisfactory, and those whose mothers' status during pregnancy is deficient. Going one step down the tree, we arrive at the birth stage where children from either of the two previous groups can have normal or low birth weights or can be born dead. Presumably, the probabilities of having low-birth weight will depend on the mother's status, and these probabilities would have to be determined by experimental studies. The evolutions of the four groups appearing at the bottom of Figure 1a are described in Figures 1b to 1e.

Rather than attempting to describe each element of the model in detail, we will consider only one group as an illustration of the nature of the model. Specifically, we have selected group IV shown in Figure 1e, which gives the complete description of possible outcomes and conditioning events of the evolution of children of low-birth weight whose mothers' status during pregnancy were deficient. It is assumed that between birth and 6 months of age, the probabilities of their possible nutritional outcomes depend in part on the mother's status. The model assumes that the evolution of those children that are malnourished at 6 months depends primiarily on the diet provided to them during the next 6 months. Similar assumptions are made for subsequent periods.

After a glance through Figure 1e and the rest of the model, the reader will notice that there are several paths that lead to a given nutritional status at each level (i.e., birth, 6, 12 and 18 months). Given the probabilities for all the branches of the tree, he can calculate the number of children that follow a given path leading to the nutritional status at any level he is interested in. This is accomplished by multiplying the Rate of Conception by all the probabilities lying in that particular path.

To insure that this procedure is completely clear to the reader, we will illustrate it by a specific example. Assume that we want to determine the number of children that follow the path described below in terms of the abbreviations defined in Figures 1a and 1e:

C → MSD	P_1 = 0.6 (see Figure 1a)
MSD → LBW	P_2 = 0.08 (see Figure 1a)
LBW → M	P_3 = 0.72 (see Figure 1e)
M → PF	P_4 = 0.5 (see Figure 1e)
PF → M	P_5 = 0.9 (see Figure 1e)
M → M	P_6 = 0.92 (see Figure 1e)

Therefore, the fraction (f) of the children passing along this particular path is given by:

$$f = P_1 \times P_2 \times P_2 \times P_3 \times P_5 \times P_6$$

$$= (0.6) \times (0.08) \times (0.72) \times (0.5) \times (0.9) \times (0.92)$$

$$= 0.0143$$

If we multiply the rate of conception by this value of f, we obtain the number of children passing along this path.

Repeating this procedure for every path that leads to the equivalent states of nutritional status at the level of interest, and then adding the partial results, one obtains the total number of children of the cohort that, at this level, have the specified nutritional status. We point out that the feature provided by this path-following technique - the obtainable partial results - would enable the nutrition planner to keep track of a rich variety of additional information about the dependence of the outcome on differences in circumstances.

The nutrition planner will be interested in having this structure to reproduce the situation of the community. This process of calibration of the model is attainable by an iterative process of "trial and check", in which the adjustment of one or more parameters in the tree leads to results that are consistent with the available information on the community. Unfortunately, the available information generally is of an aggregated nature, meaning that it sets conditions on groups of probabilities rather than on individual probabilities. It is thus clear that more detailed data on the community will lessen the difficulties in the calibration stage.

The process of calibration can be carried out more easily with the aid of an electronic computer for performing the calculations at each stage of the iterative procedure. Therefore, we have designed a computer program (described in the appendix) for this purpose.*

Once the calibration is completed, the nutrition planner would be able to forecast the future evolution of the children of the community, under the assumption of no N&H program, by assuming a birth rate and applying the model to all cohorts born within the period of his forecast. The results of this forecast would serve as a basis of comparison for the results forecasted with the application of the N&H model.

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*The computer program actually applies to both the status quo model and the N&H model.

3.1 Illustration of the Status Quo Model

It was impossible to find in the literature the type of detailed information required to calibrate our model to a real case. In spite of this fact, it was decided to develop a hypothetical illustration in order to get experience with the process of calibration of the model. The idea was then to calibrate the model to reproduce to a certain extent the aggregated data for a real community. We chose as a guidance the data summarized in Table 1, which are representative of the situation in El Salvador.* In addition, we found that the task of selecting a self-consistent set of probabilities was aided by first formulating a set of assumptions describing the expected qualitative relations between the probabilities. This set of general assumptions is described in the appendix and they only can be viewed as a very rough first approximation of the relations. Based on this set of assumptions, and with the help of the computer, we carried out a series of trial and check evaluations of probabilities in which the results obtained were compared to the figures of guidance of Table 1. After 5 runs of the computer program, with different estimates of the probabilities, we came out with the set of probabilities that appear on the branches of the trees shown in Figures 1a to 1e. The results obtained on the basis of these probabilities are shown in Table 2. Comparison of Tables 1 and 2, show that the results are close to the

*These figures were found by Kyriakos Sarris from demographic data.

TABLE 1 RATES OF MALNUTRITION AND DEATH OF CHILDREN IN EL SALVADOR*

	Values expressed as percentages			
	Birth	6 months	12 months	18 months
Malnutrition	7	8.5	20**	30**
Death	1.16	3.2	2	1

*Based on data summarized by Kyriakos Sarris (4)

**Estimated from data for children between 1 and 2 years

TABLE 2 HYPOTHETICAL RATES OF MALNUTRITION AND DEATH OF CHILDREN COMPUTED BY THE STATUS QUO MODEL

	Values expressed as percentages			
	Birth	6 months	12 months	18 months
Malnutrition	7.2	9.2	26	30.1
Death	1.0	5.0	3.2	3.5
Normal Children	91.8	84.3	68.6	61.3
Recovered Children	-	1.5	2.2	3.1

"calibration data" in some cases but not in others. Better agreement could be obtained by performing additional runs, but we believe that this would not be worthwhile at this stage.

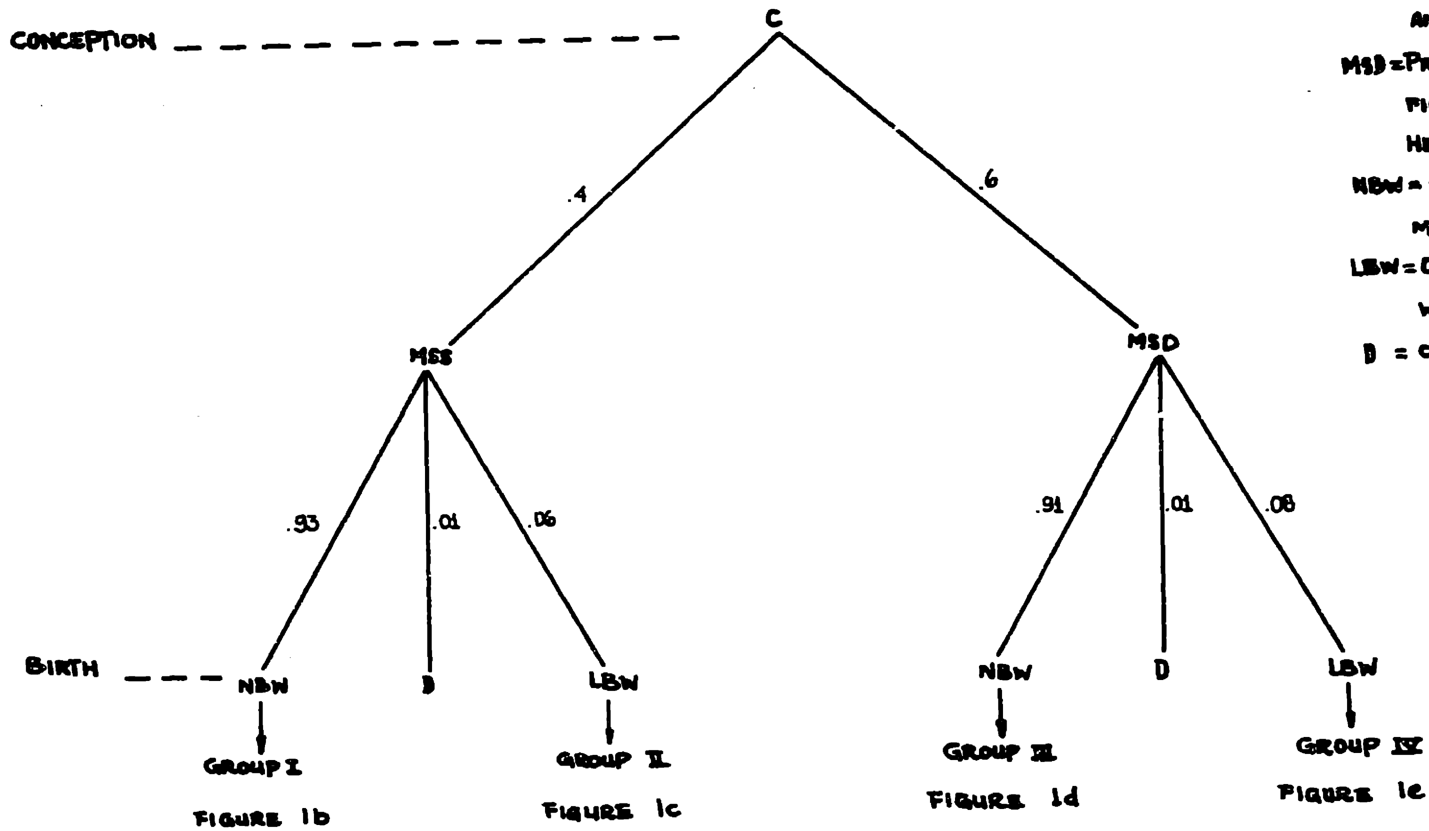


FIGURE 1a

ABBREVIATIONS

C = CONCEPTION

MSS = PREGNANT WOMEN WITH SATISFACTORY NUTRITIONAL AND HEALTH STATUS

MSD = PREGNANT WOMEN WITH DEFICIENT NUTRITIONAL AND HEALTH STATUS

NBW = CHILDREN WITH NORMAL BIRTH WEIGHT

LBW = CHILDREN WITH LOW BIRTH WEIGHT

D = CHILDREN WHO DIE

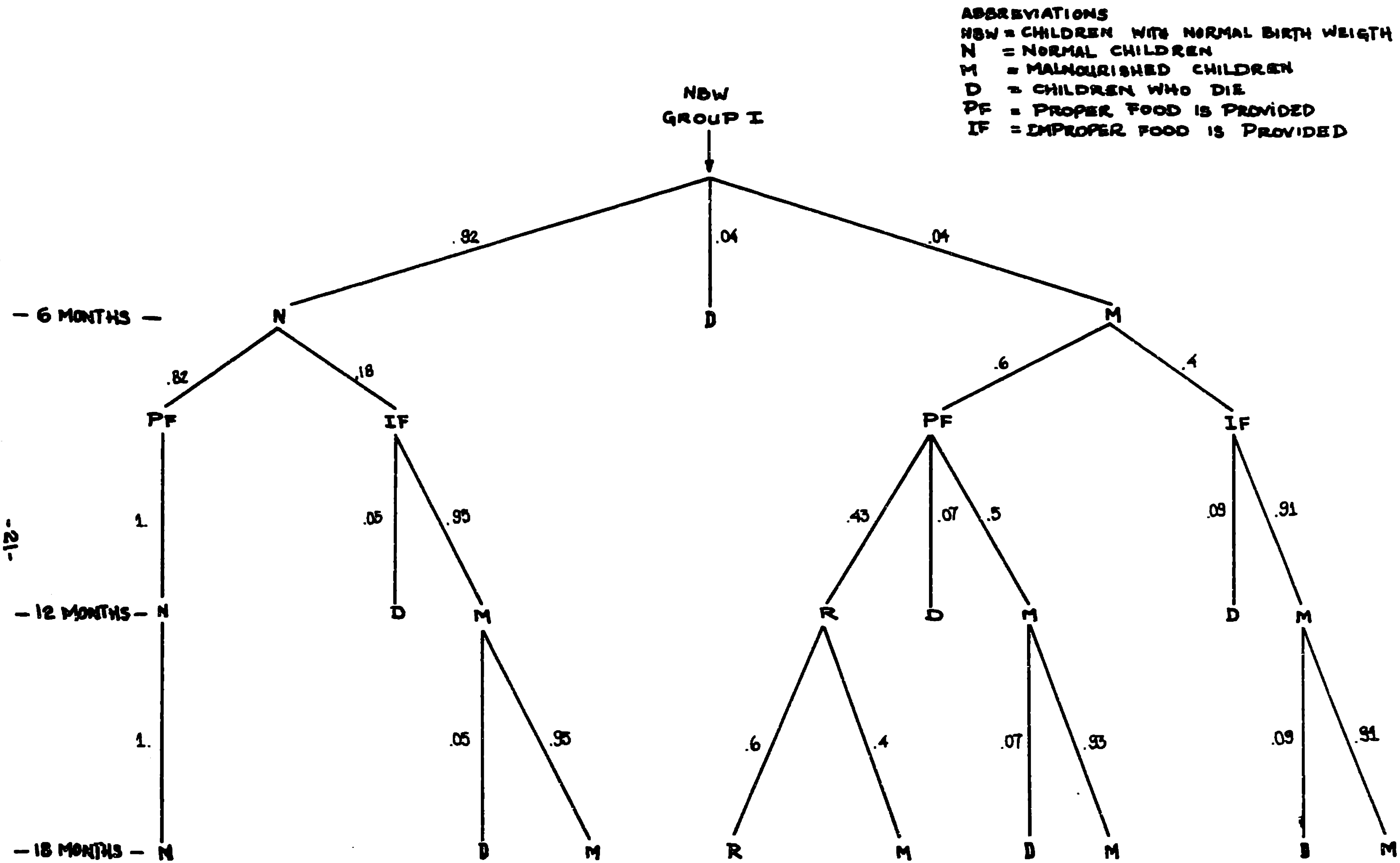

ABBREVIATIONS
NBW = CHILDREN WITH NORMAL BIRTH WEIGTH
N = NORMAL CHILDREN
M = MALNOURISHED CHILDREN
D = CHILDREN WHO DIE
PF = PROPER FOOD IS PROVIDED
IF = IMPROPER FOOD IS PROVIDED
NBW
GROUP I
.82
.04
.04
— 6 MONTHS —
N
D
M
.82
.18
.6
.4
PF
IF
PF
IF
1.
.05
.95
.43
.07
.5
.09
.91
— 12 MONTHS —
N
D
M
R
D
M
D
M
1.
.05
.95
.6
.4
.07
.93
.09
.91
— 18 MONTHS —
N
D
M
R
M
D
M
D
M

FIGURE 1b

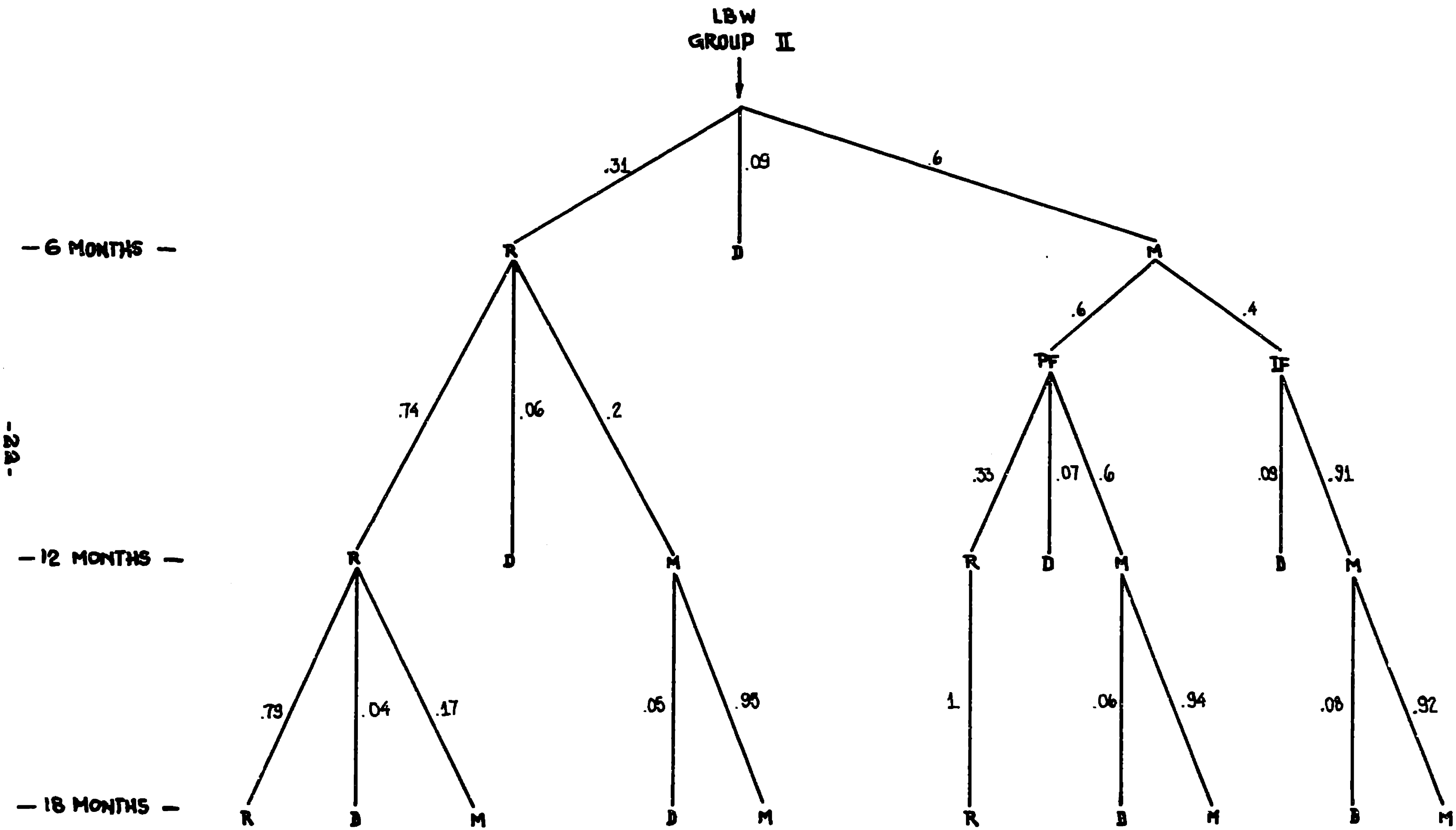

LBW
GROUP II
— 6 MONTHS —
— 12 MONTHS —
— 18 MONTHS —
R
D
M
PF
IF
.31
.09
.6
.74
.06
.2
.4
.33
.07
.91
.79
.04
.17
.05
.95
1
.94
.08
.92

FIGURE 1c

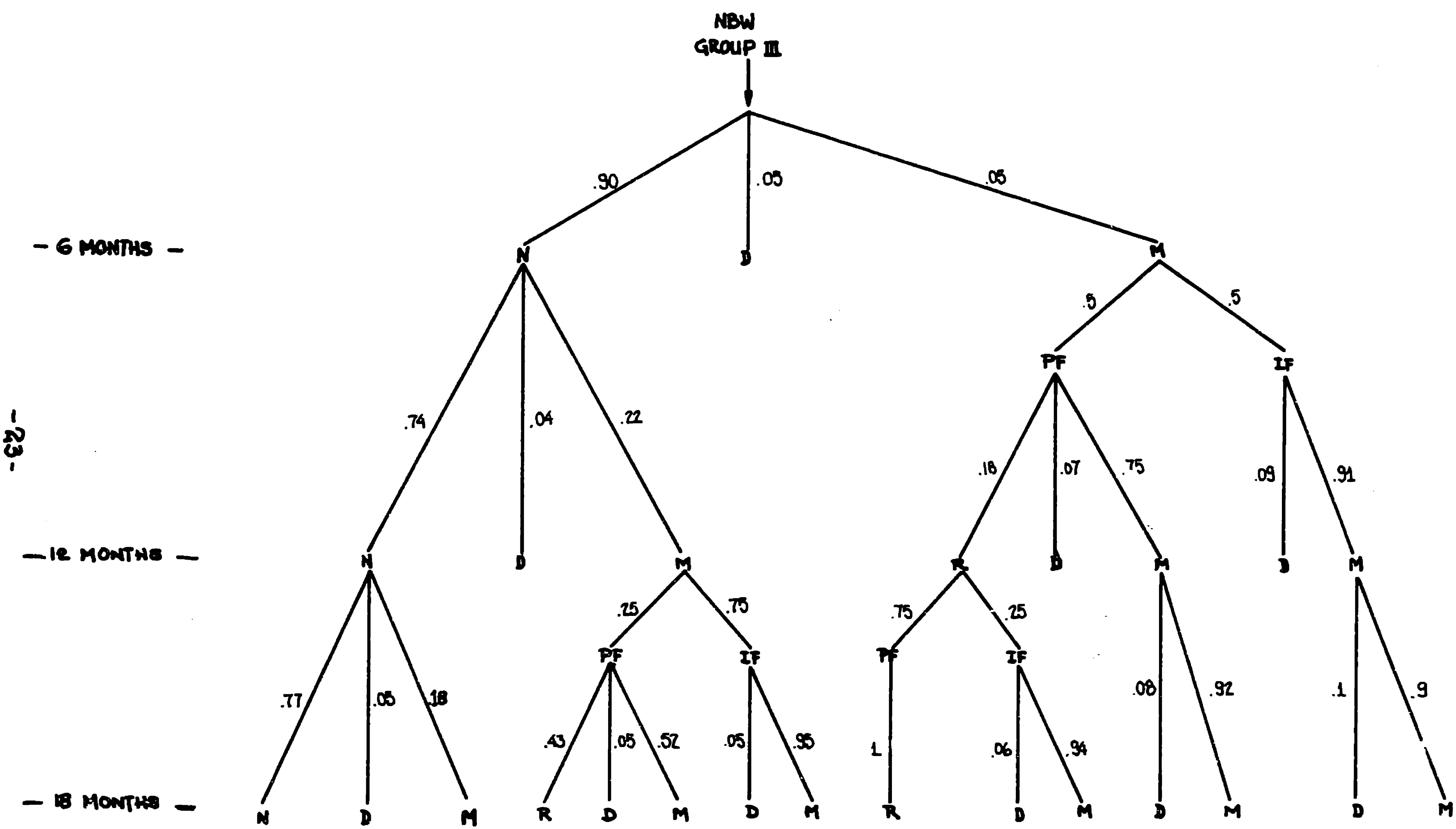

NBW
GROUP III
— 6 MONTHS —
— 12 MONTHS —
— 18 MONTHS —
.90
.05
.05
N
D
M
.74
.04
.22
.5
.5
PF
IF
.18
.07
.75
.09
.91
N
D
M
R
D
M
D
M
.25
.75
.75
.25
PF
IF
PF
IF
.77
.05
.18
.43
.05
.52
.05
.95
1
.06
.94
.08
.92
.1
.9
N
D
M
R
D
M
D
M
R
D
M
D
M
D
M

FIGURE 1d

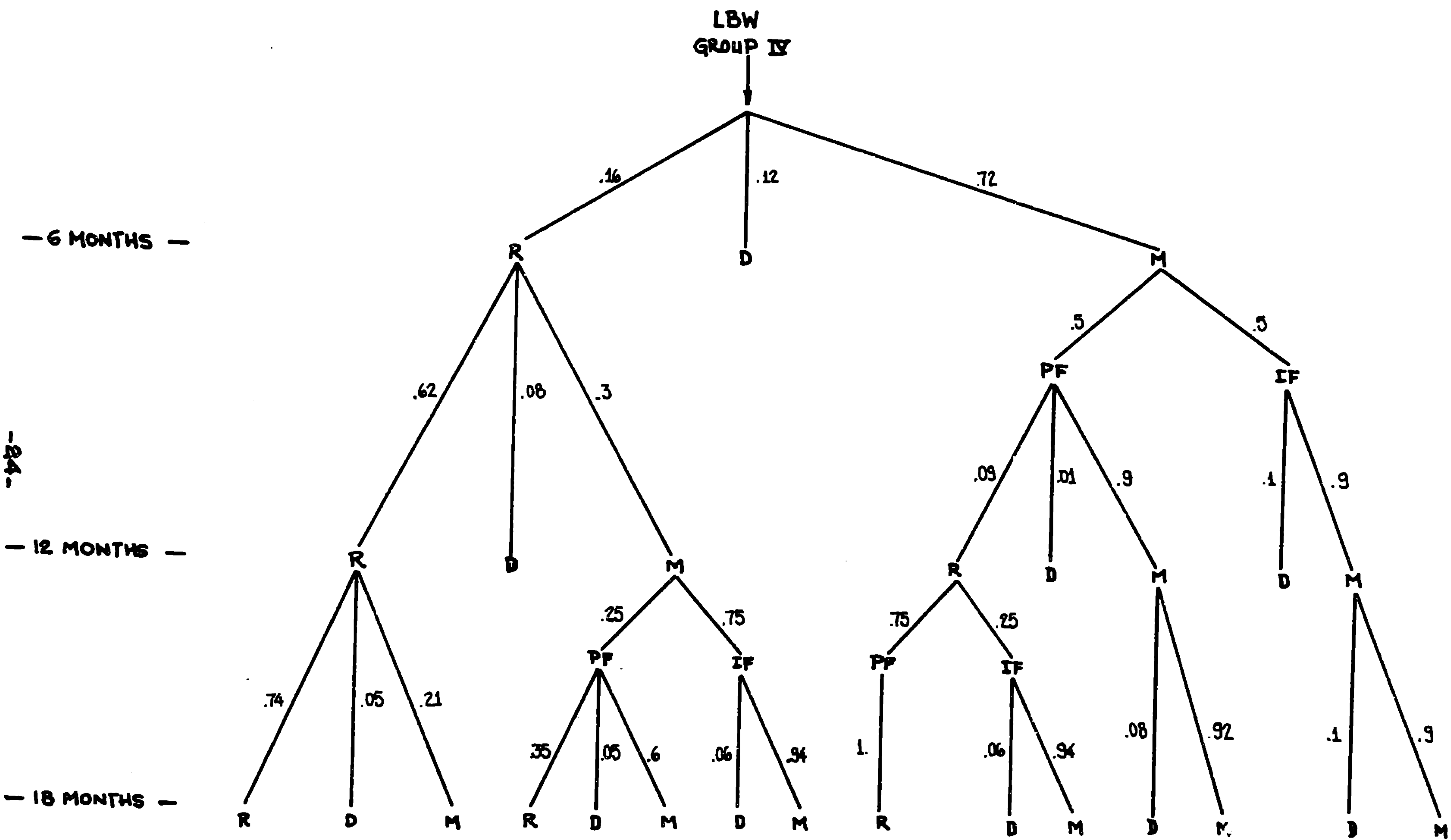

LBW
GROUP IV
— 6 MONTHS —
— 12 MONTHS —
— 18 MONTHS —
.16
.12
.72
R
D
M
.62
.08
.3
.5
.5
PF
IF
.09
.01
.9
.1
.9
R
D
M
R
D
M
D
M
.25
.75
.75
.25
PF
IF
PF
IF
.74
.05
.21
.35
.05
.6
.06
.94
1.
.06
.94
.08
.92
.1
.9
R
D
M
R
D
M
D
M
R
D
M
D
M
D
M

FIGURE 1e.

4.

4.1 The N & H Model

Having developed a model to simulate the status quo situation, the next step was to consider the design of a model to simulate the evolution of a given cohort under the existence of a N&H program in the community. A model with the same general philosophy as the status quo model was developed and the model is summarized in Figures 2a to 2i (ignore the probabilities in the branches at this stage). The members of the cohort are also followed from conception until the age of 18 months. The N&H program would emphasize the importance of beginning to offer its services to women during their pregnancy. The nutritional and health status of the pregnant women would be evaluated at an early stage, and medical and nutritional help provided if needed. One other objective of the program would be to provide pregnant mothers with education on mother and child nutrition and hygiene. It is expected that the children of these mothers would have lower probabilities of being malnourished between birth and 18 months than the children of mothers who are not in the program. For this reason, the N&H model branches out at the top to classify the conceived children according to the mother's involvement with the program (Figure 2a). (However, the program will also be able to admit children that are malnourished and whose mothers were not involved with the program during pregnancy). As a result, there are 12 categories at the birth stage (bottom of Figure 2a). The detailed descriptions of the evolution of these categories are made in Figures 2b to 2i. To get acquainted with the structure of the model from birth on, we suggest that the reader studies one of those figures in detail.

As an example, consider Figure 2i, which models the evolution of the group of low birth weight children whose mothers had a deficient status and were not involved in the program during pregnancy. It is assumed that mother's milk is the principal food during the first 6 months, and that other foods ("weaning foods") are introduced after 6 months. It is also assumed that the child's development is checked at 6 month intervals. If a child is found to be malnourished and then enters the program, a food supplement is provided. The model considers both the possibility of a child being or not being provided with the supplement to account for factors such as personal beliefs, distance to the program centers, taste considerations, etc.

The nutritional outcome at 12 months for children malnourished at 6 months and not provided with the supplement is further conditioned by the possibilities of being provided with proper or improper food in the home. Similar assumptions are made for the period from 12 to 18 months. With this brief verbal description of a few possibilities, the reader will be able to understand the rest of the structure of the model by himself.

Any desired result for that cohort at any level (birth, 6, 12, and 18 months) could be obtained by using the same path-following procedure described for the status quo model. The computer program, already mentioned in Section 3, was written to carry out all the calculations down the tree. (See Appendix for detailed description). Although it computes the total for every possible event in the tree, the printed output is restricted to only a few aggregated results (described later in the illustration). In case it were of interest, any particular result in the tree can be obtained by preparing a single and simple instruction for the computer program.

Now that we have a complete picture of the N&H model for one cohort it will not be difficult to realize that the status quo model is embedded in it, and they are equivalent if we just make the appropriate probabilities in the N&H model equal to zero (i.e., the probability of a mother being involved with the program during pregnancy, the probability of being provided with the food supplement at any level). We are now able to move on one more step toward the goal of the nutrition planner; a monitoring technique that will help them to have a periodical cross-sectional evaluation of the children in the target group, and subsequently deals with the evolution of a series of cohorts. This is the objective of 4.2.

ABBREVIATIONS

C = CONCEPTION
MIP = PREGNANT WOMEN IN THE PROGRAM
MOP = PREGNANT WOMEN NOT IN THE PROGRAM
MSS = PREGNANT WOMEN WITH SATISFACTORY NUTRITIONAL AND HEALTH STATUS.
MSD = PREGNANT WOMEN WITH DEFICIENT NUTRITIONAL AND HEALTH STATUS.
NBW = CHILDREN WITH NORMAL BIRTH WEIGHT
LBW = CHILDREN WITH LOW BIRTH WEIGHT
D = CHILDREN WHO DIE.

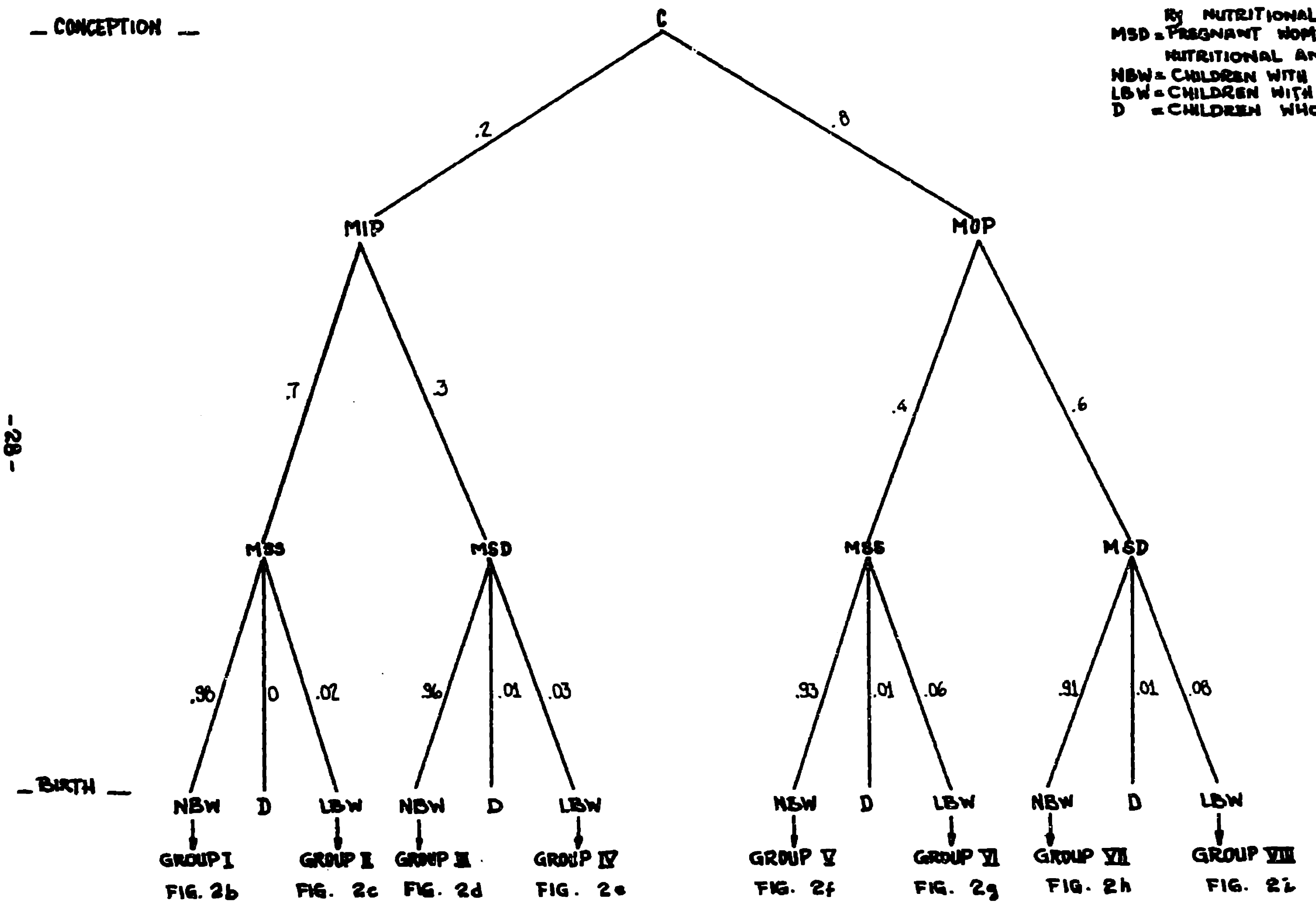


FIGURE 2a.

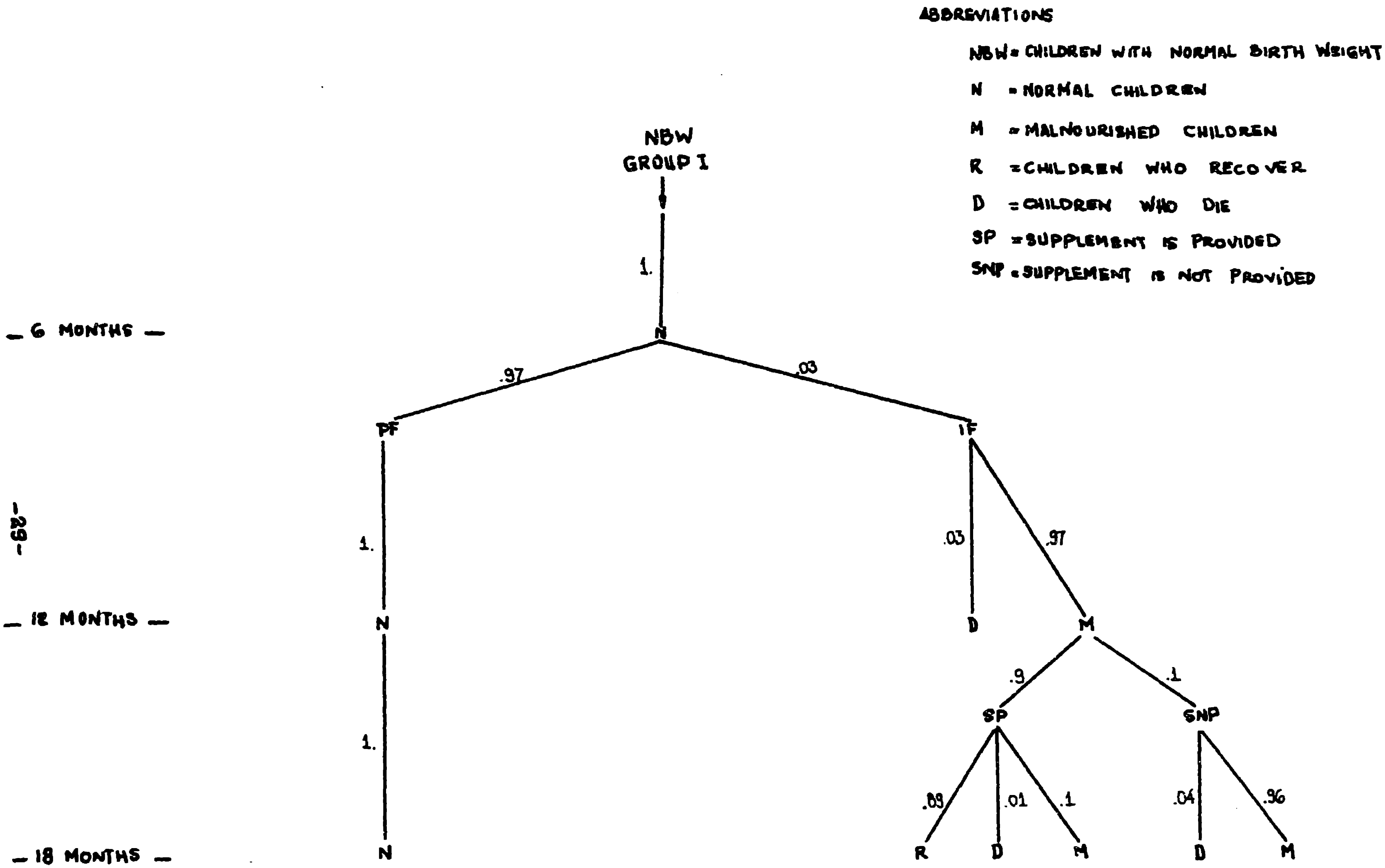

ABBREVIATIONS
NBW = CHILDREN WITH NORMAL BIRTH WEIGHT
N = NORMAL CHILDREN
M = MALNOURISHED CHILDREN
R = CHILDREN WHO RECOVER
D = CHILDREN WHO DIE
SP = SUPPLEMENT IS PROVIDED
SNP = SUPPLEMENT IS NOT PROVIDED
NBW
GROUP I
1.
— 6 MONTHS —
N
.97
.03
PF
IF
1.
.03
.97
— 12 MONTHS —
N
D
M
.9
.1
SP
SNP
1.
.89
.01
.1
.04
.96
— 18 MONTHS —
N
R
D
M
D
M

FIGURE 2b

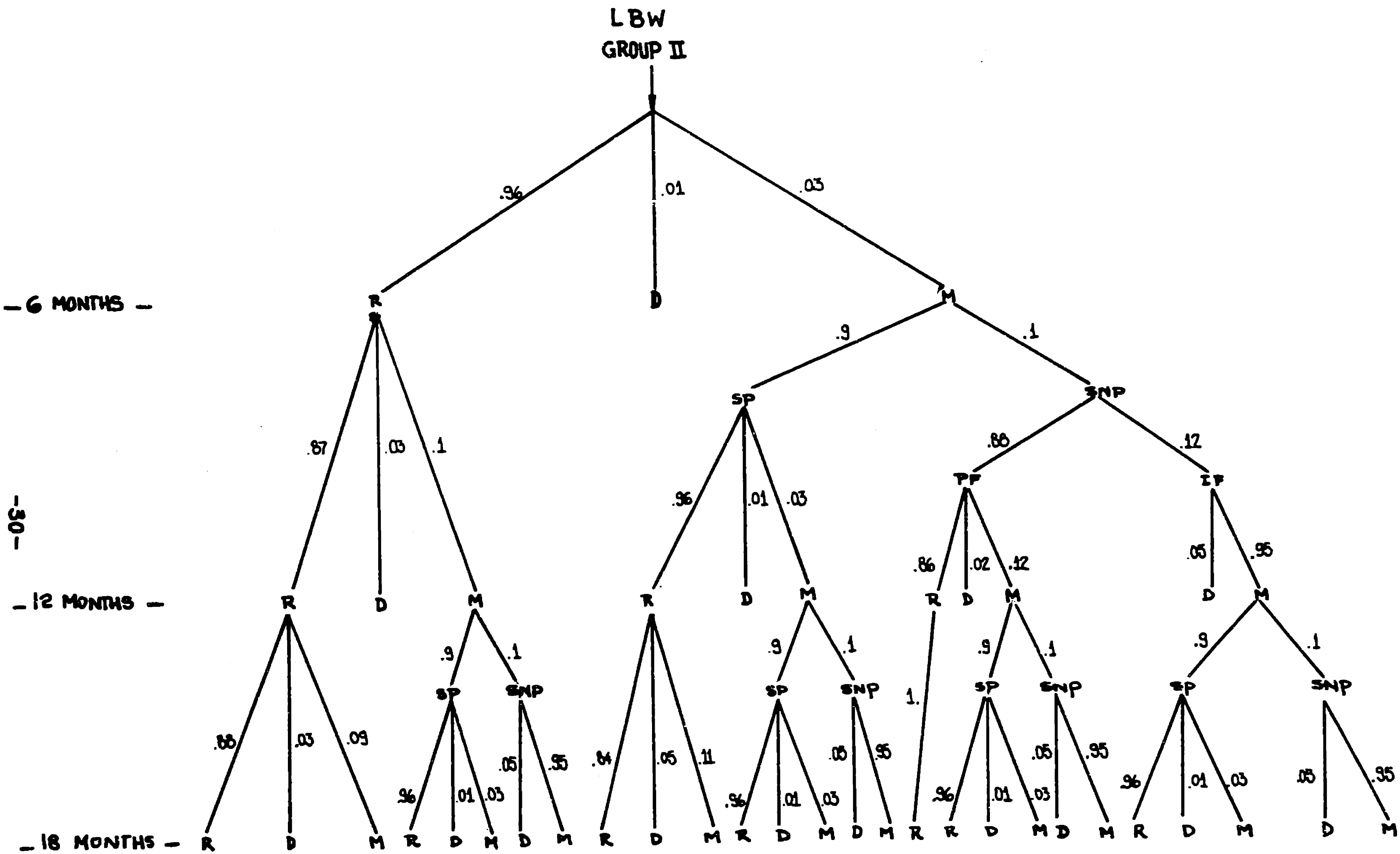


FIGURE 2c.

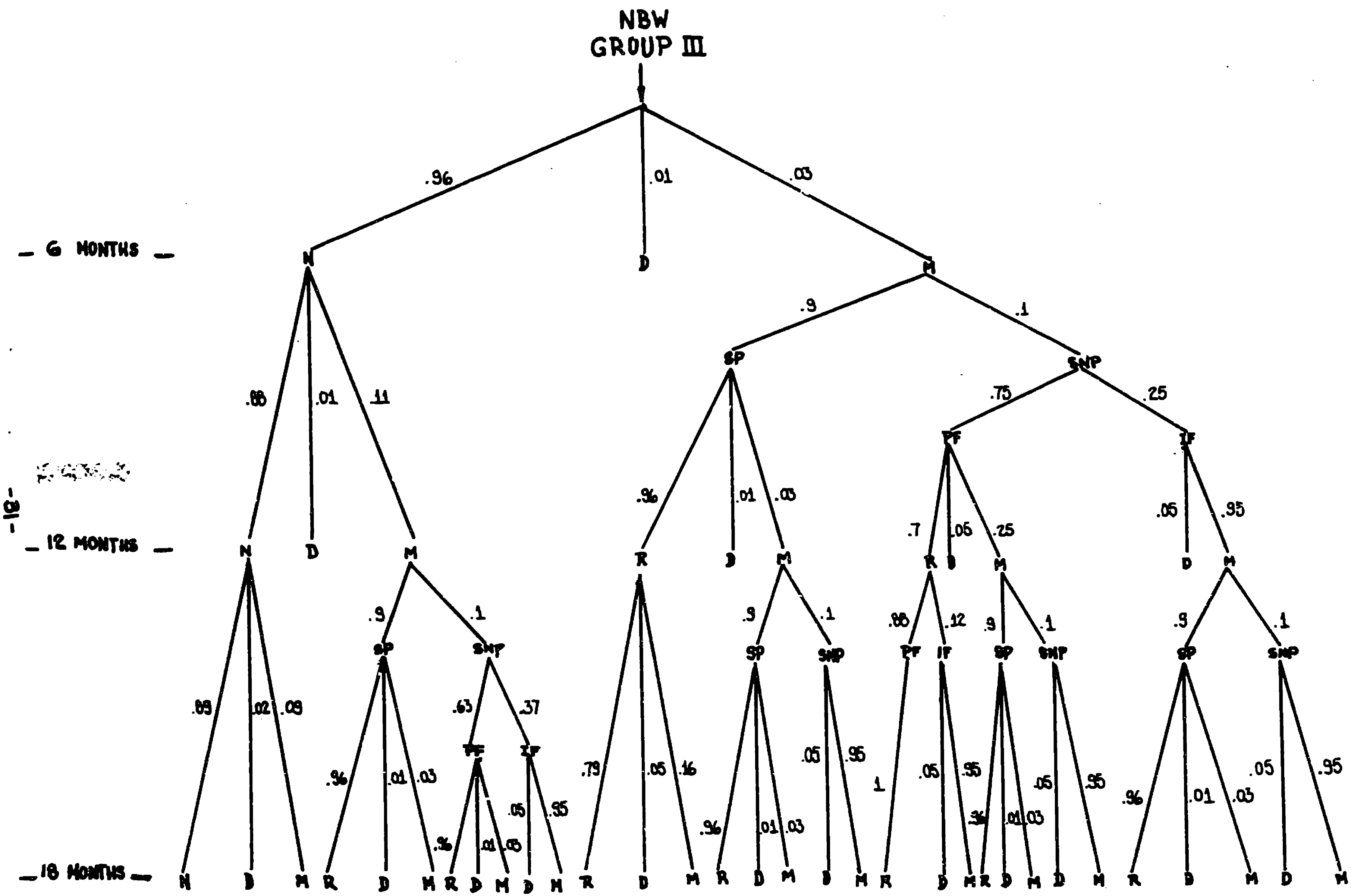


FIGURE 2 d

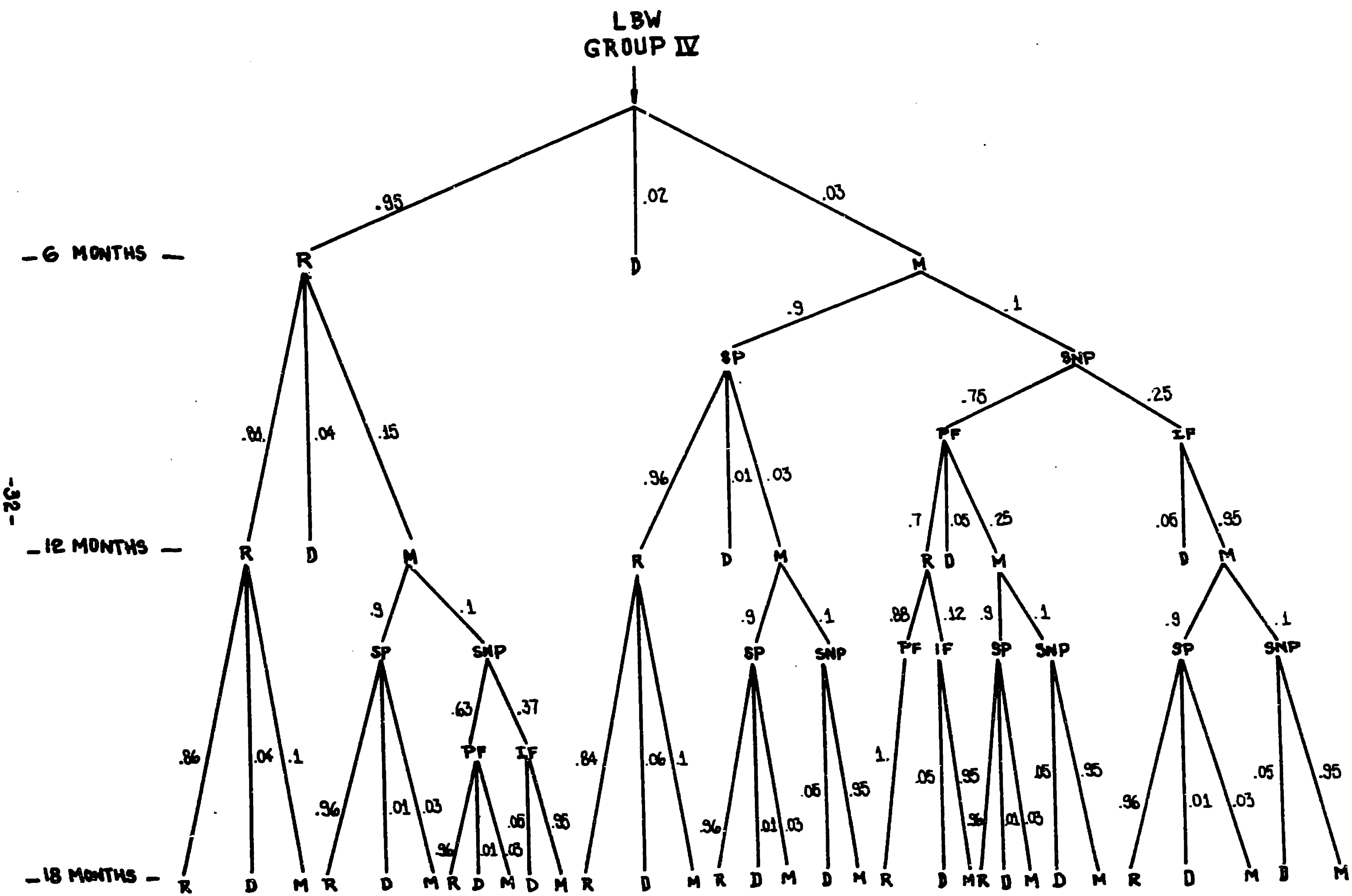


FIGURE 2 e

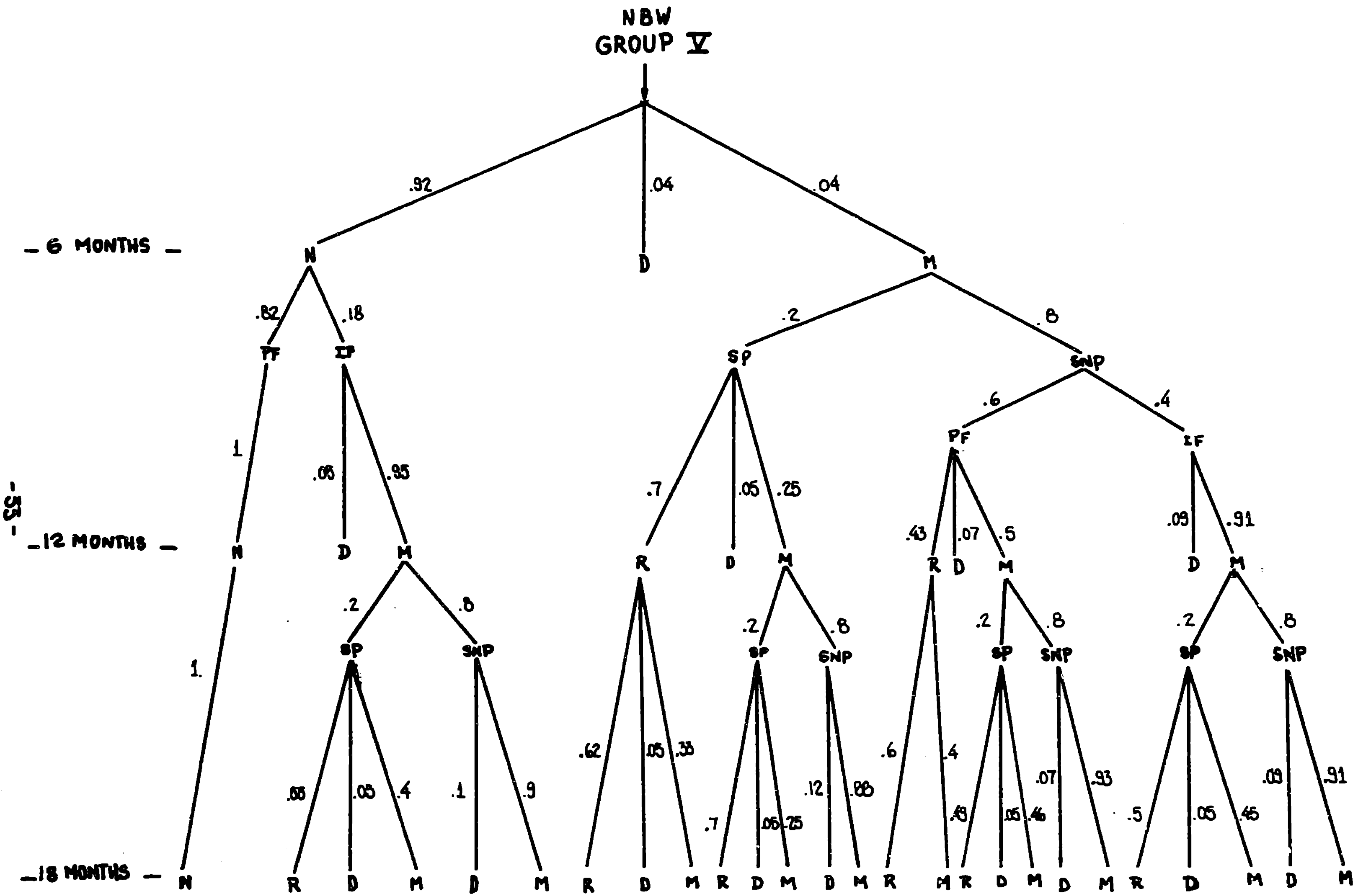

NBW
GROUP V
— 6 MONTHS —
— 12 MONTHS —
— 18 MONTHS —
.92
.04
.04
N
D
M
.82
.18
PF
IF
.2
.8
SP
SNP
.6
.4
PF
IF
1
.06
.95
.7
.05
.25
.43
.07
.5
.09
.91
N
D
M
R
D
M
R
D
M
D
M
.2
.8
SP
SNP
1.
.65
.05
.4
.1
.9
.62
.05
.33
.7
.05
.25
.12
.88
.6
.4
.49
.05
.46
.07
.93
.5
.05
.45
.09
.91
N
R
D
M
D
M
R
D
M
R
D
M
D
M
R
M
R
D
M
D
M
R
D
M
D
M

FIGURE 2f

-53-

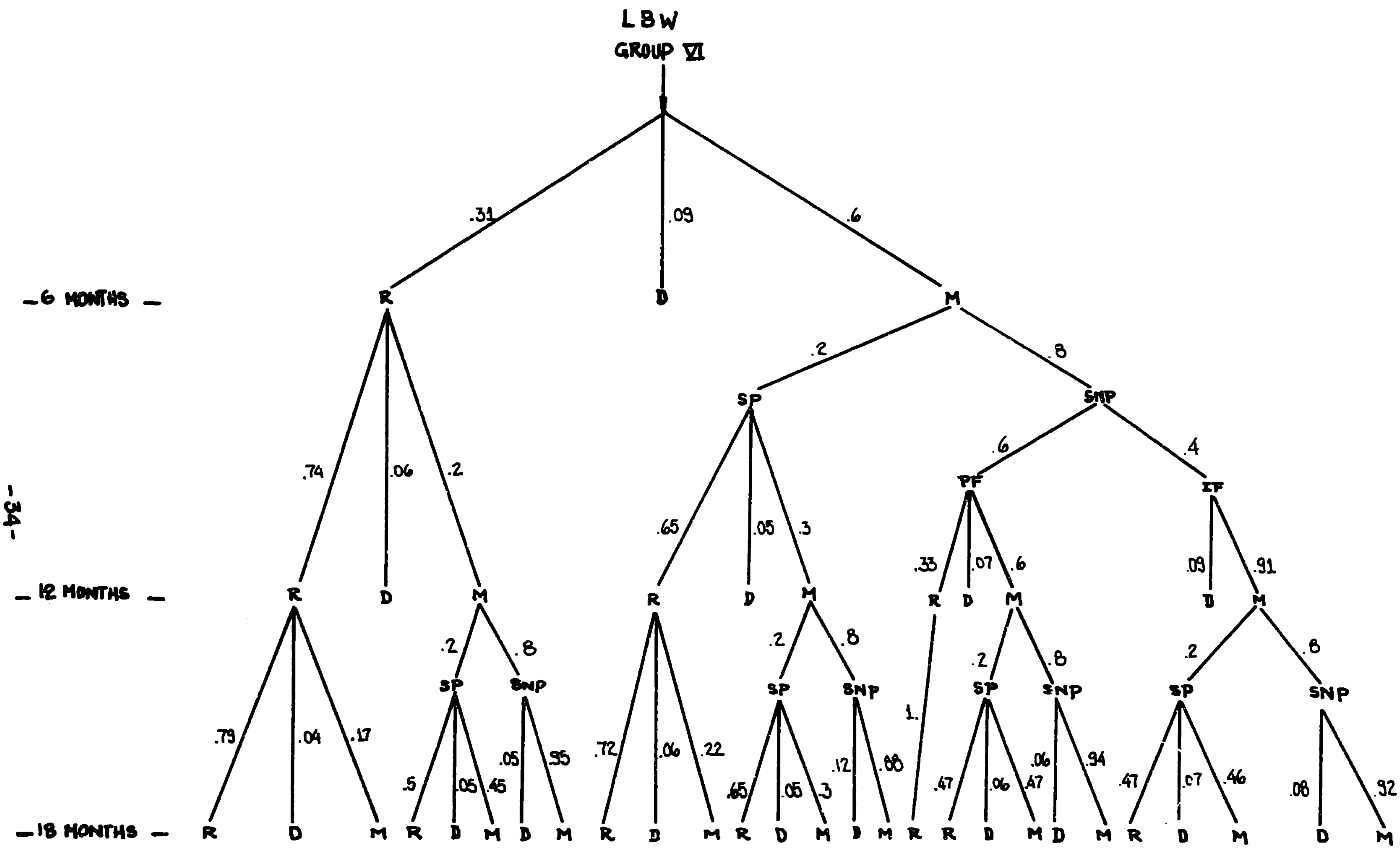

LBW
GROUP VI
—6 MONTHS —
— 12 MONTHS —
—18 MONTHS —
R
D
M
SP
SNP
PF
IF
.31
.09
.6
.2
.8
.74
.06
.65
.05
.3
.4
.33
.07
.91
.79
.04
.17
.5
.45
.95
.72
.22
.12
.88
1.
.47
.94
.46
.08
.92

FIGURE 2g

NBW
GROUP VII

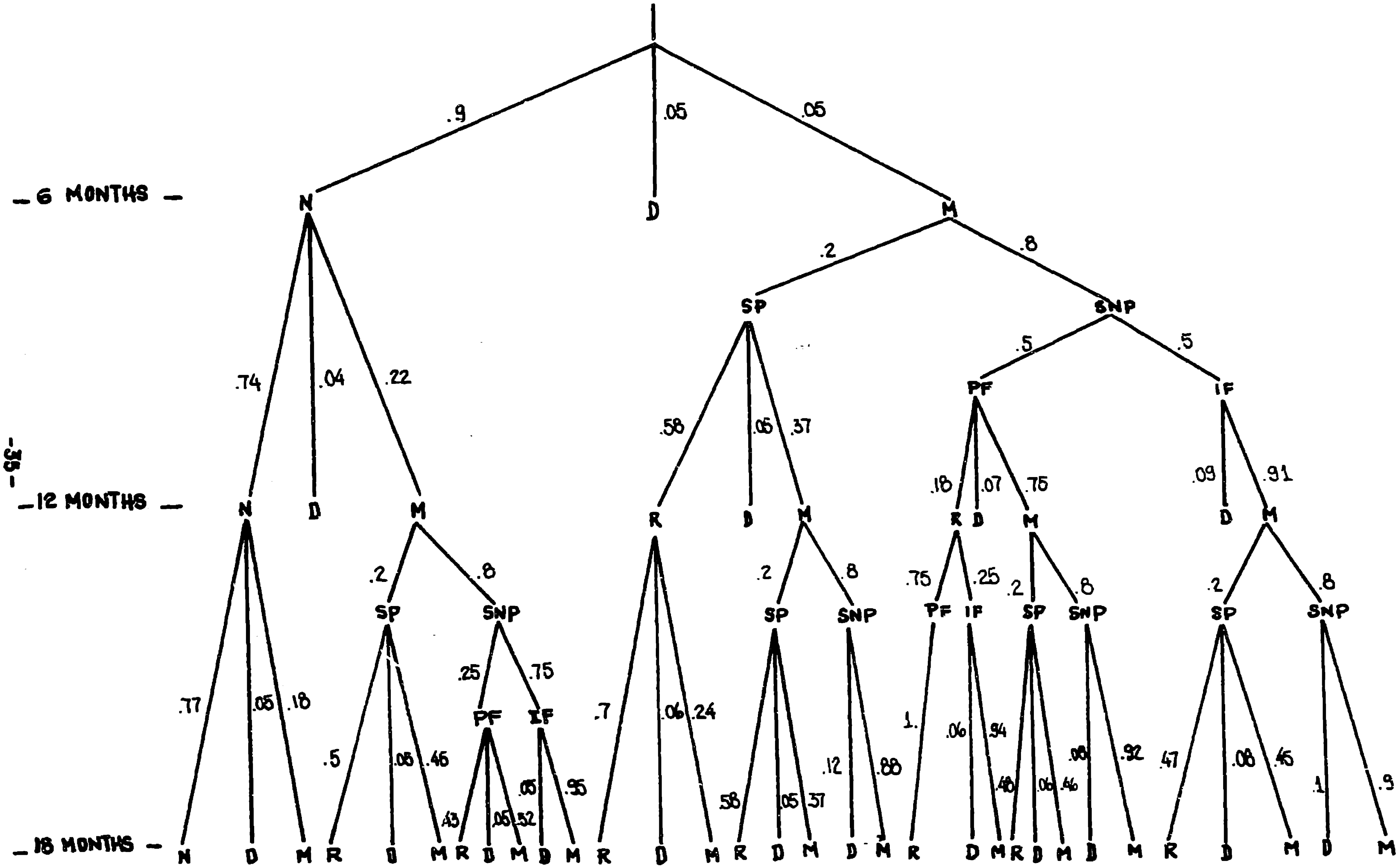


FIGURE 2 h

LBW
GROUP VIII

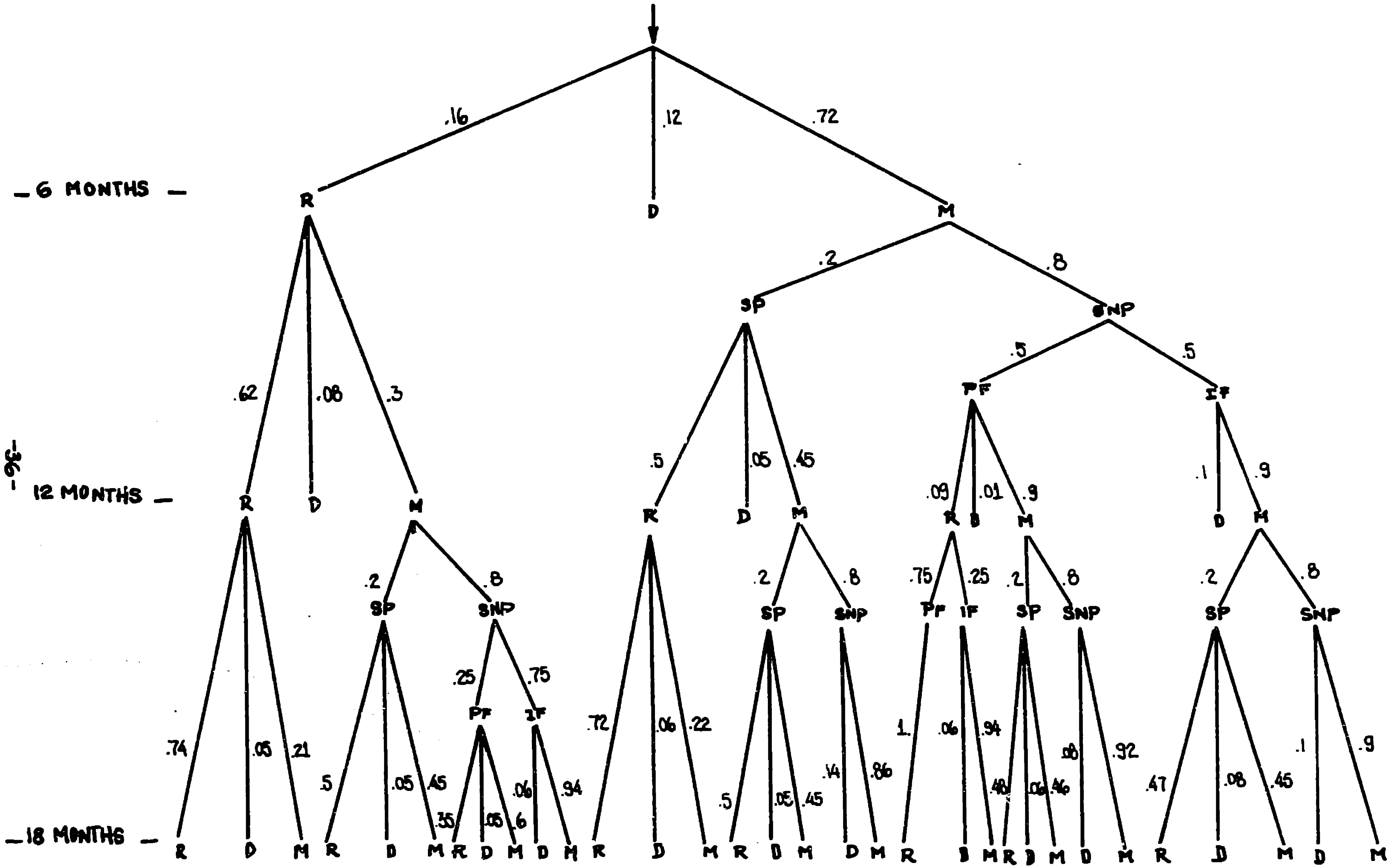


FIGURE 2 i

4.2 The Use of the N&H Model for the Cross-Sectional Evaluation of a Target Group under the Implementation of an N&H Program

Let us assume that a nutrition planning group wants to have semiannual evaluations of the number of malnourished children during the three year period of operation of a nutrition and health program. Let us further assume that their interest is in the number of malnourished children within a target group which consists of children between 0 and 18 months of age.

The question that arises is: How can this information be conveyed to them by making use of the longitudinal N&H model developed before? In order to meet this goal we first would have to be able to divide the target group (children with ages between 0 and 18 months) into separate cohorts whose evolutions we could describe by using the N&H model. We have assumed that we can do this by grouping the children born in one year into two cohorts; one born in January and the other born in July. We recognize that to be more accurate it would be necessary to define more than 2 cohorts per year, but we decided to use 2 in the preliminary approach for the sake of simplicity.

If we consider the target group to consist of children between 0 and 18 months, we can then say that at January of 1981 (arbitrarily assumed year), the cohorts that are in the target group are:

(a) The cohort born in January of 1981 — cohort 1

(b) the cohort born in July of 1980 — cohort 2

(c) the cohort born in January of 1980 — cohort 3

(d) the cohort born in July of 1979 — cohort 4

If we are interested in a cross-sectional evaluation of the malnourished children in the target group in January of 1981, we then have to add together the following groups:

(a) the number of children of cohort 4 that are malnourished <u>at 18 months</u>

(b) the number of children of cohort 3 that are malnourished <u>at 12 months</u>

(c) the number of children of cohort 2 that are malnourished <u>at 6 months</u>

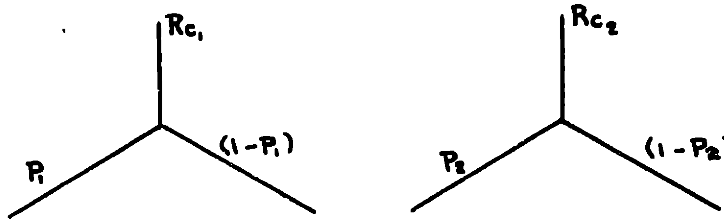
(d) the number of children of cohort 1 that are malnourished <u>at birth</u> (low birth weight children).

Notice that as time passes, new cohorts enter the target group while others leave it (e.g., in July of 1981 cohort 4 is no longer part of the target group and a new cohort enters the target group i.e. the cohort born in July of 1981).

Then, by taking cross-sectional evaluations periodically (in our case every six months) we can give the nutrition planner the semiannual picture that he is interested in. Given that we can supply the same structure of the N&H model to any cohort, the question that remains is how to model the influence that the evolution of one cohort has on the subsequent cohorts. Several hypothesis could be argued about the way in which this influence occurs, but only one was used in the model for simplicity. We assumed that the benefits implicit in the improvement observed in the group of mothers reached by the initial coverage spread out through time to make potential mothers of future cohorts aware of the utility of being assisted by the program. This statement was translated into practical terms by saying that the probability of a certain mother being in the program during pregnancy for a given cohort is related to the number of mothers reached by the program during its previous history; for simplicity it was assumed that this probability is only a function of the number of pregnant mothers enrolled in the program during the preceding period. The implementation of this assumption, which is analogous to that in the mathematical theory of epidemics,[6] is developed out of the following verbal statements: "the chance of any potential mother (pregnant women of the next cohort) being enrolled in the program during pregnancy is proportional to the number of mothers of the previous cohort enrolled in the program."

The mathematical derivation corresponding to this statement is based on the nomenclature stated in Figure 3.

FIGURE 3



R_{c_1} : Number of conceptions in a given cohort

R_{c_2} : Number of conceptions in subsequent cohort

P_1 : Probability that a given mother of a given cohort is enrolled in the program during pregnancy

P_2 : Probability that a given mother of the subsequent cohort is enrolled in the program during pregnancy

β : Contact rate

Then we can write the expression for the number of mothers of the subsequent cohort enrolled in the program during pregnancy as a function of the number of mothers of the initial cohort enrolled in the program during pregnancy:

$$P_2 \times R_{c_2} = P_1 \times R_{c_2} + \Delta\chi \qquad (4.1)$$

where $\Delta\chi$ is the variation in the number of mothers enrolled in the program during pregnancy and is given by:

$$\Delta\chi = \beta \times R_{c_2} \; (P_1 x R_{c_1}) \qquad (4.2)$$

then substituting (4.2) in (4.1)

$$P_2 \times R_{c_2} = P_1 \times R_{c_2} + \beta \times R_{c_2} \; (P_1 \times R_{c_1})$$

or:

$$P_2 = P_1 \times (1 + \beta \times R_{c_1}) \qquad (4.3)$$

This mathematical relation was implemented in the computer program of the N&H model in order to obtain the evolution of consecutive cohorts.

The cross-sectional evaluation at any given time can be performed by adding up the number of malnourished children, at that time, of all those cohorts that were born in a period between the given time and 18 months before this date. Performing this summation for every 6 month period gives the semiannual cross-sectional evaluation. If we start the cross-sectional evaluations at the beginning of the N&H program we have to consider there those cohorts already existing which are within the target group age at that moment. Furthermore, we should provide for the possibility that malnourished children of these cohorts be enrolled in the food supplementation program. This is carried out in the illustration below.

4.3 Illustration of the N & H Model and its Implementation for Cross-Sectional Evaluations

To illustrate the N&H model we considered the same hypothetical community used for the status quo model, as a reference. As a consequence, the probabilities of those branches of the N&H model corresponding to a situation of no involvement with the program were assigned the same values that had been given to their equivalents in the status quo model. This assumption seemed reasonable in order to state the invariability of the conditions for those who are not involved in the program in any matter. For the evaluation of the rest of the probabilities we faced the same sort of uncertainties experimented with the status quo model.

In order to obtain a self-consistent set of probabilities we agreed on a series of assumptions interrelating the probabilities. It was even more necessary to make this type of assumption in this illustration than for the status quo model, given that the N&H model is more than twice as big as the status quo model. The set of assumptions adopted are stated in the appendix, and we claim again that they should only be viewed as a guide for consistent estimation of probabilities and by no means as a description of interrelations for a real case. Figures 2a to 2i contain the set of estimated values for the parameters of the first cohort used in this illustration.

Table 3 summarizes the aggregate results obtained for the evolution of a cohort of 10,000 children for which this set of probabilities apply. Notice that the initial coverage of the program is 20% for this case. In order to make it easier for the reader to understand this table, we list the definitions of the output variables printed by the computer program.

M1 (K,L) Number of children of the cohort K whose mothers were in the program since pregnancy and who are malnourished at the L^{th} check.

M0 (K,L) Number of children of the cohort K whose mothers were never in the program and who are malnourished at the L^{th} check.

MS1(K,L) Number of children of the cohort K whose mothers were in the program during pregnancy and who are malnourished at the L^{th} check, in spite of having been provided with the supplement.

MS0(K,L) Number of children of the cohort K whose mothers were not in the program during pregnancy and who are malnourished at the L^{th} check, in spite of having been provided with the supplement.

R1 (K,L) Number of children of cohort K whose mothers were in the program during pregnancy and who recovered from malnutrition by the L^{th} check without the help of the supplement.

R0 (K,L) Number of children of cohort K whose mothers were never in the program and who were recovered at check L without the help of the supplement.

RS1(K,L) Number of children of cohort K whose mothers were in the program during pregnancy and who were found to be recovered at the L^{th} check with the help of the supplement.

RS0(K,L) Number of children of cohort K whose mothers were not in the program and who were found recovered from malnutrition at the L^{th} check after being provided with the supplement.

N1 (K,L) Number of children of cohort K whose mothers were in the program during pregnancy and who are normal at the L^{th} check.

N0 (K,L) Number of children of cohort K whose mothers were never in the program and are normal at the L^{th} check.

D1 (K,L) Number of children of cohort K whose mothers were in the program during pregnancy and who died between checks (L-1) and L.

TABLE 3

	K = 1			
	B	6	12	18
	L=1	L=2	L=3	L=4
M1(K,L)	34.00	18.30	71.88	54.67
MS1(K,L)			0.49	7.00
N1(K,L)	1948.00	1924.96	1850.62	1793.45
D1(K,L)	18.00	6.16	8.05	12.98
R1(K,L)		32.58	28.98	27.14
RS1(K,L)			15.81	72.55
MO(K,L)	576.00	729.12	1579.36	1663.65
MSO(K,L)			12.86	156.36
NO(K,L)	7344.00	6669.12	5154.18	4485.09
DO(K,L)	80.00	400.80	213.87	238.37
RO(K,L)		120.96	131.37	181.37
RSO(K,L)			31.64	184.57

DO (K,L) Number of children of cohort K whose mothers were never in the program and who died between checks (L-1) and L.

As it would be expected, we can see that the percentages of malnutrition and death for the evolution of this cohort under the N&H program are lower than what they would be if the cohort's evolution were under the status quo conditions.

Under the assumptions of the model, the number of mothers of every new cohort that are enrolled in the program during pregnancy is related to the number of mothers of the previous cohort enrolled in the program during pregnancy. (We have assumed that the services provided by the program can increase sufficiently fast to handle the increase in the demand). Then, in our case, the 20% of initial coverage provides the value of P_1 ($P_1 = 0.2$) which is necessary for the calculation of the coverage for the next cohort (P_2) as stated by Equation (4.3). Once this calculation is made, we are able to compute the results for the next cohort. This process is carried out automatically by the computer for all the cohorts that we specify. Given that we are interested in the semiannual cross-sectional evaluations during three years of operation of the program (since the beginning of it), it was necessary to have the longitudinal evolution of the 7 consecutive cohorts starting with the beginning of the program, plus the longitudinal evolution of the cohorts born 6, 12 and 18 months before the beginning of the program (providing the model with the details that give those cohorts the chance of being provided with the food supplement at the moments of their evolutions when the program starts; i.e. making the probability of having the supplement, since the date of beginning of the program, different from zero).

Tables 4 to 9 summarize the results obtained for the 6 cohorts (each assumed to be of 10,000 children) that followed the one summarized in Table 3, while Tables 10 to 12 contain the results obtained for the cohorts born 18, 12 and 6 months before the beginning of the program, respectively.

Based on the information provided by the tables we then performed the semiannual cross-sectional evaluations of the number of malnourished children which appear in Table 13 and are graphically represented in Figure 4. This figure shows the decrease in the number of malnourished children after the operation of the N&H program with a 20% rate of initial coverage.

TABLE 4

K = 2

	B L=1	6 L=2	12 L=3	18 L=4
M1(K,L)	37.40	20.13	70.06	60.13
MS1(K,L)			0.54	7.70
N1(K,L)	2142.80	2117.45	2035.68	1972.79
D1(K,L)	19.80	6.78	8.86	14.28
R1(K,L)		35.84	31.88	29.86
RS1(K,L)			17.39	79.80
MO(K,L)	561.60	710.89	1539.88	1622.06
MSO(K,L)			12.54	152.45
NO(K,L)	7160.39	6502.39	5025.32	4372.96
DO(K,L)	78.00	390.78	208.52	232.41
RO(K,L)		117.94	128.09	176.84
RSO(K,L)			30.85	179.96

TABLE 5

	K = 3			
	B	6	12	18
	L=1	L=2	L=3	L=4
M1(K,L)	41.14	22.14	86.97	66.15
MS1(K,L)			0.60	8.47
N1(K,L)	2357.08	2329.20	2239.25	2170.07
D1(K,L)	21.78	7.45	9.74	15.71
R1(K,L)		39.42	35.07	32.84
RS1(K,L)			19.13	87.78
MO(K,L)	545.76	690.84	1496.45	1576.31
MSO(K,L)			12.19	148.15
NO(K,L)	6958.44	6318.99	4883.59	4249.62
DO(K,L)	75.80	379.76	202.64	225.86
RO(K,L)		114.61	124.48	171.85
RSO(K,L)			29.98	174.88

TABLE 6

	K = 4			
	B L=1	6 L=2	12 L=3	18 L=4
M1(K,L)	45.25	24.36	95.67	72.76
MS1(K,L)			0.66	9.32
N1(K,L)	2592.78	2562.12	2463.17	2387.07
D1(K,L)	23.96	8.20	10.72	17.28
R1(K,L)		43.36	38.58	36.13
RS1(K,L)			21.04	96.56
MO(K,L)	528.34	668.79	1448.67	1525.98
MSO(K,L)			11.80	143.42
NO(K,L)	6736.29	6117.25	4727.67	4113.95
DO(K,L)	73.38	367.63	196.17	218.65
RO(K,L)		110.95	120.50	166.36
RSO(K,L)			29.02	169.30

TABLE 7

	K = 5			
	B	6	12	18
	L=1	L=2	L=3	L=4
M1(K,L)	49.78	26.79	105.23	80.04
MS1(K,L)			0.72	10.25
N1(K,L)	2852.06	2818.33	2709.49	2625.78
D1(K,L)	26.35	9.02	11.79	19.01
R1(K,L)		47.70	42.43	39.74
RS1(K,L)			23.15	106.22
MO(K,L)	509.17	644.52	1396.12	1470.63
MSO(K,L)			11.37	138.22
NO(K,L)	6491.91	5895.34	4556.17	3964.71
DO(K,L)	70.72	354.30	189.06	210.71
RO(K,L)		106.93	116.13	160.33
RSO(K,L)			27.07	163.16

TABLE 8

	K = 6			
	B	6	12	18
	L=1	L=2	L=3	L=4
M1(K,L)	54.76	29.47	115.76	88.04
MS1(K,L)			0.80	11.27
N1(K,L)	3137.26	3100.16	2980.44	2888.35
D1(K,L)	28.99	9.92	12.97	20.91
R1(K,L)		52.47	46.68	43.72
RS1(K,L)			25.46	116.84
MO(K,L)	488.09	617.84	1338.31	1409.73
MSO(K,L)			10.90	132.50
NO(K,L)	6223.11	5651.23	4367.52	3800.55
DO(K,L)	67.79	339.63	181.23	201.99
RO(K,L)		102.50	111.32	153.69
RSO(K,L)			26.81	156.40

TABLE 9

	K = 7			
	B	6	12	18
	L=1	L=2	L=3	L=4
M1(K.L)	60.23	32.42	127.33	96.85
MS1(K,L)			0.88	12.40
N1(K,L)	3450.99	3410.17	3278.48	3177.19
D1(K,L)	31.89	10.91	14.27	23.00
R1(K,L)		57.72	51.34	48.09
RS1(K,L)			28.01	128.52
MO(K,L)	464.90	588.48	1274.72	1342.75
MSO(K,L)			10.38	126.20
NO(K,L)	5927.42	5382.72	4160.00	3619.97
DO(K,L)	64.57	323.49	172.62	192.39
RO(K,L)		97.63	106.03	146.39
RSO(K,L)			25.54	148.97

TABLE 10

MO(K,L)	720.00	911.40	2444.92	2740.50
MSO(K,L)			0.00	0.00
NO(K,L)	9180.00	8336.39	6442.72	5606.36
DO(K,L)	100.00	501.00	301.66	325.11
RO(K,L)		151.20	209.70	286.28
RSO(K,L)			0.00	0.00

Cohort born 18 months before the start of the program

TABLE 11

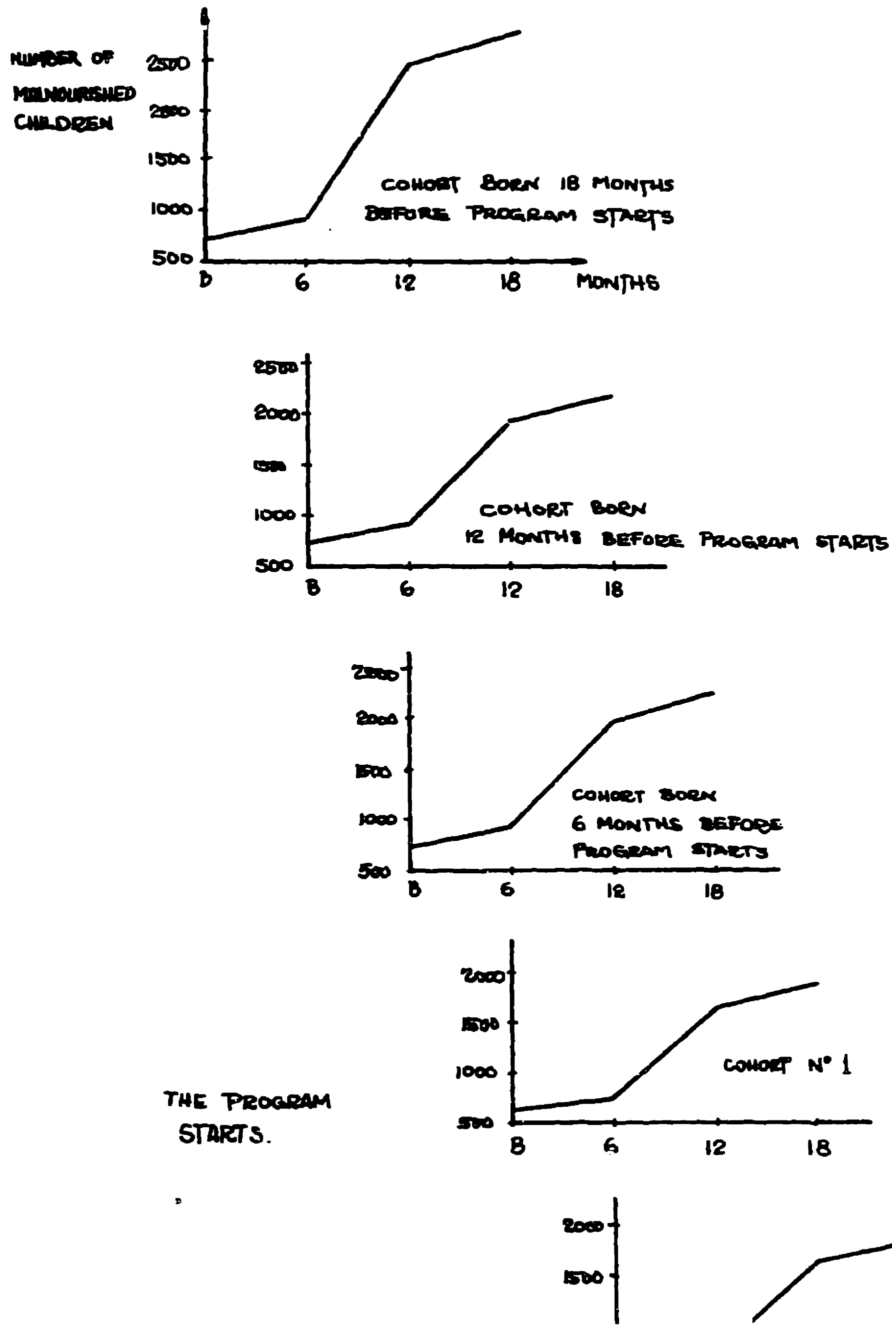
MO(K,L)	720.00	911.40	1907.29	2030.69
MSO(K,L)			0.00	166.21
NO(K,L)	9180.00	8336.39	6442.72	5606.36
DO(K,L)	100.00	501.00	260.81	387.92
RO(K,L)		151.20	169.57	232.54
RSO(K,L)			0.00	195.87

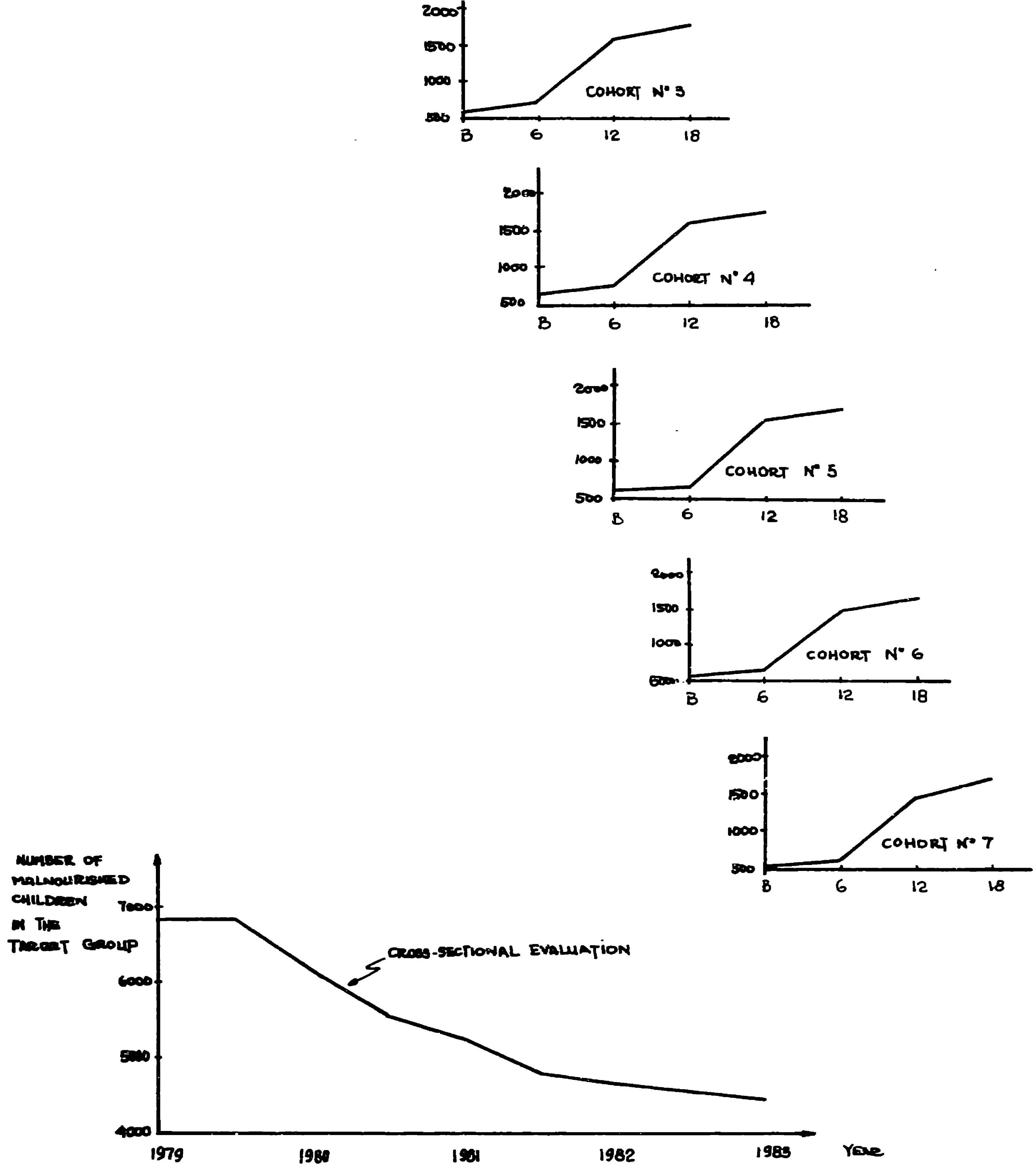
Cohort born 12 months before the start of the program

TABLE 12

MO(K,L)	720.00	911.40	1974.20	2079.56
MSO(K,L)			16.08	195.45
NO(K,L)	9180.00	8336.39	6442.72	5606.36
DO(K,L)	100.00	501.00	267.34	297.96
RO(K,L)		151.20	164.22	226.71
RSO(K,L)			39.55	230.72

Cohort born 6 months before the start of the program


NUMBER OF MALNOURISHED CHILDREN
2500
2800
1500
1000
500
COHORT BORN 18 MONTHS BEFORE PROGRAM STARTS
0
6
12
18
MONTHS
2500
2000
1000
500
COHORT BORN 12 MONTHS BEFORE PROGRAM STARTS
B
6
12
18
2000
1500
1000
500
COHORT BORN 6 MONTHS BEFORE PROGRAM STARTS
B
6
12
18
THE PROGRAM STARTS.
2000
1500
1000
500
COHORT N° 1
B
6
12
18
2000
1500



COHORT N° 3
COHORT N° 4
COHORT N° 5
COHORT N° 6
COHORT N° 7
B
6
12
18
500
1000
1500
2000
NUMBER OF MALNOURISHED CHILDREN IN THE TARGET GROUP
CROSS-SECTIONAL EVALUATION
4000
5000
6000
7000
1979
1980
1981
1982
1983
YEAR

5. Concluding Remarks and Suggestions for Future Work

This preliminary attempt allowed us to explore the possibilities of employing a detailed simulation model to aid the nutrition planner in consideration of the design of nutrition and health programs for pre-school children. A principal attribute of the approach is that it is capable of providing both the longitudinal and cross-sectional views of the target group.

Two major types of assumptions have to be made in the stages of design and implementation of a model of this type for its use in the analysis of a specific community; these are the assumptions relative to the estimation of parameters of the model (probabilities) and the assumptions relative to the structure of the model itself.

The assumptions relative to the estimation of probabilities are of both quantitative and qualitative nature, and they arise out of the conviction that the application of a model of this type cannot be fully based on actual data because it would require very expensive, careful and detailed studies. The setting of these assumptions requires a very deep understanding of the situation considered, because they are mainly responsible for the fidelity of the results of the model to the actual system behavior. Although it was not the objective of this thesis, it is worthwhile to emphasize the important role that the setting of these assumptions play in both the calibration of the model and its later use for studying different programs for a specific community. However, there will still be many probabilities to be determined from detailed field studies which, given their number and the high costs implicit in their determination, remain as the biggest challenge for the application of these types of models. There is the hope that longitudinal studies will be more frequent in the near future, and the parallel design and implementation of a model of this type is suggested as a subject of further research.

The assumptions relative to the structure of the model itself are also important because they affect the reliability of the results as well as the usefulness of the model to the nutrition planner. We want to discuss here some of the assumptions made for the structure of this model and their limitations in order to recommend possible orientations for future work:

(a) The separation of the number of children born in one year into two cohorts that are six months apart does not seem to lead to homogeneous groups in what refers to age differences. This factor is very important because it involves the whole spirit of the longitudinal studies approach. We feel that an extension of the work to consider one month intervals rather than six month intervals would be an interesting orientation for future work.

(b) The assumption of 0 to 18 months for the range of age for the target group does not cover the entire vulnerable period. This factor is also very important because it is expected that in certain areas the vulnerable period reaches up to 3 years of age. The extension of the target group is directly related to the level of complexity of the structure of the model not only because of the incredibly large rate of growth of the structure in itself, but also because of the implications of required computations for aggregated results. This tends to be a common problem in almost all systems studies, and it is a major challenge to the ingenuity of the analyst. It is suggested that a study of the possibility of extension of the target group range of age be a subject of further work.

(c) The assumption that the only positive feedback in the model resides in the probability for a mother of being in the program during pregnancy, seemed reasonable at the beginning because of the extremely important role that this factor plays in the child's evolution. We now believe, however, that there might be other important factors not emphasized by us in this preliminary work and which might be the subject of interest of nutrition planners. Therefore, we wish to point out that other types of feedback could be implemented to account for influences of the program on consecutive cohorts.

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APPENDICES

A.1 Assumptions Used in the Estimation of Probabilities for the Status Quo Model Illustration

As stated in Section 3, the following set of assumptions are only to be viewed as an aid for the determination of a self-consistent set of probabilities:

a) Figure 1a assumes that the nutritional outcome at birth is dependent on the mother's status. To evaluate the corresponding probabilities we have assumed that children whose mother's status are deficient have a 25% higher probability of low birth-weight than children whose mothers are well nourished. A similar assumption is made for the probability of death at birth. Based on these 2 assumptions and the requirement that the sum of the probabilities of occurrence of all possible events must add up to one*, one can derive the set of probabilities corresponding to deficient mother's status from his evaluation of the probabilities for the case of satisfactory mother's status, or vice versa. Figure 5 will be of help for the mathematical illustration of the statement.

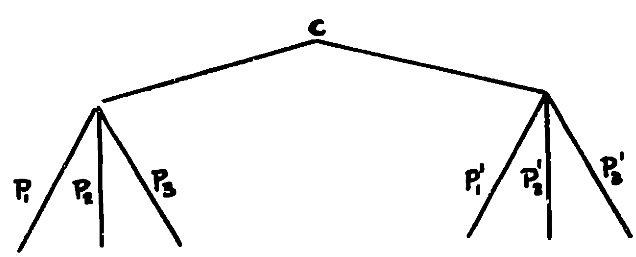


FIG. 5

*this statement always holds

It translates into:

$$P_3' = 1,25\ P_3$$

$$P_2' = 1.25\ P_2$$

$$P_1' = 1 - P_2' - P_3' = 1 - 1.25\ (P_2 + P_3) = 1 - 1.25\ (1 - P_1)$$

$$P_1' = 1.25\ P_1 - 0.25$$

b) For the cases of children with normal birth weight (Groups I and IV, Figures 1b and 1d respectively), the probability of becoming malnourished during the first six months is 20% higher for those having mothers whose status is deficient than for those having mothers whose status is satisfactory. A similar assumption is made for the probability of death and again the probability of continuing normal is readily determined from the requirement that the sum of probabilities of all possible events be equal to one.

c) For the case of children with low birth weight, the probability of becoming malnourished during the first six months is 20% higher for those having mothers whose status is deficient than for those having mothers whose status is satisfactory. A similar assumption is also made for the probability of death. The probability of recovery is again easily obtainable.

d) For a child that has had proper food and recovers, the probability of having improper food is half what it was in the first time.

e) For a normal birth weight child that becomes malnourished for the first time at 12 months, and whose mother had a deficient status, the probability of having improper food is 50% higher than the probability of having improper food for a child that becomes malnourished for the first time at 6 months. The ground for this assumption is that in the second case the malnutrition could be developed out of deficiencies in the mother's milk or in the quantities provided; while in the first case, the child has had a considerable food intake and the fact that he has evolved from a normal state to a malnourished one supports the belief that this probability of improper food intake is bigger. The 1.5 factor is only one assumption as valid as any other one that could have been made.

f) For a child whose mother's status is deficient and has been normal during all her history, the probability of becoming malnourished at 18 months is 20% lower than it was at 12. The same assumption is made for the probability of death.

g) For normal birth weight children, in comparing children malnourished at 6 months, the probability of becoming malnourished after having proper food, in the case of mothers with deficient status, is 50% higher than for the case of mothers with acceptable nutritional status.

h) For a low birth weight child that is malnourished at 6 months, the probability of continuing to be malnourished at 12 months, in spite of having proper food, is 20% higher than the corresponding probability for a normal birth weight child.

i) Children with a low birth weight will have twice as high a probability of becoming malnourished, during the first six months, as the children with normal birth weight.

j) The probabilities of becoming malnourished at 12 months for children that have not been malnourished at 6, increase as a function of their past history in what relates to having had low birth weight and mothers with deficient status.

A.2 Assumptions Used in the Estimation of Probabilities for the N and H Model Illustration

a) The status quo model is embedded in the N&H model in such a manner that those children who do not have any contact with the program will have the same rates of malnutrition, death, etc. as in the status quo model.

The following relations are assumed for low birth weight children who are malnourished at 6 months and whose mothers were not in the program during pregnancy.

b) The probability of continuing to be malnourished during the 6-12 month period is one half as high for children receiving the supplement as it is for children receiving proper food but no supplement.

c) The probability of continuing to be malnourished after receiving the supplement for a second period is the same as it was for this child when receiving the supplement for the first time.

d) For a child who is malnourished at both 6 and 12 months, the effect of receiving the supplement only after 12 months is to decrease the probability of malnutrition and death to one half of the case of a child who never receives the supplement.

The following relations are assumed to apply to children whose mothers were in the program during pregnancy:

e) The probability of a malnourished child to receive the supplement equal to 0.8 at all levels.

f) For the normal birth weight children, the probability of having improper food at any level is half of what it would be for the corresponding branch of the no program tree.

g) For the normal birth weight children whose mothers had deficient status during pregnancy, the effect of proper food is to have a conditional probability of malnutrition equal to half of its value in the best case of those when the mothers are not in the program during pregnancy.

h) For the low birth weight children, the probability of becoming malnourished for the first time at 12 months is equal to half of what it would be if the mother had not been in the program during pregnancy.

i) For the low birth weight children whose mothers have satisfactory nutritional and health status, the probability of having improper food after 6 months is half of what it is for the corresponding branch in the tree of the normal birth weight children whose mother was deficient.

A.3 Computer Program Specifications for the Direct Use

The program was run on the IBM 360/165 located at the Information Processing Center at MIT. The job run time was about .142 minutes and the system residence time was 3 minutes. The total charge per run was in the order of $4.

The computer program was written based on Figures 6a to 6i instead of Figures 2a to 2i. (Both sets of figures are equivalent with differences only in the order of paths). Therefore, in order to use the computer program one has to reallocate the values estimated for the branches of Figures 2a to 2i to their corresponding branches in Figures 6a to 6i. The input to the computer program is formed by the value of the rate of conception and the values of the probabilities. The ordering and format to be used for the probabilities are specified by the READ statements in the computer listing. The general nomenclature for the probabilities is $P_{ij}(k,l)$ and it is fully described in part b).

. Additional Information

This section describes the arrays defined for the implementation of the program. They are:

P_{ij} (k,l): (defines for the probabilities). Is a set of 2 by 2 arrays, where i, j, k and l are variable numbers which vary according to the particular branch considered. The meaning of each subscript is explained below:

i : varies from 0 to 8, and defines the "basic group" in which the particular probability is located. Group 0 corresponds to that part of the tree before it branches out to the main 8 groups. Numbers 1 to 8 correspond to each one of these 8 groups.

j : varies from 1 to 9. It defines the "stage of decision" in the tree to which the particular probability corresponds. It locates the coefficient in the vertical direction.

k : it defines the number of the decision within a particular <u>basic group</u>, at a given level j.

These decisions are numerated from left to right.

l : defines the branch of the particular decision to which the particular probability corresponds.

Several arrays were defined to account for the several categories to which a particular child might correspond at any particular check-point (birth, 6, 12 and 18 months). The names of these arrays and their meanings are stated below:

R : number of children that

(a) recovered during the last interchecking period without supplement's help, or

(b) recovered in the same way before the last period and did not get malnourished up to the present check.

RS : number of children that

(a) recovered with supplement's help during the currently finished interchecking period, or

(b) recovered with supplement's help before the currently finished interchecking period and did not get malnourished up to the present check.

M : number of children that are found malnourished in the currently referred check, and have never made use of the supplement.

MS : number of children that having been exposed to the supplementation program (have had the supplement), are again found malnourished in the present check.

N : number of children that are found to be normal in the present check.

D : number of children that died during the last interchecking period.

The dimensions of these arrays and the explanation of the subscripts are given below:

R (i, j, k, l, m)

i : defines the number of the main group i = 1,2,....8

j : defines the number of the interchecking period with which we are concerned j = 2, 3, 4

k : indicator of whether or not the mother is in the program during pregnancy k = 1 → mother is; k = 2 → mother is not.

l : number of times that a child has been found malnourished including the present check l = 1,2

m : number of times that the child has been declared recovered including the result of the present check m = 1, 2, 3.

When there was more than one box corresponding to a specific set of values for i, j, k, l, and m, we defined a new array of only one dimension whose name was given by the corresponding values of i, j, k, l, and m (e.g., Rijklm(n)).

Where the subindex n was defined to increase from left to right in Figures 6a to 6i.

RS (i, j, k, l, m)

i : defines the number of the group i = 1, 2, ... 8

j : defines the number of the checking period with which we are concerned j = 2, 3, 4

k : indicator of whether or not the mother is in the program during pregnancy k = 1, 2

l : number of times that a child has been found malnourished including the present time l = 1, 2, 3

m : number of times that a child has been declared recovered including the result of the present check m = 1, 2

When there was more than one box corresponding to a specific set of values for i, j, k, l, and m we used the same procedure that we used for the R arrays. The only difference is that instead of calling the new array RS ijklm (n), we call it H ijklm (n) (we use H instead of RS because the computer program does not accept a name of variable with more than 6 characters.

M (i, j, k, l, m)

i : number of the group   i = 1, 2, ... 8

j : number of the checking period with which we are concerned

j = 2, 3, 4

k : indicator of whether or not the mother is in the program during pregnancy   k = 1, 2

l : number of times that the child has been found malnourished including present check   l = 1, 2, 3, 4

m : number of times that he has been declared recovered including the result of the present check   m = 1, 2, 3

(3 stands for no times. It is done in this way because the computer does not accept a subscript equal to zero).

The same procedure as before is used when there is more than one box with the same set of values for i, j, k, l, and m. The new arrays are called M ijklm (n).

MS (i, j, k, l, m)

i : number of the group   i = 1, 2, ... 8

j : number of the checking period   j = 2, 3, 4

k : indicator of whether or not the mother is in the program during pregnancy   k = 1, 2 l : number of times the child has been found malnourished

including present check l = 2, 3, 4

m : number of times that they have been declared recovered

including the result of the present check m = 1, 2

(2 stand for 0 times, because the computer doe not accept

a subscript equal to zero).

Again, the same procedure as before is used when there is more than one box with the same set of values for i, j, k, l,and m. The new arrays are called V ijklm (n) instead of MS ijklm (n), for the same reasons stated for the case of RS.

N (i, j, k)

i : number of the group i = 1, 2, ... 8

j : indicator of whether or not the mother is in the program

during pregnancy j = 1, 2

k : number of the checking period k = 2, 3, 4

D (i, j, k)

i : number of the group i = 1, 2, ... 8

j : indicator of whether or not the mother is in the program

during pregnancy j = 1, 2

k : number of the checking period k = 2, 3, 4

When there is more than one box corresponding to a specific set of values of i, j, and k, we define a new variable D ijk (l) (where l stands for the number of the box from left to right).

ABBREVIATIONS

C = CONCEPTION
MIP = PREGNANT WOMEN IN THE PROGRAM
MOP = PREGNANT WOMEN NOT IN THE PROGRAM
MNA = PREGNANT WOMEN WITH SATISFACTORY NUTRITIONAL AND HEALTH STATUS
MND = PREGNANT WOMEN WITH DEFICIENT NUTRITIONAL AND HEALTH STATUS.
NBW = CHILDREN WITH NORMAL BIRTH WEIGHT
UBW = CHILDREN WITH LOW BIRTH WEIGHT
DIO = CHILDREN WHO DIE
DOO = CHILDREN WHO DIE

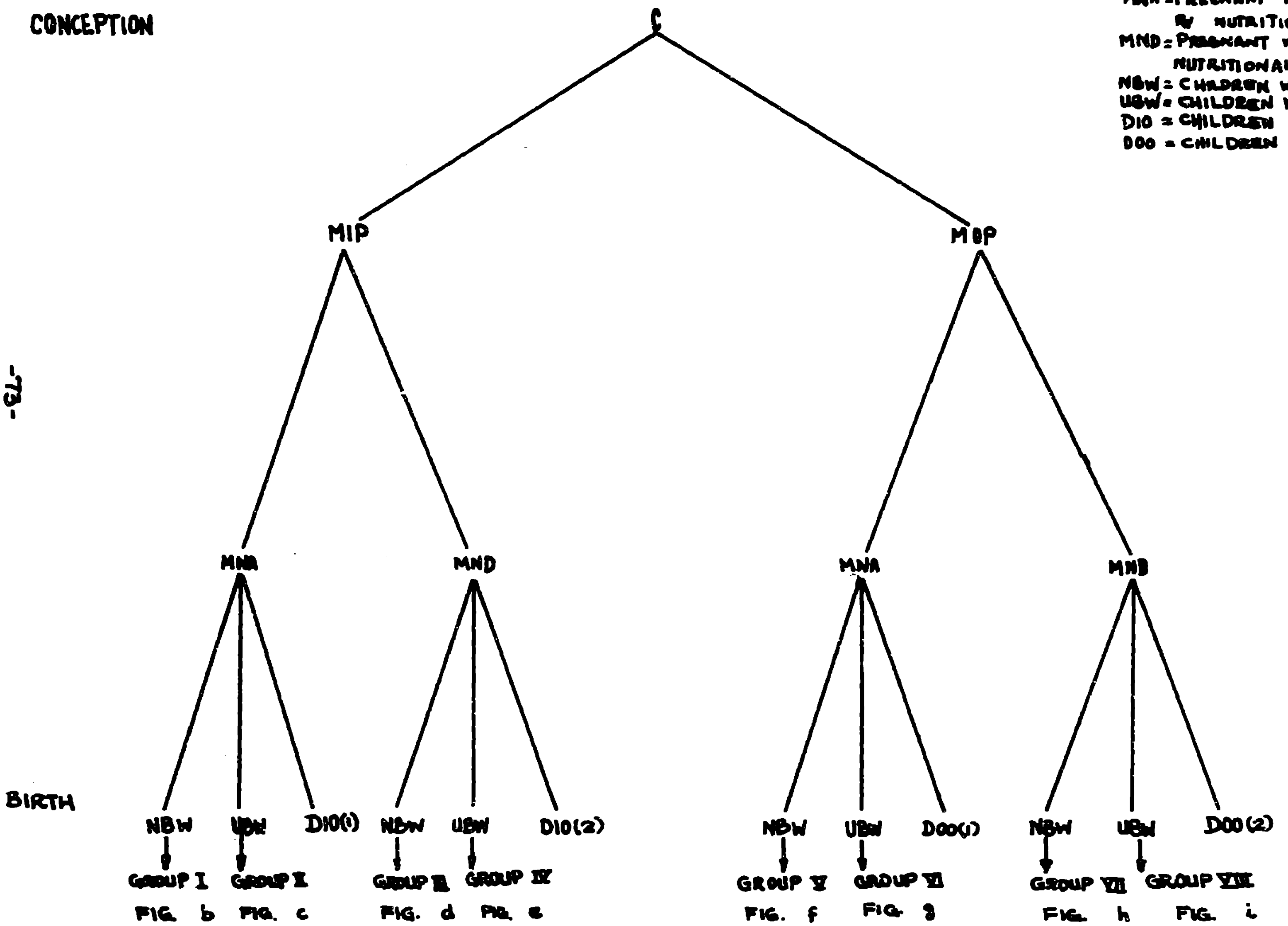
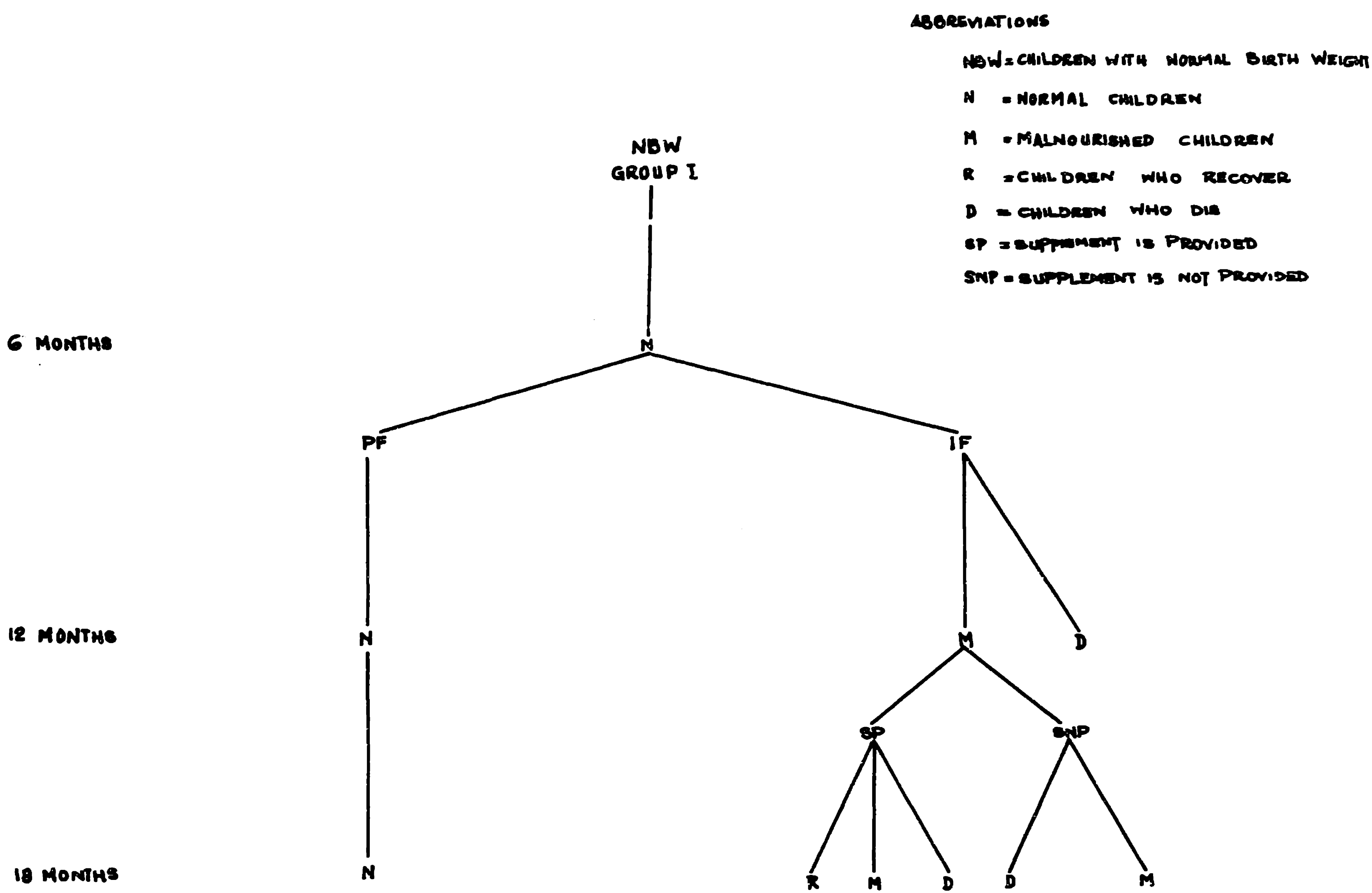


FIGURE 6a.



ABBREVIATIONS
NBW = CHILDREN WITH NORMAL BIRTH WEIGHT
N = NORMAL CHILDREN
M = MALNOURISHED CHILDREN
R = CHILDREN WHO RECOVER
D = CHILDREN WHO DIE
SP = SUPPLEMENT IS PROVIDED
SNP = SUPPLEMENT IS NOT PROVIDED
NBW
GROUP I
6 MONTHS
12 MONTHS
18 MONTHS
N
PF
IF
N
M
D
SP
SNP
N
R
M
D
D
M

FIGURE 6b

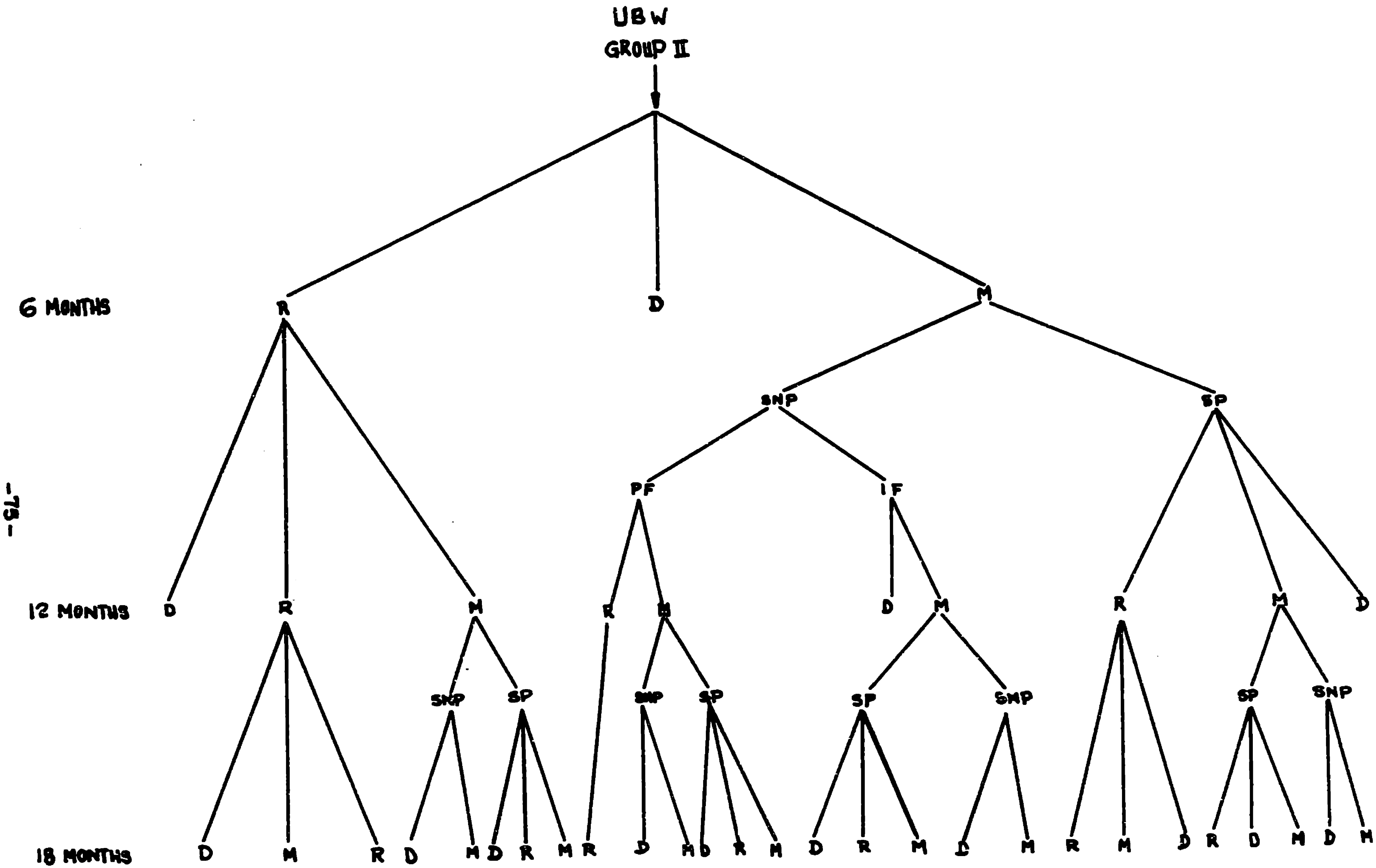


FIGURE 8c

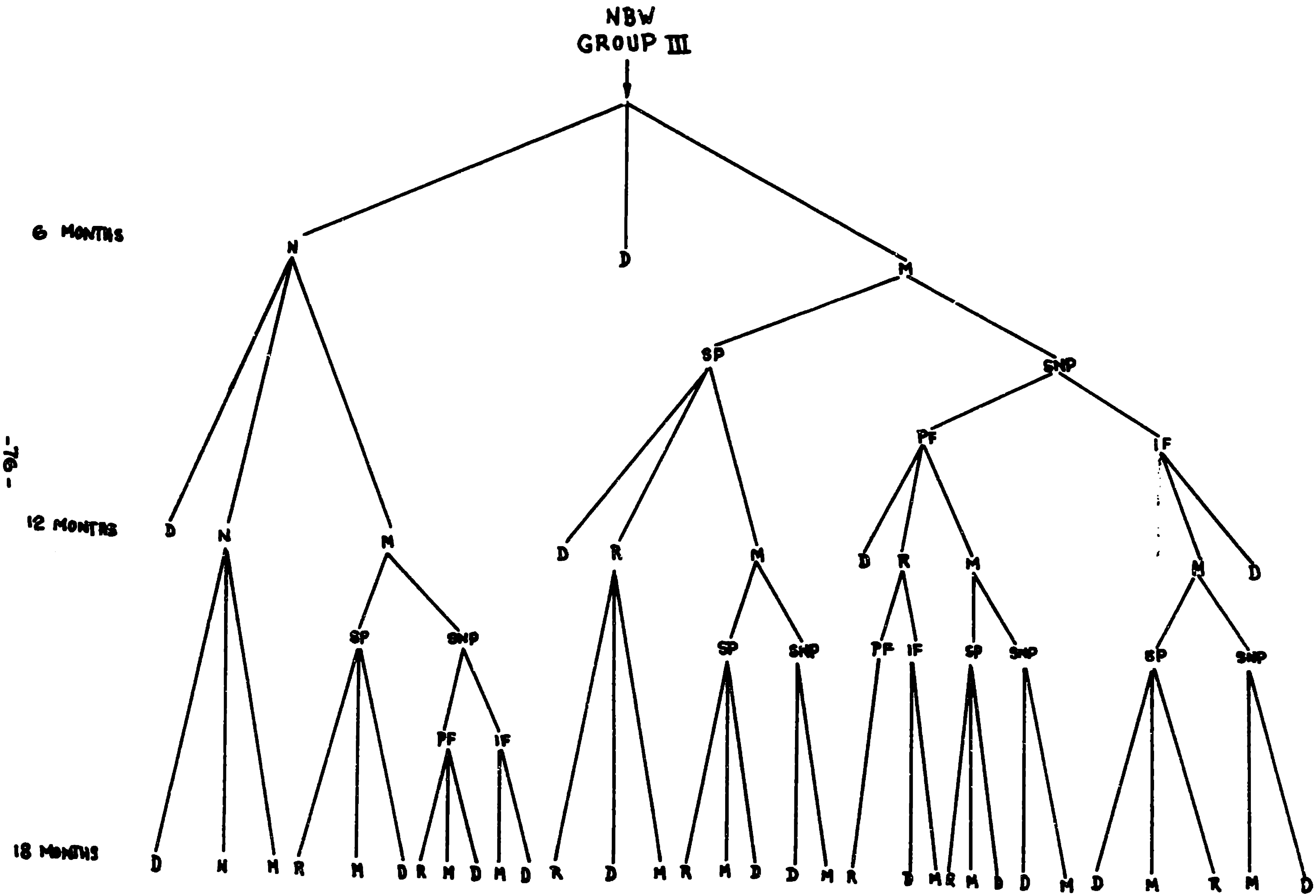


FIGURE 6d

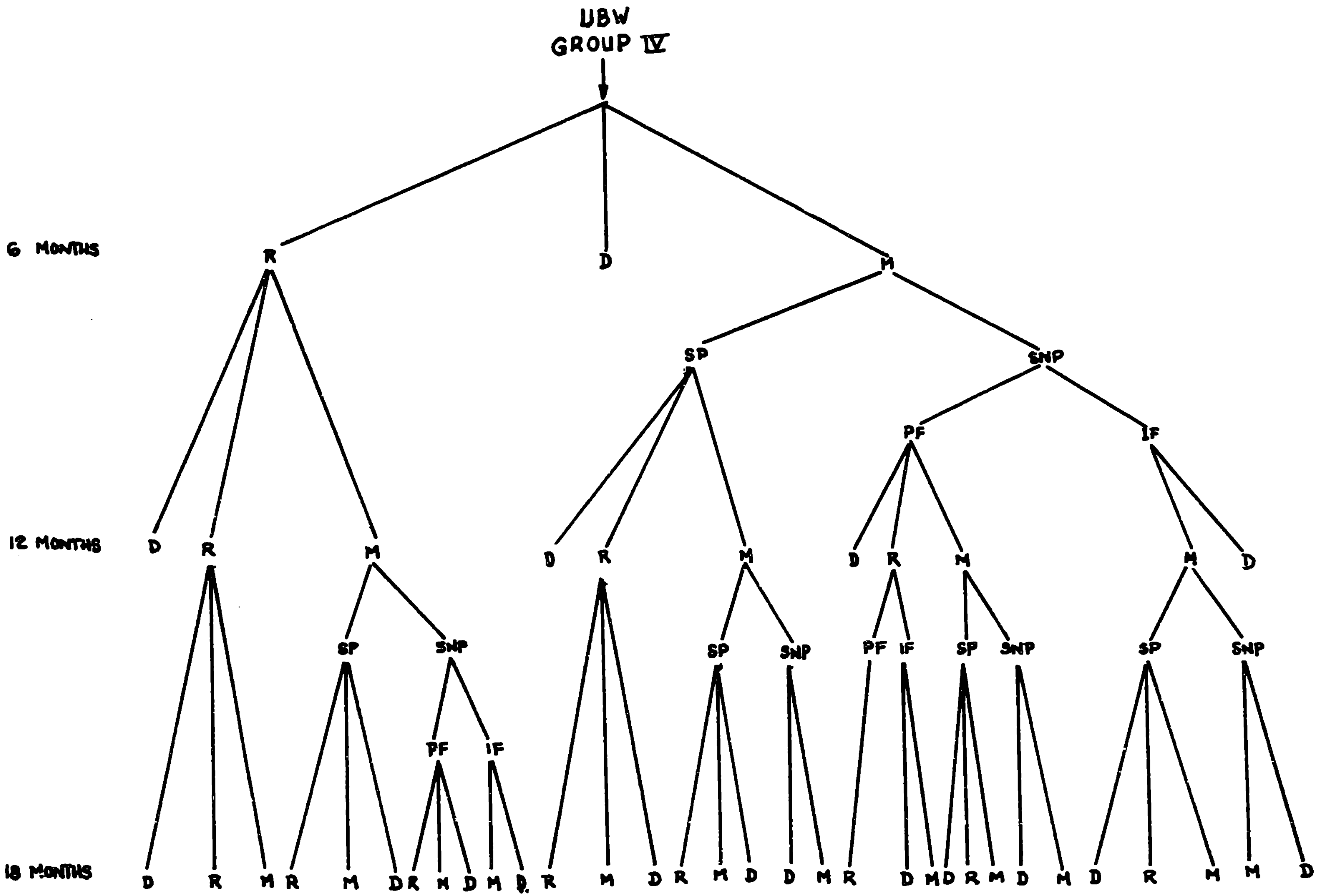


FIGURE 6a

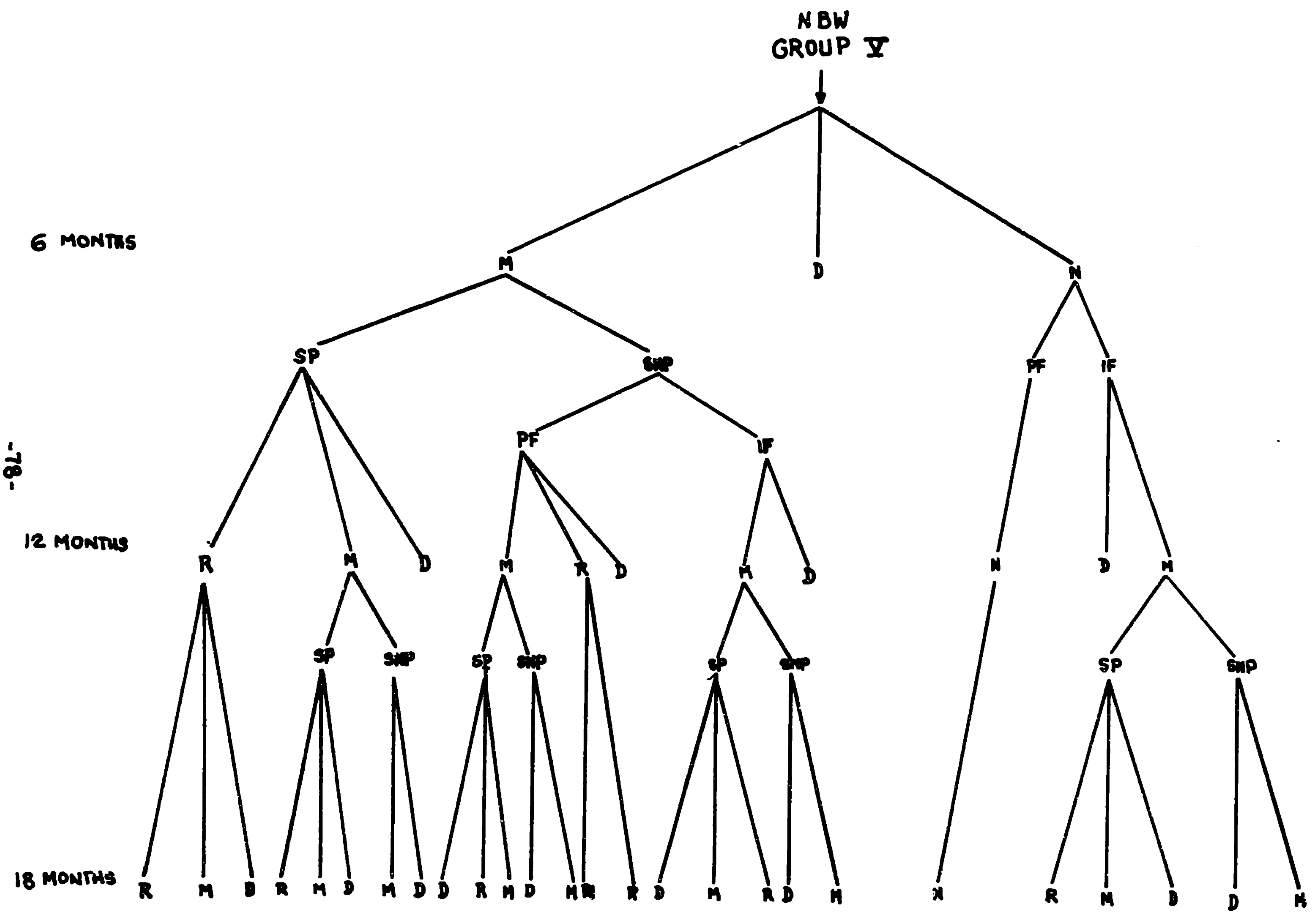


FIGURE 6f

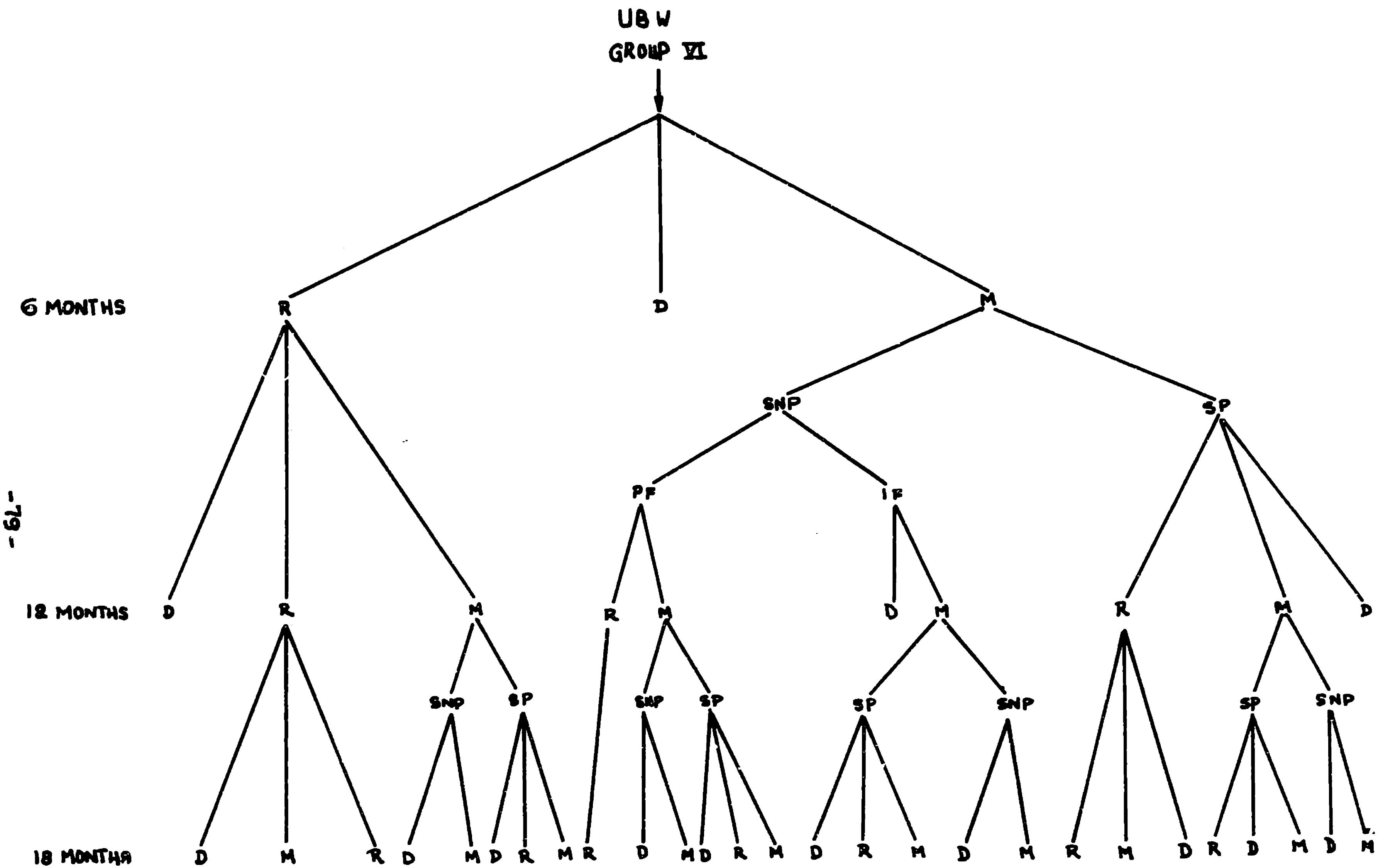

UBW
GROUP VI
6 MONTHS
12 MONTHS
18 MONTHS
R
D
M
SNP
SP
PF
IF
D R M R M D M R M D
SNP SP SNP SP SP SNP SP SNP
D M R D M D M D R M R D M D M D R M D M D R M R M D R D M D M

FIGURE 6g

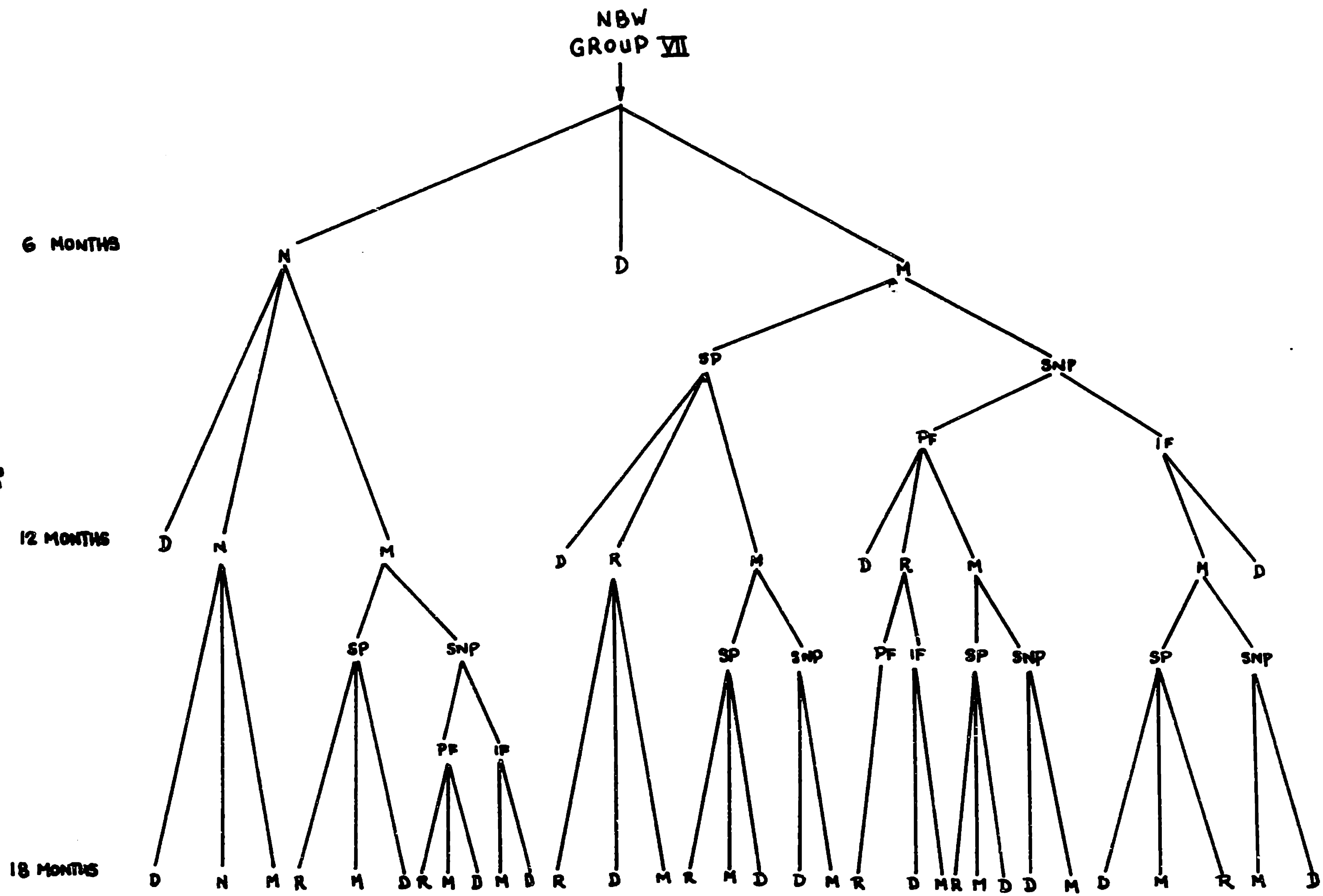

NBW
GROUP VII
6 MONTHS
N
D
M
SP
SNP
PF
IF
12 MONTHS
D N M D R M D R M M D
SP SNP SP SNP PF IF SP SNP SP SNP
PF IF
18 MONTHS
D N M R M D R M D M D R D M R M D D M R D M R M D D M D M R M D

FIGURE 6 h

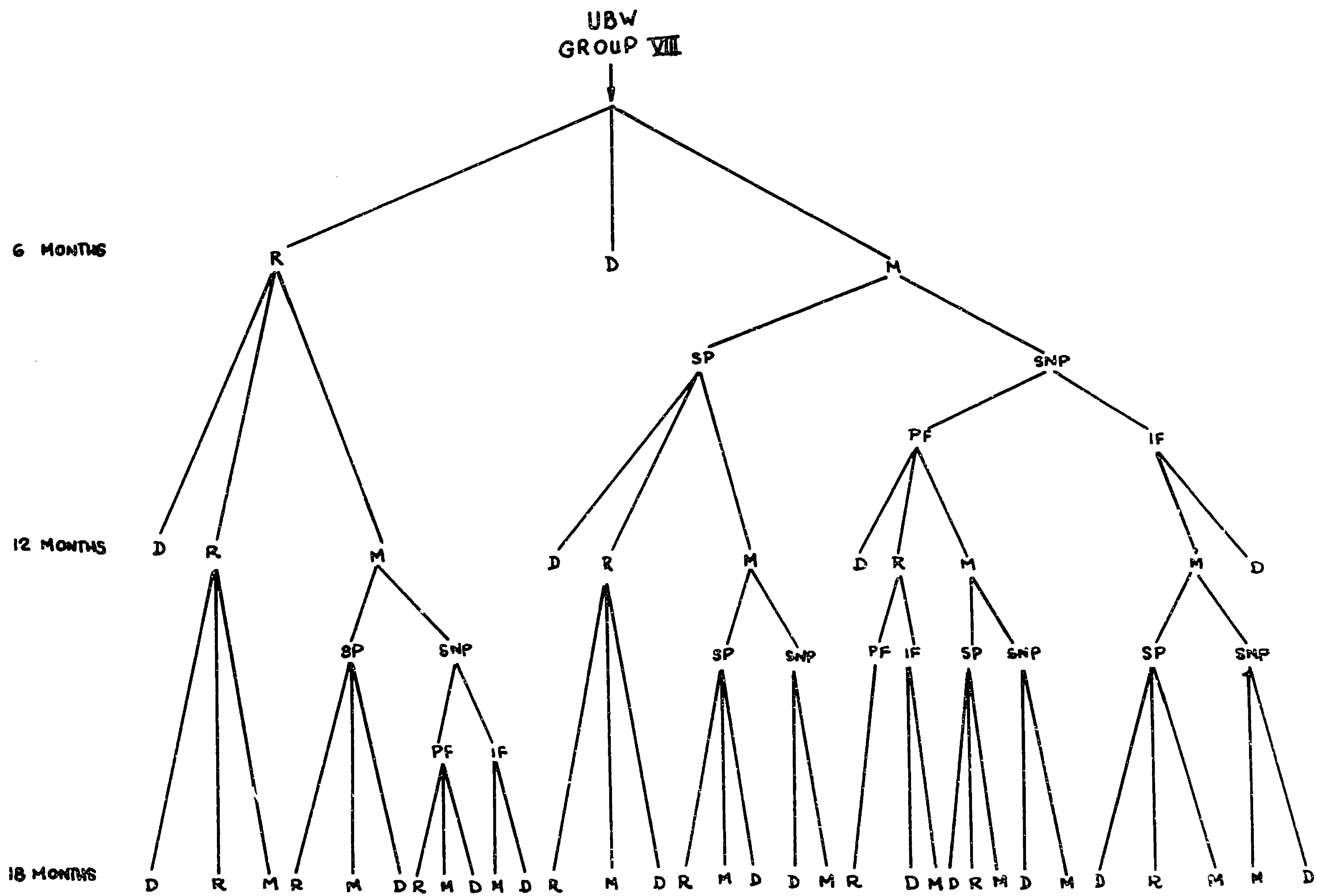


FIGURE 6 1

```
      REAL M1(7,4),MO(7,4),MS1(7,4),MSO(7,4),N1(7,4),NO(7,4)
      REAL NBW1,NBW3,NBW5,NBW7
      REAL M(8,4,2,4,3),M23130(2),M24140(2),M33120(2),M34120(2),M34130(2
     1),M43130(2),M44131(3),M44140(2),M53020(2),M54030(2),M63030(2),M640
     240(2),M73020(2),M74020(2),M74030(2),M83030(2),M84031(3),M84040(2),
     3MS(8,4,2,4,2),N(8,2,4)
      DIMENSION R1(7,4),RO(7,4),RS1(7,4),RSO(7,4),D1(7,4),DO(7,3),D1O(2)
     1,DOO(2),D1OTOT(7),DOOTOT(7)
      DIMENSION P01(1,2),P02(2,2),P03(4,3),P14(1,2),P15(2,2),P16(2,2),P1
     27(2,3),P24(1,3),P25(2,3),P26(4,3),P27(6,3),P28(5,3),P29(4,3)
      DIMENSION P34(1,3),P35(2,3),P36(4,3),P37(6,3),P38(7,3),P39(6,3),P4
     14(1,3),P45(2,3),P46(4,3),P47(6,3),P48(7,3),P49(6,3),P54(1,3),P55(2
     2,2),P56(4,3),P57(6,3),P58(7,3),P59(4,3)
      DIMENSION P64(1,3),P65(2,3),P66(4,3),P67(6,3),P68(5,3),P69(4,3),P7
     14(1,3),P75(2,3),P76(4,3),P77(6,3),P78(7,3),P79(6,3),P84(1,3),P85(4
     2,3),P86(4,3),P87(6,3),P88(7,3),P89(6,3)
      DIMENSION R84122(2),R84022(2),H24122(2),H24131(3),H34121(3),H44122
     1(2),H44131(3),H54021(3),H64022(2),H74021(3),H64022(2),H84031(3)
      DIMENSION R(8,4,2,2,3),R44122(2),R44022(2),RS(8,4,2,3,2),V24131(2)
     1,V24140(4),V34130(4),V44131(2),V44140(4),V54030(4),V64031(2),V6404
     20(4),V74030(4),V84031(2),V84040(4),D(8,2,3),H64031(3)
      DIMENSION D113(2),D212(4),D213(10),D312(4),D313(12),D412(4),D413(1
     12),D502(4),D503(9),D602(4),D603(10),D702(4),D703(12),D802(4),D803(
     212)
      READ(5,888)RC
  888 FORMAT(F10.2)
      READ(5,100)P01
  100 FORMAT(2F4.2)
      READ(5,101)((P02(I,J),J=1,2),I=1,2)
  101 FORMAT(4F4.2)
      READ(5,102)((P03(I,J),J=1,3),I=1,4)
  102 FORMAT(12F4.2)
      READ(5,100)P14
      READ(5,101)((P15(I,J),J=1,2),I=1,2)
      READ(5,101)((P16(I,J),J=1,2),I=1,2)
      READ(5,103)((P17(I,J),J=1,3),I=1,2)
```

```
103 FORMAT(6F4.2)                                           NUTR0037
    READ(5,104)P24                                          NUTR0038
104 FORMAT(3F4.2)                                           NUTR0039
    READ(5,103)((P25(I,J),J=1,3),I=1,2)                     NUTR0040
    READ(5,105)((P26(I,J),J=1,3),I=1,4)                     NUTR0041
105 FORMAT(12F4.2)                                          NUTR0042
    READ(5,106)((P27(I,J),J=1,3),I=1,6)                     NUTR0043
106 FORMAT(18F4.2)                                          NUTR0044
    READ(5,107)((P28(I,J),J=1,3),I=1,5)                     NUTR0045
107 FORMAT(15F4.2)                                          NUTR0046
    READ(5,105)((P29(I,J),J=1,3),I=1,4)                     NUTR0047
    READ(5,104)P34                                          NUTR0048
    READ(5,103)((P35(I,J),J=1,3),I=1,2)                     NUTR0049
    READ(5,105)((P36(I,J),J=1,3),I=1,4)                     NUTR0050
    READ(5,106)((P37(I,J),J=1,3),I=1,6)                     NUTR0051
108 FORMAT(20F4.2)                                          NUTR0052
    READ(5,108)((P38(I,J),J=1,3),I=1,7)                     NUTR0053
    READ(5,106)((P39(I,J),J=1,3),I=1,6)                     NUTR0054
    READ(5,104)P44                                          NUTR0055
    READ(5,103)((P45(I,J),J=1,3),I=1,2)                     NUTR0056
    READ(5,105)((P46(I,J),J=1,3),I=1,4)                     NUTR0057
    READ(5,106)((P47(I,J),J=1,3),I=1,6)                     NUTR0058
    READ(5,108)((P48(I,J),J=1,3),I=1,7)                     NUTR0059
    READ(5,106)((P49(I,J),J=1,3),I=1,6)                     NUTR0060
    READ(5,104)P54                                          NUTR0061
    READ(5,101)((P55(I,J),J=1,2),I=1,2)                     NUTR0062
    READ(5,105)((P56(I,J),J=1,3),I=1,4)                     NUTR0063
    READ(5,106)((P57(I,J),J=1,3),I=1,6)                     NUTR0064
    READ(5,108)((P58(I,J),J=1,3),I=1,7)                     NUTR0065
    READ(5,105)((P59(I,J),J=1,3),I=1,4)                     NUTR0066
    READ(5,104)P64                                          NUTR0067
    READ(5,103)((P65(I,J),J=1,3),I=1,2)                     NUTR0068
    READ(5,105)((P66(I,J),J=1,3),I=1,4)                     NUTR0069
    READ(5,106)((P67(I,J),J=1,3),I=1,6)                     NUTR0070
    READ(5,107)((P68(I,J),J=1,3),I=1,5)                     NUTR0071
    READ(5,105)((P69(I,J),J=1,3),I=1,4)                     NUTR0072
```

```
READ(5,104)P74
READ(5,103)((P75(I,J),J=1,3),I=1,2)
READ(5,105)((P76(I,J),J=1,3),I=1,4)
READ(5,106)((P77(I,J),J=1,3),I=1,6)
READ(5,108)((P78(I,J),J=1,3),I=1,7)
READ(5,106)((P79(I,J),J=1,3),I=1,6)
READ(5,104)P84
READ(5,103)((P85(I,J),J=1,3),I=1,2)
READ(5,105)((P86(I,J),J=1,3),I=1,4)
READ(5,106)((P87(I,J),J=1,3),I=1,6)
READ(5,108)((P88(I,J),J=1,3),I=1,7)
READ(5,106)((P89(I,J),J=1,3),I=1,6)
BETA=0.00001
DELTA=1.0
DO 699 K=1,7
NBW1=RC*P01(1,1)*P02(1,1)*P03(1,1)
UBW2=RC*P01(1,1)*P02(1,1)*P03(1,2)
NBW3=RC*P01(1,1)*P02(1,2)*P03(2,1)
UBW4=RC*P01(1,1)*P02(1,2)*P03(2,2)
NBW5=RC*P01(1,2)*P02(2,1)*P03(3,1)
UBW6=RC*P01(1,2)*P02(2,1)*P03(3,2)
NBW7=RC*P01(1,2)*P02(2,2)*P03(4,1)
UBW8=RC*P01(1,2)*P02(2,2)*P03(4,2)
D10(1)=RC*P01(1,1)*P02(1,1)*P03(1,3)
D10(2)=RC*P01(1,1)*P02(1,2)*P03(2,3)
D00(1)=RC*P01(1,2)*P02(2,1)*P03(3,3)
D00(2)=RC*P01(1,2)*P02(2,2)*P03(4,3)
N(1,1,2)=NBW1
N(1,1,3)=N(1,1,2)*P14(1,1)
M(1,3,1,1,3)=N(1,1,2)*P14(1,2)*P15(2,1)
D(1,1,2)=N(1,1,2)*P14(1,2)*P15(2,2)
N(1,1,4)=N(1,1,3)
RS(1,4,1,1,1)=M(1,3,1,1,3)*P16(2,1)*P17(1,1)
MS(1,4,1,2,2)=M(1,3,1,1,3)*P16(2,1)*P17(1,2)
M(1,4,1,2,3)=M(1,3,1,1,3)*P16(2,2)*P17(2,2)
D113(1)=M(1,3,1,1,3)*P16(2,1)*P17(1,3)
```

```
      D113(2)=M(1,3,1,1,3)*P16(2,2)*P17(2,1)                            NUTRO109
      D(1,1,3)=D113(1)+D113(2)                                          NUTRO110
      M(2,2,1,2,3)=UBW2*P24(1,3)                                        NUTRO111
      R(2,2,1,1,1)=UBW2*P24(1,1)                                        NUTRO112
      C(2,1,1)=UBW2*P24(1,2)                                            NUTRO113
      M(2,3,1,2,1)=R(2,2,1,1,1)*P25(1,3)                                NUTRO114
      M23130(1)=M(2,2,1,2,3)*P25(2,1)*P26(3,1)*P27(3,2)                 NUTRO115
      M23130(2)=M(2,2,1,2,3)*P25(2,1)*P26(3,2)*P27(4,2)                 NUTRO116
      M(2,3,1,3,3)=M23130(1)+M23130(2)                                  NUTRO117
      MS(2,3,1,3,2)=M(2,2,1,2,3)*P25(2,2)*P26(4,2)                      NUTRO118
      R(2,3,1,1,2)=R(2,2,1,1,1)*P25(1,2)                                NUTRO119
      R(2,3,1,2,1)=M(2,2,1,2,3)*P25(2,1)*P26(3,1)*P27(3,1)              NUTRO120
      RS(2,3,1,2,1)=M(2,2,1,2,3)*P25(2,2)*P26(4,1)                      NUTRO121
      D212(1)=R(2,2,1,1,1)*P25(1,1)                                     NUTRO122
      D212(2)=M(2,2,1,2,3)*P25(2,1)*P26(3,1)*P27(3,3)                   NUTRO123
      D212(3)=M(2,2,1,2,3)*P25(2,1)*P26(3,2)*P27(4,1)                   NUTRO124
      D212(4)=M(2,2,1,2,3)*P25(2,2)*P26(4,3)                            NUTRO125
      D(2,1,2)=0.0                                                      NUTRO126
      DO 850 I=1,4                                                      NUTRO127
      D(2,1,2)=D(2,1,2)+D212(I)                                         NUTRO128
  850 CONTINUE                                                          NUTRO129
      M(2,4,1,2,2)=R(2,3,1,1,2)*P26(1,2)                                NUTRO130
      M(2,4,1,3,1)=M(2,3,1,2,1)*P26(2,1)*P27(1,2)                       NUTRO131
      M24140(1)=M23130(1)*P28(2,1)*P29(1,2)                             NUTRO132
      M24140(2)=M23130(2)*P28(3,2)*P29(4,2)                             NUTRO133
      M(2,4,1,4,3)=M24140(1)+M24140(2)                                  NUTRO134
      V24131(1)=M(2,3,1,2,1)*P26(2,2)*P27(2,3)                          NUTRO135
      V24131(2)=RS(2,3,1,2,1)*P27(5,2)                                  NUTRO136
      MS(2,4,1,3,1)=V24131(1)+V24131(2)                                 NUTRO137
      V24140(1)=M23130(1)*P28(2,2)*P29(2,3)                             NUTRO138
      V24140(2)=M23130(2)*P28(3,1)*P29(3,3)                             NUTRO139
      V24140(3)=MS(2,3,1,3,2)*P27(6,1)*P28(4,3)                         NUTRO140
      V24140(4)=MS(2,3,1,3,2)*P27(6,2)*P28(5,2)                         NUTRO141
      MS(2,4,1,4,2)=0.0                                                 NUTRO142
      DO 200 I=1,4                                                      NUTRO143
      MS(2,4,1,4,2)=MS(2,4,1,4,2)+V24140(I)                             NUTRO144
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200 CONTINUE                                                          NUTRO145
    R(2,4,1,1,3)=R(2,3,1,1,2)*P26(1,3)                                NUTRO146
    R(2,4,1,2,2)=R(2,3,1,2,1)                                         NUTRO147
    H24122(1)=M(2,3,1,2,1)*P26(2,2)*P27(2,2)                          NUTRO148
    H24122(2)=RS(2,3,1,2,1)*P27(5,1)                                  NUTRO149
    RS(2,4,1,2,2)=H24122(1)+H24122(2)                                 NUTRO150
    H24131(1)=M23130(1)*P28(2,2)*P29(2,2)                             NUTRO151
    H24131(2)=M23130(2)*P28(3,1)*P29(3,2)                             NUTRO152
    H24131(3)=MS(2,3,1,3,2)*P27(6,1)*P28(4,1)                         NUTRO153
    RS(2,4,1,3,1)=H24131(1)+H24131(2)+H24131(3)                       NUTRO154
    D213(1)=R(2,3,1,1,2)*P26(1,1)                                     NUTRO155
    D213(2)=M(2,3,1,2,1)*P26(2,1)*P27(1,1)                            NUTRO156
    D213(3)=M(2,3,1,2,1)*P26(2,2)*P27(2,1)                            NUTRO157
    D213(4)=M23130(1)*P28(2,1)*P29(1,1)                               NUTRO158
    D213(5)=M23130(1)*P28(2,2)*P29(2,1)                               NUTRO159
    D213(6)=M23130(2)*P28(3,1)*P29(3,1)                               NUTRO160
    D213(7)=M23130(2)*P28(3,2)*P29(4,1)                               NUTRO161
    D213(8)=RS(2,3,1,2,1)*P27(5,3)                                    NUTRO162
    D213(9)=MS(2,3,1,3,2)*P27(6,1)*P28(4,2)                           NUTRO163
    D213(10)=MS(2,3,1,3,2)*P27(6,2)*P28(5,1)                          NUTRO164
    D(2,1,3)=0.0                                                      NUTRO165
    DO 300 I=1,10                                                     NUTRO166
    D(2,1,3)=D(2,1,3)+D213(I)                                         NUTRO167
300 CONTINUE                                                          NUTRO168
    M(3,2,1,1,3)=NBW3*P34(1,3)                                        NUTRO169
    N(3,1,2)=NBW3*P34(1,1)                                            NUTRO170
    D(3,1,1)=NBW3*P34(1,2)                                            NUTRO171
    M(3,3,1,1,3)=N(3,1,2)*P35(1,3)                                    NUTRO172
    M33120(1)=M(3,2,1,1,3)*P35(2,2)*P36(4,1)*P37(5,3)                 NUTRO173
    M33120(2)=M(3,2,1,1,3)*P35(2,2)*P36(4,2)*P37(6,1)                 NUTRO174
    M(3,3,1,2,3)=M33120(1)+M33120(2)                                  NUTRO175
    MS(3,3,1,2,2)=M(3,2,1,1,3)*P35(2,1)*P36(3,3)                      NUTRO176
    R(3,3,1,1,1)=M(3,2,1,1,3)*P35(2,2)*P36(4,1)*P37(5,2)              NUTRO177
    RS(3,3,1,1,1)=M(3,2,1,1,3)*P35(2,1)*P36(3,2)                      NUTRO178
    D312(1)=N(3,1,2)*P35(1,1)                                         NUTRO179
    D312(2)=M(3,2,1,1,3)*P35(2,1)*P36(3,1)                            NUTRO180
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      D312(3)=M(3,2,1,1,3)*P35(2,2)*P36(4,1)*P37(5,1)                       NUTRO181
      D312(4)=M(3,2,1,1,3)*P35(2,2)*P36(4,2)*P37(6,2)                       NUTRO182
      D(3,1,2)=0.0                                                          NUTRO183
      DO 400 I=1,4                                                          NUTRO184
      D(3,1,2)=D(3,1,2)+D312(I)                                             NUTRO185
  400 CONTINUE                                                              NUTRO186
      N(3,1,3)=N(3,1,2)*P35(1,2)                                            NUTRO187
      N(3,1,4)=N(3,1,3)*P36(1,2)                                            NUTRO188
      M(3,4,1,1,3)=N(3,1,3)*P36(1,3)                                        NUTRO189
      M(3,4,1,2,1)=R(3,3,1,1,1)*P38(5,2)*P39(2,2)                           NUTRO190
      M34120(1)=M(3,3,1,1,3)*P36(2,2)*P37(2,1)*P38(1,2)                     NUTRO191
      M34120(2)=M(3,3,1,1,3)*P36(2,2)*P37(2,2)*P38(2,1)                     NUTRO192
      M(3,4,1,2,3)=M34120(1)+M34120(2)                                      NUTRO193
      M34130(1)=M33120(1)*P38(6,2)*P39(4,2)                                 NUTRO194
      M34130(2)=M33120(2)*P38(7,2)*P39(6,1)                                 NUTRO195
      M(3,4,1,3,3)=M34130(1)+M34130(2)                                      NUTRO196
      MS(3,4,1,2,2)=M(3,3,1,1,3)*P36(2,1)*P37(1,2)                          NUTRO197
      MS(3,4,1,2,1)=RS(3,3,1,1,1)*P37(3,3)                                  NUTRO198
      V34130(1)=MS(3,3,1,2,2)*P37(4,1)*P38(3,2)                             NUTRO199
      V34130(2)=MS(3,3,1,2,2)*P37(4,2)*P38(4,2)                             NUTRO200
      V34130(3)=M33120(1)*P38(6,1)*P39(3,2)                                 NUTRO201
      V34130(4)=M33120(2)*P38(7,1)*P39(5,2)                                 NUTRO202
      MS(3,4,1,3,2)=0.0                                                     NUTRO203
      DO 500 I=1,4                                                          NUTRO204
      MS(3,4,1,3,2)=MS(3,4,1,3,2)+V34130(I)                                 NUTRO205
  500 CONTINUE                                                              NUTRO206
      D313(1)=N(3,1,3)*P36(1,1)                                             NUTRO207
      D313(2)=M(3,3,1,1,3)*P36(2,1)*P37(1,3)                                NUTRO208
      D313(3)=M(3,3,1,1,3)*P36(2,2)*P37(2,1)*P38(1,3)                       NUTRO209
      D313(4)=M(3,3,1,1,3)*P36(2,2)*P37(2,2)*P38(2,2)                       NUTRO210
      D313(5)=RS(3,3,1,1,1)*P37(3,2)                                        NUTRO211
      D313(6)=MS(3,3,1,2,2)*P37(4,1)*P38(3,3)                               NUTRO212
      D313(7)=MS(3,3,1,2,2)*P37(4,2)*P38(4,1)                               NUTRO213
      D313(8)=R(3,3,1,1,1)*P38(5,2)*P39(2,1)                                NUTRO214
      D313(9)=M33120(1)*P38(6,1)*P39(3,3)                                   NUTRO215
      D313(10)=M33120(1)*P38(6,2)*P39(4,1)                                  NUTRO216
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      D313(11)=M33120(2)*P38(7,1)*P39(5,1)                              NUTRO217
      D313(12)=M33120(2)*P38(7,2)*P39(6,2)                              NUTRO218
      D(3,1,3)=0.0                                                      NUTRO219
      DO 600 I=1,12                                                     NUTRO220
      D(3,1,3)=D(3,1,3)+D313(I)                                         NUTRO221
  600 CONTINUE                                                          NUTRO222
      R(3,4,1,1,1)=M(3,3,1,1,3)*P36(2,2)*P37(2,1)*P38(1,1)              NUTRO223
      R(3,4,1,1,2)=R(3,3,1,1,1)*P38(5,1)*P39(1,1)                       NUTRO224
      RS(3,4,1,1,1)=M(3,3,1,1,3)*P36(2,1)*P37(1,1)                      NUTRO225
      RS(3,4,1,1,2)=RS(3,3,1,1,1)*P37(3,1)                              NUTRO226
      H34121(1)=MS(3,3,1,2,2)*P37(4,1)*P38(3,1)                         NUTRO227
      H34121(2)=M33120(1)*P38(6,1)*P39(3,1)                             NUTRO228
      H34121(3)=M33120(2)*P38(7,1)*P39(5,3)                             NUTRO229
      RS(3,4,1,2,1)=H34121(1)+H34121(2)+H34121(3)                       NUTRO230
      M(4,2,1,2,3)=UBW4*P44(1,3)                                        NUTRO231
      R(4,2,1,1,1)=UBW4*P44(1,1)                                        NUTRO232
      D(4,1,1)=UBW4*P44(1,2)                                            NUTRO233
      M(4,3,1,2,1)=R(4,2,1,1,1)*P45(1,3)                                NUTRO234
      M43130(1)=M(4,2,1,2,3)*P45(2,2)*P46(4,1)*P47(5,3)                 NUTRO235
      M43130(2)=M(4,2,1,2,3)*P45(2,2)*P46(4,2)*P47(6,1)                 NUTRO236
      M(4,3,1,3,3)=M43130(1)+M43130(2)                                  NUTRO237
      MS(4,3,1,3,2)=M(4,2,1,2,3)*P45(2,1)*P46(3,3)                      NUTRO238
      R(4,3,1,1,2)=R(4,2,1,1,1)*P45(1,2)                                NUTRO239
      R(4,3,1,2,1)=M(4,2,1,2,3)*P45(2,2)*P46(4,1)*P47(5,2)              NUTRO240
      RS(4,3,1,2,1)=M(4,2,1,2,3)*P45(2,1)*P46(3,2)                      NUTRO241
      D412(1)=R(4,2,1,1,1)*P45(1,1)                                     NUTRO242
      D412(2)=M(4,2,1,2,3)*P45(2,1)*P46(3,1)                            NUTRO243
      D412(3)=M(4,2,1,2,3)*P45(2,2)*P46(4,1)*P47(5,1)                   NUTRO244
      D412(4)=M(4,2,1,2,3)*P45(2,2)*P46(4,2)*P47(6,2)                   NUTRO245
      D(4,1,2)=0.0                                                      NUTRO246
      DO 700 I=1,4                                                      NUTRO247
      D(4,1,2)=D(4,1,2)+D412(I)                                         NUTRO248
  700 CONTINUE                                                          NUTRO249
      M(4,4,1,2,2)=R(4,3,1,1,2)*P46(1,3)                                NUTRO250
      M44131(1)=M(4,3,1,2,1)*P46(2,2)*P47(2,1)*P48(1,2)                 NUTRO251
      M44131(2)=M(4,3,1,2,1)*P46(2,2)*P47(2,2)*P48(2,1)                 NUTRO252
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      M44131(3)=R(4,3,1,2,1)*P48(5,2)*P49(2,2)                          NUTRO253
      M(4,4,1,3,1)=M44131(1)+M44131(2)+M44131(3)                        NUTRO254
      M44140(1)=M43130(1)*P48(6,2)*P49(4,2)                             NUTRO255
      M44140(2)=M43130(2)*P48(7,2)*P49(6,1)                             NUTRO256
      M(4,4,1,4,3)=M44140(1)+M44140(2)                                  NUTRO257
      V44131(1)=M(4,3,1,2,1)*P46(2,1)*P47(1,2)                          NUTRO258
      V44131(2)=RS(4,3,1,2,1)*P47(3,2)                                  NUTRO259
      MS(4,4,1,3,1)=V44131(1)+V44131(2)                                 NUTRO260
      V44140(1)=MS(4,3,1,3,2)*P47(4,1)*P48(3,2)                         NUTRO261
      V44140(2)=MS(4,3,1,3,2)*P47(4,2)*P48(4,2)                         NUTRO262
      V44140(3)=M43130(1)*P48(6,1)*P49(3,3)                             NUTRO263
      V44140(4)=M43130(2)*P48(7,1)*P49(5,3)                             NUTRO264
      MS(4,4,1,4,2)=0.0                                                 NUTRO265
      DO 800 I=1,4                                                      NUTRO266
      MS(4,4,1,4,2)=MS(4,4,1,4,2)+V44140(I)                             NUTRO267
  800 CONTINUE                                                          NUTRO268
      R(4,4,1,1,3)=R(4,3,1,1,2)*P46(1,2)                                NUTRO269
      R44122(1)=M(4,3,1,2,1)*P46(2,2)*P47(2,1)*P48(1,1)                 NUTRO270
      R44122(2)=R(4,3,1,2,1)*P48(5,1)*P49(1,1)                          NUTRO271
      R(4,4,1,2,2)=R44122(1)+R44122(2)                                  NUTRO272
      H44122(1)=M(4,3,1,2,1)*P46(2,1)*P47(1,1)                          NUTRO273
      H44122(2)=RS(4,3,1,2,1)*P47(3,1)                                  NUTRO274
      RS(4,4,1,2,2)=H44122(1)+H44122(2)                                 NUTRO275
      H44131(1)=MS(4,3,1,3,2)*P47(4,1)*P48(3,1)                         NUTRO276
      H44131(2)=M43130(1)*P48(6,1)*P49(3,2)                             NUTRO277
      H44131(3)=M43130(2)*P48(7,1)*P49(5,2)                             NUTRO278
      RS(4,4,1,3,1)=H44131(1)+H44131(2)+H44131(3)                       NUTRO279
      D413(1)=R(4,3,1,1,2)*P46(1,1)                                     NUTRO280
      D413(2)=M(4,3,1,2,1)*P46(2,1)*P47(1,3)                            NUTRO281
      D413(3)=M(4,3,1,2,1)*P46(2,2)*P47(2,1)*P48(1,3)                   NUTRO282
      D413(4)=M(4,3,1,2,1)*P46(2,2)*P47(2,2)*P48(2,2)                   NUTRO283
      D413(5)=RS(4,3,1,2,1)*P47(3,3)                                    NUTRO284
      D413(6)=MS(4,3,1,3,2)*P47(4,1)*P48(3,3)                           NUTRO285
      D413(7)=MS(4,3,1,3,2)*P47(4,2)*P48(4,1)                           NUTRO286
      D413(8)=R(4,3,1,2,1)*P48(5,2)*P49(2,1)                            NUTRO287
      D413(9)=M43130(1)*P48(6,1)*P49(3,1)                               NUTRO288
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      D413(10)=M43130(1)*P48(6,2)*P49(4,1)                              NUTR0289
      D413(11)=M43130(2)*P48(7,1)*P49(5,1)                              NUTR0290
      D413(12)=M43130(2)*P48(7,2)*P49(6,2)                              NUTR0291
      D(4,1,3)=0.0                                                      NUTR0292
      DO 900 I=1,12                                                     NUTR0293
      D(4,1,3)=D(4,1,3)+D413(I)                                         NUTR0294
  900 CONTINUE                                                          NUTR0295
      M(5,2,2,1,3)=NBW5*P54(1,1)                                        NUTR0296
      N(5,2,2)=NBW5*P54(1,3)                                            NUTR0297
      D(5,2,1)=NBW5*P54(1,2)                                            NUTR0298
      M(5,3,2,1,3)=N(5,2,2)*P55(2,2)*P56(4,2)                           NUTR0299
      M53020(1)=M(5,2,2,1,3)*P55(1,2)*P56(2,1)*P57(3,1)                 NUTR0300
      M53020(2)=M(5,2,2,1,3)*P55(1,2)*P56(2,2)*P57(4,1)                 NUTR0301
      M(5,3,2,2,3)=M53020(1)+M53020(2)                                  NUTR0302
      MS(5,3,2,2,2)=M(5,2,2,1,3)*P55(1,1)*P56(1,2)                      NUTR0303
      R(5,3,2,1,1)=M(5,2,2,1,3)*P55(1,2)*P56(2,1)*P57(3,2)              NUTR0304
      RS(5,3,2,1,1)=M(5,2,2,1,3)*P55(1,1)*P56(1,1)                      NUTR0305
      D502(1)=M(5,2,2,1,3)*P55(1,1)*P56(1,3)                            NUTR0306
      D502(2)=M(5,2,2,1,3)*P55(1,2)*P56(2,1)*P57(3,3)                   NUTR0307
      D502(3)=M(5,2,2,1,3)*P55(1,2)*P56(2,2)*P57(4,2)                   NUTR0308
      D502(4)=N(5,2,2)*P55(2,2)*P56(4,1)                                NUTR0309
      D(5,2,2)=0.0                                                      NUTR0310
      DO 901 I=1,4                                                      NUTR0311
      D(5,2,2)=D(5,2,2)+D502(I)                                         NUTR0312
  901 CONTINUE                                                          NUTR0313
      N(5,2,3)=N(5,2,2)*P55(2,1)*P56(3,1)                               NUTR0314
      N(5,2,4)=N(5,2,3)                                                 NUTR0315
      M(5,4,2,2,1)=R(5,3,2,1,1)*P58(4,1)                                NUTR0316
      M(5,4,2,2,3)=M(5,3,2,1,3)*P57(6,2)*P58(7,2)                       NUTR0317
      M54030(1)=M53020(1)*P58(3,2)*P59(2,2)                             NUTR0318
      M54030(2)=M53020(2)*P58(5,2)*P59(4,2)                             NUTR0319
      M(5,4,2,3,3)=M54030(1)+M54030(2)                                  NUTR0320
      MS(5,4,2,2,1)=RS(5,3,2,1,1)*P57(1,2)                              NUTR0321
      MS(5,4,2,2,2)=M(5,3,2,1,3)*P57(6,1)*P58(6,2)                      NUTR0322
      V54030(1)=MS(5,3,2,2,2)*P57(2,1)*P58(1,2)                         NUTR0323
      V54030(2)=MS(5,3,2,2,2)*P57(2,2)*P58(2,1)                         NUTR0324
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      V54030(3)=M53020(1)*P58(3,1)*P59(1,3)                             NUTR0325
      V54030(4)=M53020(2)*P58(5,1)*P59(3,2)                             NUTR0326
      MS(5,4,2,3,2)=0.0                                                 NUTR0327
      DO 902 I=1,4                                                      NUTR0328
      MS(5,4,2,3,2)=MS(5,4,2,3,2)+V54030(I)                             NUTR0329
  902 CONTINUE                                                          NUTR0330
      R(5,4,2,1,2)=R(5,3,2,1,1)*P58(4,2)                                NUTR0331
      RS(5,4,2,1,2)=RS(5,3,2,1,1)*P57(1,1)                              NUTR0332
      RS(5,4,2,1,1)=M(5,3,2,1,3)*P57(6,1)*P58(6,1)                      NUTR0333
      H54021(1)=MS(5,3,2,2,2)*P57(2,1)*P58(1,1)                         NUTR0334
      H54021(2)=M53020(1)*P58(3,1)*P59(1,2)                             NUTR0335
      H54021(3)=M53020(2)*P58(5,1)*P59(3,3)                             NUTR0336
      RS(5,4,2,2,1)=H54021(1)+H54021(2)+H54021(3)                       NUTR0337
      D503(1)=RS(5,3,2,1,1)*P57(1,3)                                    NUTR0338
      D503(2)=MS(5,3,2,2,2)*P57(2,1)*P58(1,3)                           NUTR0339
      D503(3)=MS(5,3,2,2,2)*P57(2,2)*P58(2,2)                           NUTR0340
      D503(4)=M53020(1)*P58(3,1)*P59(1,1)                               NUTR0341
      D503(5)=M53020(1)*P58(3,2)*P59(2,1)                               NUTR0342
      D503(6)=M53020(2)*P58(5,1)*P59(3,1)                               NUTR0343
      D503(7)=M53020(2)*P58(5,2)*P59(4,1)                               NUTR0344
      D503(8)=M(5,3,2,1,3)*P57(6,1)*P58(6,3)                            NUTR0345
      D503(9)=M(5,3,2,1,3)*P57(6,2)*P58(7,1)                            NUTR0346
      D(5,2,3)=0.0                                                      NUTR0347
      DO 903 I=1,9                                                      NUTR0348
      D(5,2,3)=D(5,2,3)+D503(I)                                         NUTR0349
  903 CONTINUE                                                          NUTR0350
      M(6,2,2,2,3)=UBW6*P64(1,3)                                        NUTR0351
      R(6,2,2,1,1)=UBW6*P64(1,1)                                        NUTR0352
      D(6,2,1)=UBW6*P64(1,2)                                            NUTR0353
      M(6,3,2,2,1)=R(6,2,2,1,1)*P65(1,3)                                NUTR0354
      M63030(1)=M(6,2,2,2,3)*P65(2,1)*P66(3,1)*P67(3,2)                 NUTR0355
      M63030(2)=M(6,2,2,2,3)*P65(2,1)*P66(3,2)*P67(4,2)                 NUTR0356
      M(6,3,2,3,3)=M63030(1)+M63030(2)                                  NUTR0357
      MS(6,3,2,3,2)=M(6,2,2,2,3)*P65(2,2)*P66(4,2)                      NUTR0358
      R(6,3,2,1,2)=R(6,2,2,1,1)*P65(1,2)                                NUTR0359
      R(6,3,2,2,1)=M(6,2,2,2,3)*P65(2,1)*P66(3,1)*P67(3,1)              NUTR0360
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      RS(6,3,2,2,1)=M(6,2,2,2,3)*P65(2,2)*P66(4,1)
      D602(1)=R(6,2,2,1,1)*P65(1,1)
      D602(2)=M(6,2,2,2,3)*P65(2,1)*P66(3,1)*P67(3,3)
      D602(3)=M(6,2,2,2,3)*P65(2,1)*P66(3,2)*P67(4,1)
      D602(4)=M(6,2,2,2,3)*P65(2,2)*P66(4,3)
      D(6,2,2)=0.0
      DO 731 I=1,4
      D(6,2,2)=D(6,2,2)+D602(I)
  731 CONTINUE
      M(6,4,2,2,2)=R(6,3,2,1,2)*P66(1,2)
      M(6,4,2,3,1)=M(6,3,2,2,1)*P66(2,1)*P67(1,2)
      M64040(1)=M63030(1)*P68(2,1)*P69(1,2)
      M64040(2)=M63030(2)*P68(3,2)*P69(4,2)
      M(6,4,2,4,3)=M64040(1)+M64040(2)
      V64031(1)=M(6,3,2,2,1)*P66(2,2)*P67(2,3)
      V64031(2)=RS(6,3,2,2,1)*P67(5,2)
      MS(6,4,2,3,1)=V64031(1)+V64031(2)
      V64040(1)=M63030(1)*P68(2,2)*P69(2,3)
      V64040(2)=M63030(2)*P68(3,1)*P69(3,3)
      V64040(3)=MS(6,3,2,3,2)*P67(6,1)*P68(4,3)
      V64040(4)=MS(6,3,2,3,2)*P67(6,2)*P68(5,2)
      MS(6,4,2,4,2)=0.0
      DO 732 I=1,4
      MS(6,4,2,4,2)=MS(6,4,2,4,2)+V64040(I)
  732 CONTINUE
      R(6,4,2,1,3)=R(6,3,2,1,2)*P66(1,3)
      R(6,4,2,2,2)=R(6,3,2,2,1)
      H64022(1)=M(6,3,2,2,1)*P66(2,2)*P67(2,2)
      H64022(2)=RS(6,3,2,2,1)*P67(5,1)
      RS(6,4,2,2,2)=H64022(1)+H64022(2)
      H64031(1)=M63030(1)*P68(2,2)*P69(2,2)
      H64031(2)=M63030(2)*P68(3,1)*P69(3,2)
      H64031(3)=MS(6,3,2,3,2)*P67(6,1)*P68(4,1)
      RS(6,4,2,3,1)=H64031(1)+H64031(2)+H64031(3)
      D603(1)=R(6,3,2,1,2)*P66(1,1)
      D603(2)=M(6,3,2,2,1)*P66(2,1)*P67(1,1)
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      D603(3)=M(6,3,2,2,1)*P66(2,2)*P67(2,1)                            NUTR0397
      D603(4)=M63030(1)*P68(2,1)*P69(1,1)                               NUTR0398
      D603(5)=M63030(1)*P68(2,2)*P69(2,1)                               NUTR0399
      D603(6)=M63030(2)*P68(3,1)*P69(3,1)                               NUTR0400
      D603(7)=M63030(2)*P68(3,2)*P69(4,1)                               NUTR0401
      D603(8)=RS(6,3,2,2,1)*P67(5,3)                                    NUTR0402
      D603(9)=MS(6,3,2,3,2)*P67(6,1)*P68(4,2)                           NUTR0403
      D603(10)=MS(6,3,2,3,2)*P67(6,2)*P68(5,1)                          NUTR0404
      D(6,2,3)=0.0                                                      NUTR0405
      DO 381 I=1,10                                                     NUTR0406
      D(6,2,3)=D(6,2,3)+D603(I)                                         NUTR0407
  381 CONTINUE                                                          NUTR0408
      M(7,2,2,1,3)=NBW7*P74(1,3)                                        NUTR0409
      N(7,2,2)=NBW7*P74(1,1)                                            NUTR0410
      D(7,2,1)=NBW7*P74(1,2)                                            NUTR0411
      M(7,3,2,1,3)=N(7,2,2)*P75(1,3)                                    NUTR0412
      M73020(1)=M(7,2,2,1,3)*P75(2,2)*P76(4,1)*P77(5,3)                 NUTR0413
      M73020(2)=M(7,2,2,1,3)*P75(2,2)*P76(4,2)*P77(6,1)                 NUTR0414
      M(7,3,2,2,3)=M73020(1)+M73020(2)                                  NUTR0415
      MS(7,3,2,2,2)=M(7,2,2,1,3)*P75(2,1)*P76(3,3)                      NUTR0416
      R(7,3,2,1,1)=M(7,2,2,1,3)*P75(2,2)*P76(4,1)*P77(5,2)              NUTR0417
      RS(7,3,2,1,1)=M(7,2,2,1,3)*P75(2,1)*P76(3,2)                      NUTR0418
      D702(1)=N(7,2,2)*P75(1,1)                                         NUTR0419
      D702(2)=M(7,2,2,1,3)*P75(2,1)*P76(3,1)                            NUTR0420
      D702(3)=M(7,2,2,1,3)*P75(2,2)*P76(4,1)*P77(5,1)                   NUTR0421
      D702(4)=M(7,2,2,1,3)*P75(2,2)*P76(4,2)*P77(6,2)                   NUTR0422
      D(7,2,2)=0.0                                                      NUTR0423
      DO 401 I=1,4                                                      NUTR0424
      D(7,2,2)=D(7,2,2)+D702(I)                                         NUTR0425
  401 CONTINUE                                                          NUTR0426
      N(7,2,3)=N(7,2,2)*P75(1,2)                                        NUTR0427
      N(7,2,4)=N(7,2,3)*P76(1,2)                                        NUTR0428
      M(7,4,2,1,3)=N(7,2,3)*P76(1,3)                                    NUTR0429
      M(7,4,2,2,1)=R(7,3,2,1,1)*P78(5,2)*P79(2,2)                       NUTR0430
      M74020(1)=M(7,3,2,1,3)*P76(2,2)*P77(2,1)*P78(1,2)                 NUTR0431
      M74020(2)=M(7,3,2,1,3)*P76(2,2)*P77(2,2)*P78(2,1)                 NUTR0432
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      M(7,4,2,2,3)=M74020(1)+M74020(2)                                  NUTR0433
      M74030(1)=M73020(1)*P78(6,2)*P79(4,2)                             NUTR0434
      M74030(2)=M73020(2)*P78(7,2)*P79(6,1)                             NUTR0435
      M(7,4,2,3,3)=M74030(1)+M74030(2)                                  NUTR0436
      MS(7,4,2,2,2)=M(7,3,2,1,3)*P76(2,1)*P77(1,2)                      NUTR0437
      MS(7,4,2,2,1)=RS(7,3,2,1,1)*P77(3,3)                              NUTR0438
      V74030(1)=MS(7,3,2,2,2)*P77(4,1)*P78(3,2)                         NUTR0439
      V74030(2)=MS(7,3,2,2,2)*P77(4,2)*P78(4,2)                         NUTR0440
      V74030(3)=M73020(1)*P78(6,1)*P79(3,2)                             NUTR0441
      V74030(4)=M73020(2)*P78(7,1)*P79(5,2)                             NUTR0442
      MS(7,4,2,3,2)=0.0                                                 NUTR0443
      DO 501 I=1,4                                                      NUTR0444
      MS(7,4,2,3,2)=MS(7,4,2,3,2)+V74030(I)                             NUTR0445
  501 CONTINUE                                                          NUTR0446
      D703(1)=N(7,2,3)*P76(1,1)                                         NUTR0447
      D703(2)=M(7,3,2,1,3)*P76(2,1)*P77(1,3)                            NUTR0448
      D703(3)=M(7,3,2,1,3)*P76(2,2)*P77(2,1)*P78(1,3)                   NUTR0449
      D703(4)=M(7,3,2,1,3)*P76(2,2)*P77(2,2)*P78(2,2)                   NUTR0450
      D703(5)=RS(7,3,2,1,1)*P77(3,2)                                    NUTR0451
      D703(6)=MS(7,3,2,2,2)*P77(4,1)*P78(3,3)                           NUTR0452
      D703(7)=MS(7,3,2,2,2)*P77(4,2)*P78(4,1)                           NUTR0453
      D703(8)=R(7,3,2,1,1)*P78(5,2)*P79(2,1)                            NUTR0454
      D703(9)=M73020(1)*P78(6,1)*P79(3,3)                               NUTR0455
      D703(10)=M73020(1)*P78(6,2)*P79(4,1)                              NUTR0456
      D703(11)=M73020(2)*P78(7,1)*P79(5,1)                              NUTR0457
      D703(12)=M73020(2)*P78(7,2)*P79(6,2)                              NUTR0458
      D(7,2,3)=0.0                                                      NUTR0459
      DO 601 I=1,12                                                     NUTR0460
      D(7,2,3)=D(7,2,3)+D703(I)                                         NUTR0461
  601 CONTINUE                                                          NUTR0462
      R(7,4,2,1,1)=M(7,3,2,1,3)*P76(2,2)*P77(2,1)*P78(1,1)              NUTR0463
      R(7,4,2,1,2)=R(7,3,2,1,1)*P78(5,1)*P79(1,1)                       NUTR0464
      RS(7,4,2,1,1)=M(7,3,2,1,3)*P76(2,1)*P77(1,1)                      NUTR0465
      RS(7,4,2,1,2)=RS(7,3,2,1,1)*P77(3,1)                              NUTR0466
      H74021(1)=MS(7,3,2,2,2)*P77(4,1)*P78(3,1)                         NUTR0467
      H74021(2)=M73020(1)*P78(6,1)*P79(3,1)                             NUTR0468
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      H74021(3)=M73020(2)*P78(7,1)*P79(5,3)                           NUTR0469
      RS(7,4,2,2,1)=H74021(1)+H74021(2)+H74021(3)                     NUTR0470
      M(8,2,2,2,3)=UBW8*P84(1,3)                                      NUTR0471
      R(8,2,2,1,1)=UBW8*P84(1,1)                                      NUTR0472
      D(8,2,1)=UBW8*P84(1,2)                                          NUTR0473
      M(8,3,2,2,1)=R(8,2,2,1,1)*P85(1.3)                              NUTR0474
      M83030(1)=M(8,2,2,2,3)*P85(2,2)*P86(4,1)*P87(5,3)               NUTR0475
      M83030(2)=M(8,2,2,2,3)*P85(2,2)*P86(4,2)*P87(6,1)               NUTR0476
      M(8,3,2,3,3)=M83030(1)+M83030(2)                                NUTR0477
      MS(8,3,2,3,2)=M(8,2,2,2,3)*P85(2,1)*P86(3,3)                    NUTR0478
      R(8,3,2,1,2)=R(8,2,2,1,1)*P85(1,2)                              NUTR0479
      R(8,3,2,2,1)=M(8,2,2,2,3)*P85(2,2)*P86(4,1)*P87(5,2)            NUTR0480
      RS(8,3,2,2,1)=M(8,2,2,2,3)*P85(2,1)*P86(3,2)                    NUTR0481
      D802(1)=R(8,2,2,1,1)*P85(1,1)                                   NUTR0482
      D802(2)=M(8,2,2,2,3)*P85(2,1)*P86(3,1)                          NUTR0483
      D802(3)=M(8,2,2,2,3)*P85(2,2)*P86(4,1)*P87(5,1)                 NUTR0484
      D802(4)=M(8,2,2,2,3)*P85(2,2)*P86(4,2)*P87(6,2)                 NUTR0485
      D(8,2,2)=0.0                                                    NUTR0486
      DO 701 I=1,4                                                    NUTR0487
      D(8,2,2)=D(8,2,2)+D802(I)                                       NUTR0488
  701 CONTINUE                                                        NUTR0489
      M(8,4,2,2,2)=R(8,3,2,1,2)*P86(1,3)                              NUTR0490
      M84031(1)=M(8,3,2,2,1)*P86(2,2)*P87(2,1)*P88(1,2)               NUTR0491
      M84031(2)=M(8,3,2,2,1)*P86(2,2)*P87(2,2)*P88(2,1)               NUTR0492
      M84031(3)=R(8,3,2,2,1)*P88(5,2)*P89(2,2)                        NUTR0493
      M(8,4,2,3,1)=M84031(1)+M84031(2)+M84031(3)                      NUTR0494
      M84040(1)=M83030(1)*P88(6,2)*P89(4,2)                           NUTR0495
      M84040(2)=M83030(2)*P88(7,2)*P89(6,1)                           NUTR0496
      M(8,4,2,4,3)=M84040(1)+M84040(2)                                NUTR0497
      V84031(1)=M(8,3,2,2,1)*P86(2,1)*P87(1,2)                        NUTR0498
      V84031(2)=RS(8,3,2,2,1)*P87(3,2)                                NUTR0499
      MS(8,4,2,3,1)=V84031(1)+V84031(2)                               NUTR0500
      V84040(1)=MS(8,3,2,3,2)*P87(4,1)*P88(3,2)                       NUTR0501
      V84040(2)=MS(8,3,2,3,2)*P87(4,2)*P88(4,2)                       NUTR0502
      V84040(3)=M83030(1)*P88(6,1)*P89(3,3)                           NUTR0503
      V84040(4)=M83030(2)*P88(7,1)*P89(5,3)                           NUTR0504
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      MS(8,4,2,4,2)=0.0                                                 NUTRO505
      DO 801 I=1,4                                                      NUTRO506
      MS(8,4,2,4,2)=MS(8,4,2,4,2)+V84040(I)                             NUTRO507
  801 CONTINUE                                                          NUTRO508
      R(8,4,2,1,3)=R(8,3,2,1,2)*P86(1,2)                                NUTRO509
      R84022(1)=M(8,3,2,2,1)*P86(2,2)*P87(2,1)*P88(1,1)                 NUTRO510
      R84022(2)=R(8,3,2,2,1)*P88(5,1)*P89(1,1)                          NUTRO511
      R(8,4,2,2,2)=R84022(1)+R84022(2)                                  NUTRO512
      H84022(1)=M(8,3,2,2,1)*P86(2,1)*P87(1,1)                          NUTRO513
      H84022(2)=RS(8,3,2,2,1)*P87(3,1)                                  NUTRO514
      RS(8,4,2,2,2)=H84022(1)+H84022(2)                                 NUTRO515
      H84031(1)=MS(8,3,2,3,2)*P87(4,1)*P88(3,1)                         NUTRO516
      H84031(2)=M83030(1)*P88(6,1)*P89(3,2)                             NUTRO517
      H84031(3)=M83030(2)*P88(7,1)*P89(5,2)                             NUTRO518
      RS(8,4,2,3,1)=H84031(1)+H84031(2)+H84031(3)                       NUTRO519
      D803(1)=R(8,3,2,1,2)*P86(1,1)                                     NUTRO520
      D803(2)=M(8,3,2,2,1)*P86(2,1)*P87(1,3)                            NUTRO521
      D803(3)=M(8,3,2,2,1)*P86(2,2)*P87(2,1)*P88(1,3)                   NUTRO522
      D803(4)=M(8,3,2,2,1)*P86(2,2)*P87(2,2)*P88(2,2)                   NUTRO523
      D803(5)=RS(8,3,2,2,1)*P87(3,3)                                    NUTRO524
      D803(6)=MS(8,3,2,3,2)*P87(4,1)*P88(3,3)                           NUTRO525
      D803(7)=MS(8,3,2,3,2)*P87(4,2)*P88(4,1)                           NUTRO526
      D803(8)=R(8,3,2,2,1)*P88(5,2)*P89(2,1)                            NUTRO527
      D803(9)=M83030(1)*P88(6,1)*P89(3,1)                               NUTRO528
      D803(10)=M83030(1)*P88(6,2)*P89(4,1)                              NUTRO529
      D803(11)=M83030(2)*P88(7,1)*P89(5,1)                              NUTRO530
      D803(12)=M83030(2)*P88(7,2)*P89(6,2)                              NUTRO531
      D(8,2,3)=0.0                                                      NUTRO532
      DO 904 I=1,12                                                     NUTRO533
      D(8,2,3)=D(8,2,3)+D803(I)                                         NUTRO534
  904 CONTINUE                                                          NUTRO535
      R1(K,2)=R(2,2,1,1,1)+R(4,2,1,1,1)                                 NUTRO536
      R1(K,3)=R(2,3,1,1,2)+R(2,3,1,2,1)+R(3,3,1,1,1)+R(4,3,1,1,2)+R(4,3,NUTRO537
     11,2,1)                                                            NUTRO538
      R1(K,4)=R(2,4,1,1,3)+R(2,4,1,2,2)+R(3,4,1,1,1)+R(3,4,1,1,2)+R(4,4,NUTRO539
     11,1,3)+R(4,4,1,2,2)                                               NUTRO540
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      RO(K,2)=R(6,2,2,1,1)+R(8,2,2,1,1)                                NUTRO541
      RO(K,3)=R(5,3,2,1,1)+R(6,3,2,1,2)+R(6,3,2,2,1)+R(7,3,2,1,1)+R(8,3,NUTRO542
     12,1,2)+R(8,3,2,2,1)                                              NUTRO543
      RO(K,4)=R(5,4,2,1,2)+R(6,4,2,1,3)+R(6,4,2,2,2)+R(7,4,2,1,1)+R(7,4,NUTRO544
     12,1,2)+R(8,4,2,1,3)+R(8,4,2,2,2)                                 NUTRO545
      RS1(K,3)=RS(2,3,1,2,1)+RS(3,3,1,1,1)+RS(4,3,1,2,1)               NUTRO546
      RS1(K,4)=RS(1,4,1,1,1)+RS(2,4,1,2,2)+RS(2,4,1,3,1)+RS(3,4,1,1,1)+RNUTRO547
     1S(3,4,1,1,2)+RS(3,4,1,2,1)+RS(4,4,1,2,2)+RS(4,4,1,3,1)           NUTRO548
      RSO(K,3)=RS(5,3,2,1,1)+RS(6,3,2,2,1)+RS(7,3,2,1,1)+RS(8,3,2,2,1) NUTRO549
      RSO(K,4)=RS(5,4,2,1,2)+RS(5,4,2,1,1)+RS(5,4,2,2,1)+RS(6,4,2,2,2)+RNUTRO550
     1S(6,4,2,3,1)+RS(7,4,2,1,1)+RS(7,4,2,1,2)+RS(7,4,2,2,1)+RS(8,4,2,2,NUTRO551
     22)+RS(8,4,2,3,1)                                                 NUTRO552
      M1(K,1)=UBW2+UBW4                                                NUTRO553
      M1(K,2)=M(2,2,1,2,3)+M(3,2,1,1,3)+M(4,2,1,2,3)                   NUTRO554
      M1(K,3)=M(1,3,1,1,3)+M(2,3,1,2,1)+M(2,3,1,3,3)+M(3,3,1,1,3)+M(3,3,NUTRO555
     11,2,3)+M(4,3,1,2,1)+M(4,3,1,3,3)                                 NUTRO556
      M1(K,4)=M(1,4,1,2,3)+M(2,4,1,2,2)+M(2,4,1,3,1)+M(2,4,1,4,3)+M(3,4,NUTRO557
     11,1,3)+M(3,4,1,2,3)+M(3,4,1,2,1)+M(3,4,1,3,3)+M(4,4,1,2,2)+M(4,4,1NUTRO558
     2,3,1)+M(4,4,1,4,3)                                               NUTRO559
      MO(K,1)=UBW6+UBW8                                                NUTRO560
      MO(K,2)=M(5,2,2,1,3)+M(6,2,2,2,3)+M(7,2,2,1,3)+M(8,2,2,2,3)      NUTRO561
      MO(K,3)=M(5,3,2,1,3)+M(5,3,2,2,3)+M(6,3,2,2,1)+M(6,3,2,3,3)+M(7,3,NUTRO562
     12,1,3)+M(7,3,2,2,3)+M(8,3,2,2,1)+M(8,3,2,3,3)                    NUTRO563
      MO(K,4)=M(5,4,2,2,1)+M(5,4,2,2,3)+M(5,4,2,3,3)+M(6,4,2,2,2)+M(6,4,NUTRO564
     12,3,1)+M(6,4,2,4,3)+M(7,4,2,1,3)+M(7,4,2,2,3)+M(7,4,2,2,1)+M(7,4,2NUTRO565
     2,3,3)+M(8,4,2,2,2)+M(8,4,2,3,1)+M(8,4,2,4,3)                     NUTRO566
      MS1(K,3)=MS(2,3,1,3,2)+MS(3,3,1,2,2)+MS(4,3,1,3,2)               NUTRO567
      MS1(K,4)=MS(1,4,1,2,2)+MS(2,4,1,3,1)+MS(2,4,1,4,2)+MS(3,4,1,2,2)+MNUTRO568
     1S(3,4,1,2,1)+MS(3,4,1,3,2)+MS(4,4,1,3,1)+MS(4,4,1,4,2)           NUTRO569
      MSO(K,3)=MS(5,3,2,2,2)+MS(6,3,2,3,2)+MS(7,3,2,2,2)+MS(8,3,2,3,2) NUTRO570
      MSO(K,4)=MS(5,4,2,2,1)+MS(5,4,2,2,2)+MS(5,4,2,3,2)+MS(6,4,2,3,1)+MNUTRO571
     1S(6,4,2,4,2)+MS(7,4,2,2,2)+MS(7,4,2,2,1)+MS(7,4,2,3,2)+MS(8,4,2,3,NUTRO572
     21)+MS(8,4,2,4,2)                                                 NUTRO573
      N1(K,1)=NBW1+NBW3                                                NUTRO574
      N1(K,2)=N(1,1,2)+N(3,1,2)                                        NUTRO575
      N1(K,3)=N(1,1,3)+N(3,1,3)                                        NUTRO576
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      N1(K,4)=N(1,1,4)+N(3,1,4)                                          NUTRO577
      NO(K,1)=NBW5+NBW7                                                  NUTRO578
      NO(K,2)=N(5,2,2)+N(7,2,2)                                          NUTRO579
      NO(K,3)=N(5,2,3)+N(7,2,3)                                          NUTRO580
      NO(K,4)=N(5,2,4)+N(7,2,4)                                          NUTRO581
      D1OTOT(K)=D10(1)+D10(2)                                            NUTRO582
      D1(K,1)=D(2,1,1)+D(3,1,1)+D(4,1,1)                                 NUTRO583
      D1(K,2)=D(1,1,2)+D(2,1,2)+D(3,1,2)+D(4,1,2)                        NUTRO584
      D1(K,3)=D(1,1,3)+D(2,1,3)+D(3,1,3)+D(4,1,3)                        NUTRO585
      DOOTOT(K)=DOO(1)+DOO(2)                                            NUTRO586
      DO(K,1)=D(5,2,1)+D(6,2,1)+D(7,2,1)+D(8,2,1)                        NUTRO587
      DO(K,2)=D(5,2,2)+D(6,2,2)+D(7,2,2)+D(8,2,2)                        NUTRO588
      DO(K,3)=D(5,2,3)+D(6,2,3)+D(7,2,3)+D(8,2,3)                        NUTRO589
      WRITE(6,911)K                                                      NUTRO590
  911 FORMAT(1H1,60X,'K=',I3,//)                                         NUTRO591
      WRITE(6,320)                                                       NUTRO592
  320 FORMAT(1HO,45X,'L=1',7X,'L=2',7X,'L=3',7X,'L=4',//)                NUTRO593
      WRITE(6,933)(M1(K,L),L=1,4)                                        NUTRO594
      WRITE(6,934)(MS1(K,L),L=3,4)                                       NUTRO595
      WRITE(6,939)(N1(K,L),L=1,4)                                        NUTRO596
      WRITE(6,935)D1OTOT(K),(D1(K,L),L=1,3)                              NUTRO597
      WRITE(6,937)(R1(K,L),L=2,4)                                        NUTRO598
      WRITE(6,938)(RS1(K,L),L=3,4)                                       NUTRO599
      WRITE(6,943)(MO(K,L),L=1,4)                                        NUTRO600
      WRITE(6,944)(MSO(K,L),L=3,4)                                       NUTRO601
      WRITE(6,949)(NO(K,L),L=1,4)                                        NUTRO602
      WRITE(6,945)DOOTOT(K),(DO(K,L),L=1,3)                              NUTRO603
      WRITE(6,947)(RO(K,L),L=2,4)                                        NUTRO604
      WRITE(6,948)(RSO(K,L),L=3,4)                                       NUTRO605
  933 FORMAT(1HO,30X,'M1(K,L)',3X,4F10.2,//)                             NUTRO606
  943 FORMAT(1HO,30X,'MO(K,L)',3X,4F10.2,//)                             NUTRO607
  934 FORMAT(1HO,30X,'MS1(K,L)',22X,2F10.2,//)                           NUTRO608
  944 FORMAT(1HO,30X,'MSO(K,L)',22X,2F10.2,//)                           NUTRO609
  935 FORMAT(1HO,30X,'D1(K,L)',3X,4F10.2,//)                             NUTRO610
  945 FORMAT(1HO,30X,'DO(K,L)',3X,4F10.2,//)                             NUTRO611
  937 FORMAT(1HO,30X,'R1(K,L)',13X,3F10.2,//)                            NUTRO612
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947 FORMAT(1H0,30X,'RO(K,L)',13X,3F10.2,//)                          NUTR0613
938 FORMAT(1H0,30X,'RS1(K,L)',22X,2F10.2,///)                        NUTR0614
948 FORMAT(1H0,30X,'RSO(K,L)',22X,2F10.2,///)                        NUTR0615
939 FORMAT(1H0,30X,'N1(K,L)',3X,4F10.2,//)                           NUTR0616
949 FORMAT(1H0,30X,'NO(K,L)',3X,4F10.2,//)                           NUTR0617
    P01(1,1)=P01(1,1)*(1.0+BETA*RC*DELTA)                            NUTR0618
    IF(P01(1,1)-1.0)1,1,3                                            NUTR0619
  3 WRITE(6,281)                                                     NUTR0620
281 FORMAT(1H1,'REVISE THE VALUE OF BETA')                           NUTRC621
    GO TO 8                                                          NUTR0622
  1 CONTINUE                                                         NUTR0623
    P01(1,2)=1.0-P01(1,1)                                            NUTR0624
699 CONTINUE                                                         NUTR0625
  8 CONTINUE                                                         NUTR0626
    STOP                                                             NUTR0627
    END                                                              NUTR0628
```