A STUDY OF THE EFFECTS OF INTESTINAL PARASITES ON THE NUTRITIONAL STATUS OF NEW ORLEANS KINDERGARTEN CHILDREN

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I. INTRODUCTION

The relationships between malnutrition and infection have long been of interest to medical researchers (67, 75). Scrimshaw, Taylor, and Gordon's monograph entitled _Interactions of Nutrition and Infection_ (69) focuses attention anew on this subject. These authors reviewed over 1500 articles and postulated the following principles common to these interactions:

Malnutrition not only alters the resistance of the host to infection but infectious disease aggravates existing malnutrition. An aggravation of the disease syndrome (synergism) may produce results which are more serious for the host than would be expected from the combined effects of the two conditions working independently. Thus, infectious diseases usually make coexisting malnutrition worse, and the consequences of infection are likely to be more serious in a malnourished host than in a well-nourished one. Although malnutrition does not appear to influence the frequency of infection, an inadequate diet may enhance the severity of an infection. In the case of intestinal helminths and intestinal protozoa, malnutrition is almost always synergistic. The authors concluded that synergism of malnutrition and infection is particularly common in populations of the less developed areas of the world and that this phenomenon is of the greatest clinical and public health significance.

Scrimshaw, Taylor, and Gordon propose the definition of malnutrition to be "...a pathological state resulting from a relative or absolute deficiency or excess of one or more essential nutrients sufficient to produce disease. The disease may be clinically manifest or it may be detectable only by biochemical or physiological tests. Malnutrition may manifest itself as starvation, undernutrition, specific deficiency, imbalance, or overnutrition."

Infection as defined by the American Public Health Association (1) is "...the invasion of a living host by an organism; its development or multiplication there; and a reaction of tissues to its presence or to toxins it generates. Infection is not synonymous with infectious disease; the results may be inapparent or manifest."

Parasites in all probability have plagued mankind from the dawn of history. One of the earliest references to parasites occurred in the "Eber's Papyrus" (67) written in 1550 B.C. The writer ascribed "āaā" disease as being caused by the "Heltu" worm. This disease was probably a form of endemic anemia caused by an intestinal parasite known today as the hookworm, Ancylostoma duodenale. The ancient Egyptians associated this disease with laborers whose job it was to handle and carry sand. This is probably one of the earliest references to a disease caused by an intestinal parasite.

Prior to the era of the early nineteen hundreds, superstitions about the salubrious or morbid effect of worms existed. An unidentified nineteenth century physician called intestinal worms the "good angels and unfailing helpers of children." Old wives' tales about the origin and effects of intestinal worms have been passed on from generation to generation unto the present time. It was not uncommon for the author and other team members of the National Nutrition Survey in Louisiana to hear of worms being attributed to an excess of sugar in the diet. Worms are still prevalent in many parts of the Southern United States.

Serious consideration of the relationship of nutrition to infection was almost entirely restricted to foreign populations until relatively recently. With the advent of the United States War on Poverty and its emphasis on malnutrition in low-income groups, attention has been focused on the etiology of malnutrition in the United States. The National Nutrition Surveys of selected states in the United States have furnished voluminous data on the clinical, socio-economic, biochemical, dental, and dietary history of thousands of low-income individuals in our population (88). Research projects at Tulane University with "Operation Headstart" children in three Gulf states have contributed to the data on malnutrition and infection.

The history of this study dates from 1967 when the nation's press and television stations popularized the so-called "hunger" problem in the United States. It was alleged that severe malnutrition existed in Mississippi and other Southern states, particularly among disadvantaged minority groups. These allegations were followed by publication of Hunger, USA (11) and presentation of the Columbia Broadcasting System's television documentary on the same subject. Hunger, USA was particularly critical of the local health professions, of public officialdom from local to national level, of private charitable groups, and the food industry for failure to recognize and come to grips with the problem of malnutrition in the United States. "Hunger" became a political issue which culminated in the appointment and hearings of the United States Senate Select Committee on Nutrition and Human Needs.

The committee chairman was Senator McGovern of South Dakota, and the members included such prominent senatorial names as Kennedy, Percy, Javits, Ellender, Talmadge, Yarborough, Hart, and Mondale. It should be pointed out that "hunger" in the context of current national discussions has come to mean not only physiological craving and insufficient food from whatever cause, but deprivation of money, social status and rights (17).

Hearings before the Senate Select Committee "to examine the problem of malnutrition and hunger in particular parts of the country" were begun on February 18, 1969 (89) and were closely reviewed by the late Dr. Walter G. Unglaub, Chief of the Nutrition Section of Tulane University's School of Public Health and Tropical Medicine. Testimony initially centered on Beaufort and Jasper Counties in South Carolina. These counties had been previously publicized by Senator Hollings (South Carolina) with his vivid descriptions of their economic doldrums (89) and by Dr. Gatch, a local pediatricion, who had fallen into local disrepute by airing the plight of poor Negroes in that area over national news media (89).

Among those testifying were Drs. Lease and Lauter of the University of South Carolina whose article, entitled Intestinal Parasites and Nutritional Status, was entered into the record (41). These authors had made a health survey of 177 Negro children in the Beaufort and Jasper County areas in which it was found that 73 percent of the children were infected with *Ascaris*, *Trichuris*, or both. It was estimated that 65 percent to 70 percent of these three- to six-year-old children had substandard hemoglobin values and 20 percent had substandard serum ascorbic acid values. Statements were made to the effect that children with a heavy load of parasites are malnourished, that treating worms takes precedence over improving nutrition, and that a great deal of protein is required from the host's diet to manufacture worms from eggs. For a detailed study of the metabolism of parasites the reader is referred to Von Brand's, Biochemistry of Parasites (96).

Lease and Lauter concluded that parasitic infections were highly prevalent in the area and indications were overwhelming that this was a critical and crucial health hazard affecting the dignity and well-being of citizens in the area. It was implied that the *Ascaris* and *Trichuris* infections in these children were a major causative factor of anemia and possibly vitamin C deficiency (86).

Another expert witness, Dr. James P. Carter, Professor of Nutrition and Parasitology at Vanderbilt and Meharry Schools of Medicine, gave additional testimony. In response to Senator McGovern's questioning on the nutrient uptake of worms, Dr. Carter replied, "I have some figures to show that 20 adult *Ascaris* will consume 2.8 grams of carbohydrate and 0.07 grams of protein daily. If a patient had 600 worms, which is not at all unusual in some developing countries, this would be equal to a loss of 84 grams of carbohydrates and 21 grams of protein per day." The author was unable to find the source of Dr. Carter's statistics.

Following extensive hearings on the relationships between intestinal parasites and malnutrition, Senator McGovern was moved to comment, "If there are children there, and you have attested to this fact, that are getting 800 to 900 calories a day and the worms eat half of that, that is an emergency." The chairman and members of the committee were apparently left with the impression that intestinal parasitism had a direct causal relationship to the malnutrition existing in South Carolina.

PURPOSE OF THE STUDY

The opportunity arose to investigate the allegations regarding nutrition and intestinal parasites with the successful funding of the research project entitled "Nutritional Evaluation of Preschool Children in New Orleans". This research project was conducted by the Tulane University Headstart Research Center) now renamed the Early Childhood Research Center). Approximately 1,000 kindergarten children in seven Orleans Parish elementary schools were included in the survey. Clinical, dietary, anthropometrical, biochemical, and intestinal parasite examinations were performed.

The purpose of this study is to test the hypothesis that a relationship exists between intestinal parasitism and the nutritional status of New Orleans preschool children. The prevalence and intensity of intestinal helminth and intestinal protozoal infections will be obtained on the sample population of young children from the lower socio-economic strata of New Orleans along with the biochemical measurements. Methods for correlating parasitological and biochemical data in nutrition surveys will be formulated. If the hypothesis is true, biochemical measurements should show that individuals suffering from intestinal parasitism exhibit a different nutritional status than similar individuals of the same socio-economic background who are apparently not parasitized.

II. DESCRIPTION OF THE STUDY

A. ORGANIZATION OF THE OVERALL RESEARCH PROJECT

Administration of the overall research project was under the auspices of the Tulane University Early Childhood Research Center. Both nutritional evaluations and psychological testing were to be performed. The nutritional evaluation portion of the study entitled "Nutritional Evaluation of Preschool Children in Metropolitan New Orleans" was designed by the late Dr. Walter G. Unglaub, Chief of the Nutrition Section of Tulane University School of Public Health and Tropical Medicine.

Arrangements were made to select approximately 1,000 kindergarten children in seven public schools of Orleans Parish which is the city of New Orleans, Louisiana. These schools were located in predominatly Negro neighborhoods. The clinical, dietary, dental, biochemical, and intestinal parasite status of the children were determined both before and after supplementary dietary interventions. All data were collected at one or more prearranged times in a cross-sectional prevalence type study. The nutritional health of the sample population was assessed under normal classroom conditions. Suspected causality factors discovered in the field could be confirmed or rejected based on coincident laboratory findings.

Both morning and afternoon kindergarten classes which did not normally participate in school lunch programs were used in arranging the test and control groups of children. Supplements were designed to augment the food intake of the children and to determine what change, if any, the additional supplement would have on the physical, psychological, and biochemical status of the children.

Test group "A" contained approximately 100 children in morning classes of schools number I and II and received both breakfasts and hot lunches. Test group "B" contained approximately 100 children in morning classes of schools III and IV and received hot lunches only. Test group "C" contained approximately 100 children in the morning class of school V and the afternoon class of school VII. This group received a dietary supplement tablet (Nutricube®) in a flavored beverage. Control group "D" contained approximately 100 children in the afternoon class of school V and the morning class of school VII and received a dietary supplement placebo tablet in a flavored beverage. Control group "E" contained approximately 50 children in the morning class of school VI and 400 children in the afternoon classes of schools I, II, III, IV, and VI and received a snack consisting of five ounces of orange juice.

The noon meals were standard United States Department of Agriculture type "A" lunches providing on the average one-third of the Recommended Daily Dietary Allowance for a ten-to twelve-year-old child (62) reduced according to the size of the individual child. The special breakfast consisted of milk, fruit juice, and cereal. Studies of the dietary supplement tablet called Nutricube® were conducted for Hoffmann-La Roche, Inc. The dietary supplement tablet was formulated to give each child an individual daily allowance of 825

International Units of vitamin A, 0.22 mg of riboflavin, 0.25 mg pyridoxine, 0.05 mg folic acid, 10.0 mg ascorbic acid, 200.0 mg calcium, 200.0 mg phosphorus, 10.0 mg iron, 170.0 mg L-lysine HCL, and 70.0 mg L-tryptophan. This formula was designed to provide one-fourth of the Recommended Daily Allowance for each nutrient except iron and amino acids.

B. RATIONALE OF THE RESEARCH PROJECT

The main research project was designed to test the effect of various intervention diets on the nutritional status of a sample population of New Orleans preschool children of a lower socio-economic status. Previous studies in New Orleans (77) had revealed that a large percentage of these preschool children had unacceptable values for hemoglobin, hematocrit and vitamin A. In the preliminary report on the results of the National Nutrition Survey in Louisiana in January 1970 (85) it was revealed that 44.5 percent of children tested between the ages of 12 and 71 months had hemoglobin levels below 11 grams percent; 73 percent of the children tested between the ages of 1 to 71 months had unacceptable values of vitamin A; and 12 percent of the children tested between the ages of 1 and 71 months had unacceptable values of ascorbic acid.

Dr. Unglaub assumed that the sample population of children would be nutritionally substandard at the start of the study, that the biochemical bases of the children would be approximately the same, and that the baseline nutritional status could be determined at the time of the predietary intervention testing. Biochemical tests used are relatively reliable yet as simple, speedy, and economical as practicable to enable accomplishment of the large volume of laboratory analyses required. Results of these tests are applicable to large population groups; individual results are not necessarily significant. Test and control groups of approximately 100 per group were arranged in order to minimize individual variations. A battery of biochemical tests was used to enable development of the maximum number of correlations.

The most important variable in the overall research project was the level of supplementation. Thus the optimal amount of augmentation of the food intake necessary to bring unacceptable biochemical nutrient values into acceptable range could be approximated. A period of six months dietary intervention time was selected as being compatible with the length of the school year, the logistical capabilities of the research team, and the estimated time necessary to produce a significant change in the biochemical nutritional status of the sample children. The preceding commentary gives the broad picture of the overall research project; the authors' study can now be described in more detail.

The author was specifically interested in determining statistical relationships between infection with intestinal parasites and nutritional status. The results of interventional and psychological portions of the research project are beyond the scope of this study and will be reported elsewhere by the major investigators concerned.

Six biochemical parameters were selected for comparison with parasitological findings. These were hemoglobin, hematocrit, serum carotene, serum vitamin A, serum ascorbic acid, and serum albumin. The latter parameter was changed to total serum proteins because serum protein electrophoresis results were not available at this time. These parameters were selected because it was thought that parasitic infections would most likely affect these values. In previous nutritional surveys of lower socio-economic populations in the United States (41,55,77,85) it was found that these same values were consistently substandard. Intestinal helminths and intestinal protozoa have likewise most often been incriminated in deficiencies of hemoglobin, vitamin A, protein, and ascorbic acid (16,18,19,23,35,75,78,80,92).

The sample population consisted of all children from the overall research project from whom feces were examined one or more times, a total of 887 children. This represented a participation rate of 85 percent for the parasitological portion of the research project. A total of 1887 stool samples from the 887 children in the sample population were analysed in this study. Of these children, 369 submitted stool samples three times; 284 submitted stool samples two times; and 234 children submitted stool samples one time. Stool samples were not collected from 145 other children in the research project.

For purposes of data analysis, parasitic infections were classified in a specific manner. Helminth infections were classified as light, moderately heavy, or heavy according to the number of ova found per direct smear (20,22,104).

The significance of an infection depends on both the number and kind of parasites present. The relative worm burden is estimated by determining the abundance of their reproductive products. Interpretations of egg counts must take into consideration such conditions as age, health, diet, and nutritional status of the host as well as the age and number of worms present. Using the direct smear containing the equivalent of about 2 mg of formed feces as described by Beaver (104), infections giving counts of less than 40 Ascaris lumbricoides, 10 Trichuris trichiura or 10 hookworm eggs per smear maybe regarded as light. Those infections giving counts of more than 200 Ascaris lumbricoides, 50 Trichuris trichiura or 50 hookworm eggs per smear maybe considered relatively heavy. Studies by Beaver and others (4, 5, 45, 46) show that egg counts made by direct smear correlate well with more complicated dilution methods. Hookworm species identified were reported as hookworm because differentiation between Necator americanus and Ancylostoma duodenale was not feasible in this study. Necator americanus is more commonly found in North America than is Ancylostoma duodenale (20, 22).

Intestinal parasites were also classified as to their significance in clinical medicine (20, 104) as medically important or medically unimportant. Medically important parasites are those known to produce injury to their host and are commonly known as pathogens as opposed to those usually harmless non-pathogens living a commensal existence with their host.

Medically important intestinal parasites found in the study were _Ascaris lumbricoides_, _Trichuris trichiura_, _Enterobius vermicularis_, _Hymenolepis diminuta_, _Entamoeba histolytica_, _Giardia lamblia_ and hookworms. Medically unimportant intestinal parasites included _Entamoeba coli_, _Endolimax nana_, _Entamoeba hartmanni_, and _Chilomastix mesnili_.

C. AIMS AND OBJECTIVES

The aims and objectives of the study were:

1. to collect and examine stool specimens for intestinal helminths and intestinal protozoa from each child during the study;

2. to determine the prevalence and intensity of intestinal parasitism in the sample population;

3. to obtain the results of the six selected biochemical measurements of the sample population;

4. to compare the nutritional status of those individuals harboring intestinal parasites with those individuals similar by age, race, and socio-economic status who were apparently negative for intestinal parasites;

5. to consider methodology for comparing parasitological and biochemical data collected from large numbers of persons in a nutrition survey.

D. MATERIALS AND METHODS

Blood and stool specimens were collected from each cooperating individual of the sample population of 887 children. All laboratory examinations were performed under the auspices of the Early Childhood Research Center laboratory. The revised standards for the National Nutrition Survey entitled "Guidelines for Classification and Interpretation of Group Blood and Urine Data Collected as part of the National Nutrition Survey" were used in this study (54). That portion of the guidelines applicable to the five-year-old children in this study are reproduced below.

	Classification Category		
	Less than Acceptable Deficient	Low	Acceptable
Hemoglobin (gm/100 ml)	< 10.0	10.0 - 10-9	≥ 11.0
Hematocrit (%)	< 30.0	30.0 33.0	≥ 34.0
Serum Carotene (μg/100 ml)		< 40.0	≥ 40.0
Serum Vitamin A (μg/100 ml)	< 20.0	20.0 - 29.0	≥ 30.0
Serum Vitamin C (mg/100 ml)	< 0.1	0.1 - 0.19	≥ 0.2
Serum Protein (g/100 ml)		< 5.5	≥ 5.5

A recent article by Owen and associates (56) has questioned the use of 30 μg percent as the acceptable limit for serum vitamin A in American children. A cross-sectional sample of 3,500 preschool children from 74 sample areas in 37 states were studied. Only 2.5 percent of all children studied had values below 20 μg percent. If a serum vitamin A level of 30 μg percent is accepted as the lower limit, some 40 percent of United States preschool children would be judged to have unacceptable levels of serum vitamin A. Since very few children had low intakes of vitamin A, most had generous intakes, and 97 percent had serum vitamin A levels above

20 μg percent the authors strongly recommended acceptance of 20 μg percent as the lower limit of normal for children in the United States between one and six years old. This would agree with the Interdepartmental Committee on Nutrition for National Defense standard (50). The author concurs with Owen and associates that 20 μg percent is a more realistic lower limit of normal for the five-year-old children in this study.

The protocol for the collection and examination of samples was as follows:

1. Blood Samples

a) Blood samples were collected both in sterile tubes containing EDTA and in sterile tubes containing no additive.

b) Blood samples were placed under refrigeration and delivered to the laboratory.

c) Analyses on blood samples were performed in accordance with biochemical methodology described in the Biochemical Methods chapter of the Manual for Nutrition Surveys, Interdepartmental Committee on Nutrition for National Defense (50). Tests were performed by personnel of the Early Childhood Research Center.

d) The following biochemical methods were used:

(1) Hemoglobin by cyanmethemoglobin method (50)

(2) Hematocrit by microhematocrit method (50)

(3) Serum carotene by Carr-Price method (50)

(4) Serum vitamin A by Carr-Price method (50)

(5) Serum vitamin C by dinitrophenylhydrazine method (50)

(6) Total serum proteins by modified microbiuret method (50)

2. Stool Samples

Stool samples were collected at three periods in this study: preintervention, midway, and postintervention.

a) Each individual received a fecal collection cup with his name and identification number written on the cup.

b) The fecal cups were collected at the schools and properly coded.

c) Stool samples were delivered to the laboratory immediately after collection at the schools.

d) Fecal samples were checked by direct microscopic examination of smears from fresh feces and also examined by the zinc sulfate centrifugation-flotation method (20) using fresh feces. A direct egg count was made on smears positive for helminths. According to Beaver (104), unstandardized direct smears contain the equivalent of about 2 mg of feces, egg counts should be reported as "eggs per smear". Differentiation of protozoan parasites was made by means of the iron-hematoxylin stain. The author performed these examinations with the assistance of personnel from the Early Childhood Research Center Laboratory and from the Parasitology Department of the Tulane University School of Public Health and Tropical Medicine. All stool samples were examined the same day they were received.

3. Statistical Methodology

It was necessary to establish procedures for comparing means of biochemical parameters with the results of parasitological examinations. Because there was a limited number of infections in certain categories by species and by intensity of infection, the author elected to classify all parasites as to their medical importance. Test groups of medically important and medically unimportant parasites were organized (20, 104). The number of light, moderate, and heavy infections of helminths were also determined.

The above classification allowed formation of relatively large test and control groups so that statistically valid comparisons could be made in looking for possible correlations between nutritional status of parasitized and nonparasitized individuals.

Biochemical data on children in the sample population were placed on tapes at the Tulane University Computer Laboratory. Computer printouts containing numbers of children, mean values of biochemical determinations, and standard deviations of biochemical determinations for test and control groups were made available to the author. Histogram printouts were used to obtain the percentages of children with deficient, low, and acceptable biochemical values. Tables were then prepared so that mean biochemical values of the various test and control groups could be compared. The "t" distribution was used at the .05 level of significance to test for statistically significant differences in mean values between test and control groups. The statistical methodology used in this study is commonly used in biological studies.

4. Identification of Subjects

To identify individuals and to facilitate computerization of the data, the following identification numbers were assigned relative to food supplementation at the schools:

School Number I

Morning classes - 1000 series - Group receiving both breakfast and lunch

Afternoon classes - 1500 series - Control group

School Number II

Morning classes - 2000 series - Group receiving both breakfast and lunch

Afternoon classes - 2500 series - Control group

School Number III

Morning classes - 3000 series - Group receiving lunch only

Afternoon classes - 3500 series - Control group

School Number IV

Morning classes - 4000 series - Group receiving lunch only

Afternoon classes - 4500 series - Control group

School Number V

Morning classes - 5000 series - Group receiving nutritional supplement tablet

Afternoon classes - 5500 series - Group receiving nutritional supplement placebo tablet

School Number VI

Morning classes - 6000 series - Control group

Afternoon classes - 6500 series - Control group

School Number VII

Morning classes - 7000 series - Group receiving nutritional supplement placebo tablet

Afternoon classes - 7500 series - Group receiving nutritional supplement tablet

III. RESULTS

A portion of the sample population of 887 children was found to be nutritionally substandard in three of the six biochemical parameters studied at the time of preintervention testing.

In evaluating the hemoglobin and hematocrit status, it was found that 24.35 percent of the children tested had unacceptable levels of hemoglobin (below 11 grams percent) and 6.26 percent had unacceptable hematocrit values (below 34 percent). Deficient levels of hemoglobin (less than 10 grams percent) were found in 4.14 percent of the children tested. This level is usually considered compatible with clinical anemia (99).

The hematocrit or packed cell volume reflects the concentration of red cells in the blood whereas hemoglobin levels reflect the concentration of hemoglobin in the blood. Together they reflect the actual or potential oxygen-carrying capacity of the blood. It can be seen that the sample population had a major problem in the hemoglobin parameter. An overall prevalence in excess of five percent in a population group is generally considered to be cause for concern (85).

In evaluating the serum vitamin A and serum carotene status of the sample population, it should be remembered that serum carotene reflects the recent dietary intake of carotenes whereas serum vitamin A, because of its storage in the liver, does not reflect recent dietary intake of preformed vitamin A or beta carotene. Using C[illegible]en and associates' proposed standard (56) 12.[illegible]3 percent of the children in the sample population had unacceptable levels of serum vitamin A. If the revised standard for the National Nutrition Survey (54) was used, 45.93 percent of the children would have been considered to have unacceptable levels of serum vitamin A (below 30 μg percent). Serum carotene levels were unacceptable in 2.80 percent of the sample population (below 40 μg percent). A problem existed in serum vitamin A nutriture in the sample population whereas the carotene intake appeared to be satisfactory. The Interdepartmental Committee of Nutrition for National Defense suggests that populations with 15 percent below 20 μg percent of serum vitamin A show evidence of deficiencies (54).

There appeared to be little of public health significance in the other two biochemical parameters studied. Only 0.27 percent of the sample population tested had unacceptable total serum protein values, and 1.15 percent had unacceptable serum ascorbic acid values. Total serum proteins are not a very sensitive measure of protein nutritional status since changes occur only after severe depletion (50). Serum ascorbic acid levels reflect recent dietary intake which appeared to be satisfactory in the sample population.

In summarizing the nutritional status of the sample population at the time of the initial testing, it can be seen that the major problems were in deficiencies of hemoglobin and in unacceptable levels of serum vitamin A. The deficiencies in hemoglobin are most likely related to iron deficiency whereas low serum vitamin A levels are most likely related to long range dietary intake levels.

In the sample population of 887 children who submitted stool samples for examination, 614 or 69.23 percent were apparently negative for intestinal helminths and intestinal protozoa; 169 or 19.05 percent were found to be infected with one or more medically important parasites; and 104 or 11.72 percent were found to be infected with one or more medically unimportant parasites. None of the children in the sample population were found to have clinically overt symptoms of an intestinal parasite related disease. Multiple parasitism was found in 9.22 percent of the children, 2.37 percent harbored two or more medically important parasites.

Results of intestinal parasite surveys in two underdeveloped countries are given here for comparative purposes. The Ministry of Health and Association of Medical Faculties in Colombia examined 15,000 persons for intestinal parasites in 1965 and 1966 (13). Eighty eight percent of this number were parasitized and 80.4 percent of those parasitized harbored pathogenic species. The more common infections found were *Ascaris* 53.8 percent, *Trichuris* 50 percent, *Uncinaria* 22 percent, *Strongyloides* 2 percent, *Enterobius* 5.9 percent, *Entamoeba histolytica* 23.7 percent, and *Endolimax nana* 34.1 percent. No attempt was made to ascertain the impact of this worm burden on the health or nutritional status of the infected population. A similar survey among the urban working class population of Lagos, Nigeria (53) indicated that of 515 persons of all ages examined, 71.5 percent harbored *Ascaris*, 66.6 percent had *Trichuris*, 58.3 percent had hookworms, 2.1 percent had *Taenia* spp., 11.7 percent had

Strongyloides, 0.4 percent had Schistosoma mansoni, 10.9 percent had Entamoeba histolytica, and 10.1 percent had Entamoeba coli. Here again no effort was made to demonstrate the effect of worm burden on the health or nutritional status of the people infected.

The differences in prevalence of parasitism between developing countries and low income populations in the New Orleans area can be seen by comparing the above results with those of Charity Hospital in New Orleans. Unpublished data from Charity Hospital (30) for the year 1968 reveal that 598 of 4,024 stool samples or 14.8 percent, were positive for intestinal parasites. The infections included Ascaris 3.6 percent, Trichuris 6.8 percent, Enterobius 0.62 percent (by stool examination and scotch tape methods), Giardia 1.96 percent, Entamoeba histolytica 0.64 percent, Entamoeba coli 2.60 percent, Endolimax nana 1.30 percent, and Chilomastix mesnili 0.17 percent. Charity Hospital figures include many young persons and adults who are less frequently infected; they are from the same socio-economic strata as the sample population in the author's study.

Seven medically important intestinal parasites were found in the sample population of the author's study. The prevalence of Ascaris was found to be 2.25 percent, Trichuris 5.27 percent, Enterobius 2.53 percent (by stool examination only), Hymenolepis diminuta 0.12 percent, hookworm 0.12 percent, Giardia 10.53 percent, and Entamoeba histolytica 0.68 percent. Four medically unimportant species were found. The prevalence of these was; Entamoeba coli 15.95 percent, Endolimax nana 5.77 percent, Entamoeba hartmanni 0.34 percent, and Chilomastix mesnili 0.12 percent.

The prevalence of intestinal parasites in the sample population of this study (Table I) is, with three exceptions, comparable with that of Charity Hospital. A higher prevalence of Giardia lamblia (10.53 percent vs 1.96 percent), Entamoeba coli (15.95 percent vs 2.60 percent), and Enterobius vermicularis (2.53 percent vs 0.62 percent) was found in the sample population than at Charity Hospital. This could be explained by the fact that the sample population consisted of five-year-old children in whom the prevalence of fecally transmitted parasites and pinworms is usually higher. The figure of 2.53 percent prevalence of pinworms using only fecal samples is significant. Scotch tape impressions of the perianal area of these children would probably result in a much higher percentage of positive findings.

Comparison of the above studies reveals that the prevalence of intestinal parasites in the lower socio-economic strata of the underdeveloped countries cited is much greater than that of low income groups in the New Orleans area.

In the sample population, the author found two heavy Ascaris lumbricoides infections. The fecal sample from child number 6031 contained 250 eggs per smear, and the fecal sample from child number 7047 contained 200 eggs per smear. Five moderately heavy Ascaris lumbricoides infections were found. The fecal sample from child 1559 had 49 eggs per smear; number 2510 had 45 eggs per smear; number 3062 had 40 eggs per smear; number 6058 had 42 eggs per smear; and number 7052 had 68 eggs per smear. One moderately heavy *Trichuris trichiura* infection (14 eggs per smear) was found in child number 6031, this child also had one of the two heavy *Ascaris lumbricoides* infections. All other helminthic infections were considered to be light.

Since Tripathy and associates (82) found that a defect in nitrogen absorption occurred when more than 48 *Ascaris* were present in children, the serum protein levels of the two children with heavy *Ascaris* infections were examined. Child number 6031 had a preintervention total serum protein level of 8.25 grams percent, and child number 7047 had a preintervention total serum protein level of 7.61 grams percent. Postintervention values were not available on either child. Based on egg counts of 250 and 200, both children should have harbored at least 48 or more female *Ascaris*. Although serum protein levels were normal, it should be remembered that total serum protein levels are a relatively insensitive measurement of protein nutrition. Serum levels fall only after severe protein depletion (50). Both children had unsatisfactory hemoglobin levels; child number 6031 had 10.4 grams percent, and child number 7047 had 10.8 grams percent.

Further assessment of the nutritional status of the seven children with heavy and moderately heavy *Ascaris* (Table II) showed that six of the seven children had unacceptable values of hemoglobin, hematocrit, vitamin A, or ascorbic acid. Further analysis, by comparing the parameter means of this small group with the parameter means of the nonparasitized group, shows a statistically significant difference in preintervention hemoglobin, vitamin A, and serum vitamin C values and a statistically significant difference in the postintervention hemoglobin and hematocrit values (Table III).

Although a relationship does appear to exist here between heavy Ascaris infection and biochemically-detectable malnutrition, the small number of individuals in the test group make the statistical validity of the relationships questionable. Table IV, a comparison of the total number of Ascaris infections with uninfected controls, shows no significant differences in mean values. It appears that the higher parameter values of the light Ascaris infected group has diluted out the low values in the heavy Ascaris infected group.

Since Giardia has been incriminated in the malabsorption of nutrients, a comparison was made between the mean values of those apparently not parasitized and those infected with Giardia (Table V). No significant differences were found between mean values of 94 children infected with Giardia and the 614 apparently nonparasitized children. It is apparent that asymptomatic giardiasis had little effect on the biochemical nutritional status of the infected group.

In Table VI the parameter means of the group with medically important parasites are compared with the parameter means of the group with medically unimportant parasites. The only significant differences is in postintervention serum vitamin A of 33.05 μg percent versus 35.71 μg percent, the group with medically unimportant parasites having the higher serum vitamin A level. The difference is too small to be of nutritional importance.

In Table VII the parameter means of the nonparasitized group are compared with the parameter means of the group with medically unimportant parasites. The only significant difference is in postintervention hemoglobin of 11.50 versus 11.31 grams percent, the medically unimportant group having the lower hemoglobin level. The difference is too small to be of nutritional importance.

In Table VIII the parameter means of the nonparasitized group are compared with the parameter means of the group with medically important parasites. No significant differences are noted between the two groups. It is apparent that asymptomatic infections with medically important parasites had little effect on the nutritional status of the infected group.

In Table IX the percentages of children with deficient, low, and acceptable biochemical values in the nonparasitized group are compared with those in the group with medically important parasites. There are no noteworthy differences in the deficient, low, and acceptable percentages between the two groups. It appears that asymptomatic infections with medically important parasites did not influence the number of children in the deficient, low, and acceptable categories.

IV. DISCUSSION

A. CAUSAL RELATIONSHIPS BETWEEN INTESTINAL PARASITISM AND MALNUTRITION

Establishing a causal relationship between intestinal parasitism and malnutrition is difficult and requires carefully controlled animal or human experimentation. Most research studies concerning human intestinal parasitism and malnutrition have been conducted in underdeveloped countries although considerable non-human experimentation has been performed in both underdeveloped and developed countries. These studies have mainly been concerned with proteins, vitamin A, vitamin B_{12}, vitamin C, iron, lipids, and carbohydrates. The investigators in the following studies attempted to show a causal relationship between intestinal parasitism and malnutrition.

1. Protein Nutritional Status and Intestinal Parasites

In a study conducted by Panda and associates in 1964 (57), chicks with acute coccidiosis produced by infection of *Eimeria acervulina* or *Eimeria necatrix* in the fourth week of life gained only 63 grams during the fifth week as compared with 247 grams for controls. Both groups had the same rate of gain during the sixth week, and during the seventh to fourteenth weeks the rate was slightly greater in the previously infected birds. Nitrogen retention during the fourteenth week was also slightly greater in the infected chicks.

Cortner (14) reviewed four childhood cases of giardiasis in which clinically manifest malabsorption was reported. His conclusions indicated positively that giardiasis can be severe enough to interfere with absorption from the duodenum and upper jejunum. Hoskins et al (31) reported hypogammaglobulinemia in two of six patients suffering from symptomatic giardiasis. The immunoglobulin deficiency was present in the two patients having the severest histopathological abnormalities. The authors state that superimposed giardiasis may intensify latent or overt immunoglobulin deficiency.

Nitrogen absorption probably is affected in clinical giardiasis although no direct studies have been made. Severe infections with pathogenic intestinal protozoa may influence nitrogen balance adversely but, according to Scrimshaw et al (69), few have been studied.

The first reported outbreaks of epidemic giardiasis were recorded in 1969 and again in 1970. Moore and associates (48) reported that 123 persons out of a total of 1094 skiers contacted after visiting Aspen, Colorado, during the 1968-1969 ski season complained of protracted, intermittent diarrhea followed by malabsorption syndromes. Stool samples were examined on 59 of these 123 persons, and 25 were found to be excreting Giardia lamblia. Forty-one of the 59 persons who submitted stool samples suffered weight losses averaging 9.7 pounds. All cases responded to treatment with quinacrine or metronidazole. Sewage contamination of the water supply was the suspected source of the infective material.

In early 1970, 23 of some 80 persons who accompanied the United States Olympic Boxing Team on a tour of Russia became ill with giardiasis. Symptoms were diarrhea, intestinal cramps, weakness, nausea, anorexia, vomiting, fever, and steatorrhea. Giardia lamblia was recovered in nine clinical cases and two asymptomatic ones. Treatment with quinacrine produced prompt relief of the symptoms. Epidemiological evidence pointed to a common source of infection in Leningrad, possibly the water supply (9). The high prevalence of Giardia in preschoolers in New Orleans may be of more than academic interest in the light of these two epidemics.

Animal nutrition researchers have long recognized that helminthic infections interfere with protein nutrition. As early as 1943, Stewart (75) at the University of Cambridge Institute of Animal Pathology studied nitrogen balance in sheep infected with a variety of nematodes. Fluctuations in protein absorption were found to parallel changes in the worm burden. The digestion of other components of the diet were not affected even in heavy infections. More recently parasitism and feedlot performances were studied in cattle at Michigan State University Veterinary College (47). Steers were exposed to the stomach worms Ostertagia ostertagia and Cooperia spp. 27 days before entering the feedlot along with worm free controls. Test cattle weighed 30 kilograms less than the controls at 216 days despite a compensatory gain during the last 90 days. Anorexia was the only apparent effect of nematode infection but was sufficient to retard

Rogers working with rats experimentally infected with Trichinella spiralis (65) observed a marked lowering of protein digestion in the immediate period four to 12 days after infection. A second and less marked response occurred after 30 days, possibly due to the departure of adult female worms from the intestinal wall. A decrease in nitrogen excretion in the urine also suggested that the acute infection affected protein absorption. By the twenty-fourth day, urinary nitrogen had increased to three times the normal amount. Rogers attributed this to inflammation and destruction of the intestinal wall. Platt and Heard showed that heavy infections of Toxocara canis in pups reduced net protein utilization, mainly by decreasing the absorption of dietary nitrogen. Nitrogen imbalance was even more exaggerated in animals fed on diets of lower protein value as compared with those on higher protein diets (60).

Darke (16) showed that human adults with heavy hookworm infections averaged 62.5 percent nitrogen absorption as compared with 73.3 percent in parasite-free subjects on the same diet and mentioned the greater importance of hookworm disease when food supplies are limited. Puerto Rican military recruits with severe hookworm disease had decreased intestinal absorption of nutrients (71). Severe hookworm infections cause more albumin loss into the gut than would be expected according to Gilles et al.(26), since the hookworms appeared to ingest tissue fluid as well as capillary blood.

In studies of nine children with heavy Ascaris lumbricoides infection, Venkatachalam and Patwardhan (92) observed a decrease in fecal nitrogen per 24 hours from 1.3 to 0.7 grams after parasites were removed. The original loss was attributed to an antiproteolytic substance secreted by the parasite. This may explain why children with inapparent *Ascaris* infections frequently show inferior growth and development.

Tripathy and associates (82) showed that *Ascaris lumbricoides* infection was associated with a defect in nitrogen absorption in five of eight children whose worm burden exceeded 40 ascarides per child.

Tripathy and associates (80) studied 12 other children with heavy *Ascaris* infections by placing them in a metabolic ward for observation and treatment. Absorption of nitrogen, fat, and d-xylose was found to be impaired. A mean reduction of five percent fecal nitrogen after deworming was found. Analysis of *Ascaris* eggs for nitrogen content revealed 3.4 mg per one million eggs. The authors concluded that since average output per child was 11.7 million eggs, only a small portion of total fecal nitrogen was accounted for by egg content. Eight of 12 children showed a concomitant increase in urinary nitrogen after deworming, demonstrating that the reduction in fecal nitrogen was real. Only three children whose dietary protein intake was 1 gram/kilogram by body weight showed noticeable improvement in nitrogen retention after deworming. Five other children with equally heavy parasite load but consuming over 2 grams/kilogram by body weight of protein showed improved absorption of nitrogen although nitrogen retention was not significantly improved. The authors concluded that children at the latter level of protein intake had more than optimum amounts of protein available for metabolic and growth needs despite losses attributable to worms.

Tripathy also found that when the worm burdens were less than 48 worms and the protein intakes were more than 2 grams/kilogram by weight, no significant overall improvement in protein nutrition occurred after deworming. However, when the worm burdens exceeded 48 worms and the protein intakes were between 1 and 1.5 grams/kilogram of body weight, a detectable improvement in nitrogen absorption was recorded after deworming.

It is interesting to note that in the above study egg productions per female _Ascaris_ averaged 383,000 eggs per day, which is considerably higher than the previously reported average of 200,000 (20).

A net loss of fecal fat amounting to 11.7 percent, the equivalent of about five percent ot total ingested calories, was seen in those children harboring more than 48 ascarides. Malabsorption of fat in the presence of human ascariasis had not been previously reported, and the authors felt that this could be a significant proportion when dietary calories are limited. Eight children with steatorrhea (fecal fat between 9.7 percent and 29.5 percent of dietary fat) also showed abnormalities in d-xylose excretion. Less than 1.2 grams of d-xylose was excreted in the urine five hours after a test oral dose of five grams. In commenting on the nature of the absorption defect observed, Tripathy and associates disagreed with Venkatachalam and Patwardhan's (92) view that antiproteolytic substances secreted by Ascaris lumbricoides are responsible for the fecal losses of nitrogen. They suggested that if this were true, antienzyme activities against both protein and fat would be necessary, and they found no evidence of the presence of a fat-digesting antienzyme. In addition, impaired absorption of the monosaccharide d-xylose cannot be explained by an antienzyme effect. Their opinion was that all of the observed absorption defects could be explained by a functional or structural lesion in the intestinal mucosa.

Later studies by Tripathy and associates (81) confirmed this opinion. Seventeen children infected with Ascaris were studied in a metabolic ward. Mean fecal nitrogen excretion amounted to 24 percent of dietary nitrogen. Eleven children demonstrated steatorrhea and impairment of d-xylose absorption, and five children showed varying degrees of jejunal mucosal atrophy based on peroral intestinal biopsy. Two to three weeks after deworming, there was a significant reduction in fecal nitrogen excretion; steatorrhea was totally corrected, and d-xylose absorption was partially corrected. The intestinal mucosal atrophy had returned to normal. The reduction in fecal nitrogen excretion after deworming was roughly proportional to worm load, but neither the defect in fat and d-xylose absorption nor the mucosal lesions could be said to parallel worm burden. Improvement in nitrogen retention after deworming was noted in children whose dietary protein intake was below 1.5 grams per kilogram of body weight, but such improvement was not noted in those children consuming higher levels of dietary protein. The authors concluded that heavy *Ascaris* infection in children can cause intestinal malabsorption which, in turn, can lead to malnutrition when dietary intakes are marginal.

In similar studies Venkatachalam and Patwardhan (92) calculated that children infected with 13 to 40 ascarides (average 26) lost approximately four grams of protein from a diet containing 35 to 50 grams of protein as a result of the deleterious effect of the worms on protein digestion and absorption..

Loughlin and Mullin (43) suggested that intestinal parasites and a variety of other causes shorten the time that food remains in the gastrointestinal tract of children ("intestinal hurry"). The result would be a lessened opportunity for digestion and absorption. Anorexia, indigestion, colitis, and bloody stools observed in severe cases of trichuriasis may fall into this category (35). Venkatachalam and Patwardhan (92) list "intestinal hurry", mechanical blockage, and mucosal damage as factors in determining the effect of ascariasis on the nutritional status of children.

Kwashiorkor has frequently been associated with intestinal helminths; Jelliffe (34) and Williams (98), among others, have expressed this opinion. Jelliffe also showed that in a child with prior growth retardation, there was a gain in body weight with no change in diet following treatment of heavy *Ascaris* infection (34).

Unpublished observations of the Institute of Nutrition for Central America and Panama (INCAP) indicated that only severe intestinal parasitism produces a detectable effect on nitrogen balance as determined by examination of children on a constant intake of protein before and after treatment (69).

Scrimshaw, Taylor, and Gordon (69) state that by interfering with intake, absorption, and retention of protein nitrogen, almost any unusually heavy infection by an intestinal helminth can probably induce protein malnutrition in individuals whose diet is otherwise adequate. Such severe intestinal helminthic infections are common in many populations The mere presence of a helminth does not, however, justify an assumption that it has clinical or metabolic significance.

2. Vitamin A Nutritional Status and Intestinal Parasites

Human diets are frequently deficient in vitamin A intake (69). The effect of infection on vitamin A metabolism is therefore important and needs further study. Children suffering from night blindness have shown rapid improvement in their eye lesions within a few days after elimination of ascarides according to authors of the World Health Organization Technical Report, Control of Ascariasis (101). They concluded that ascariasis may contribute to vitamin A deficiency although no proof of a causal relationship was given.

Shikhobalova and others studied the relationship of vitamin A and poultry parasites (72, 73). Thirty days after administration of 100, 500, or 1,000 *Ascaridia galli* eggs, chickens maintained on a constant diet showed vitamin A levels in the liver of 122, 104, and 88.5 micrograms per 100 grams body weight, respectively, compared with 177 micrograms in control birds.

An earlier study by Katsampes et al. (36) showed that intestinal absorption of vitamin A may also be impaired in the presence of *Giardia lamblia*. While studying the frequency of night blindness in the tropics, Rodger and associates (64) reported lower serum carotene and vitamin A values in persons with hookworm disease as compared with persons in the same communities without the infection. Steatorrhea and decreased absorption of vitamin A and xylose were seen in Puerto Rican recruits with severe hookworm disease by Sheehy et al.(71). Other researchers have reported malabsorption in Colombian patients with anemia, hookworms, and other intestinal parasites (90).

These studies show that infections exert a sufficiently adverse effect on vitamin A nutrition to have practical significance in animal husbandry and in public health practice (69).

3. Vitamin B_{12} Nutritional Status and Intestinal Parasites

Von Bonsdorff in Finland (94, 95) demonstrated that the fish tapeworm, *Diphyllobothrium latum*, absorbs sufficient quantities of B_{12} to cause megaloblastic anemia in affected persons. These findings have been substantiated by the use of Co^{60}, labeled vitamin B_{12} (70). Infections may be multiple but usually only one worm is present in the infected host (20).

The relationship of *Ascaris lumbricoides* infection to vitamin B_{12} nutrition has also been studied. Rojas (66) reported that after oral administration of radioactive B_{12} to heavily parasitized patients, the ovaries and gastrointestinal tracts of the ascarides contained significant amounts of radioactive B_{12}. Further research is needed to test the clinical significance of this phenomenon.

4. Ascorbic Acid Nutritional Status and Intestinal Parasites

Dodin (18) reported clinical manifestations of ascorbic acid deficiency and low urinary excretion of this vitamin in school children of Malagasy having severe ascariasis. No proof of a causal relationship was given. Among some less privileged populations, the ability of infectious disease to worsen the ascorbic acid nutrition of man continues to have public health significance (69).

5. Iron Nutritional Status and Intestinal Parasites

The fact that acute infections have adverse effects on human iron metabolism is well documented. These effects have clinical and public health importance. Infections influence iron metabolism most directly through blood loss with resulting anemia (69). Roche and co-workers (63) showed that each _Necator americanus_ causes daily blood losses of 0.031 ± 0.017 ml. of blood. Farid and co-workers (19), using the same technique, found that blood loss from _Ancylostoma duodenale_ infection was five to ten times greater than that cited for _Necator americanus_. Thus a synergistic combination of low iron intake and heavy hookworm infection has major health significance for some populations.

A fecal blood loss of about 0.005 ml. per worm per day has been reported in infections with Trichuris species. This may cause anemia in children with heavy infections of over 800 parasites (39). Part of this loss can be attributed to dysentery in such heavy infections (105).

Manchura and associates in Poland (44) described a nineteen-year-old male patient with histamine-fast achlorhydria in whom high grade anemia and growth arrest occurred in the course of giardiasis. The height of the patient corresponded to that of a twelve-year-old child. After treatment with quinacrine, the anemia disappeared and body weight and height increased. No recurrence of giardiasis was noticed after four years.

6. Lipid Nutritional Status and Intestinal Parasites

Little is known about the action of infection on fat metabolism. Increased liver and fecal fat commonly occurs after influenza and pneumonia as well as with giardiasis (69). Kotcher and associates (37) reported that unless intestinal helminth infections are very severe, fat absorption is not impaired.

Tripathy and associates (82) reported impairment of fat absorption in 8 of 12 children suffering from heavy Ascaris infections. After treatment, mean fecal excretion of dietary fat was reduced from 13.4 percent to 4.5 percent of dietary fat. There was no correlation between the degree of steatorrhea and the worm burden. Fecal fat excretion before treatment ranged from 9.7 percent to 29.5 percent.

7. Carbohydrate Nutritional Status and Intestinal Parasites

Scrimshaw, Taylor, and Gordon (69) reported no evidence of the effects of intestinal parasites on carbohydrate metabolism. Faust and Reed (21) hypothesized that the non-invasiveness of Entamoeba histolytica in certain slum dwellers of Cali, Colombia, was related to the availability of intact starch granules in the feces which are hydrolyzed by the amoeba. Inadequate protein intake in the sample population provoked a decreased pancreatic and intestinal enzyme production and an incomplete carbohydrate digestion. Forty percent of the sample population was infected with a highly virulent strain of Entamoeba histolytica. Starch configurations found in rice and Irish potatoes were more readily assimilable by the amoeba than those in maize, wheat, and sweet potatoes. The authors concluded that dietary carbohydrate need or preference as well as malnutrition may have affected the invasiveness of Entamoeba histolytica in the sample population.

Tripathy and associates (82) stated that 8 of 12 children with heavy ascariasis and steatorrhea showed abnormalities in d-xylose absorption tests. Less than 1.20 grams of d-xylose was excreted in the urine five hours after a five-gram oral dose. After treatment, there was an improvement in all eight children, but in only four were the improved values considered to be within normal range (more than 1.20 grams excretion in five hours).

Hoskins and associates (31) reported abnormal jejunal histopathology in six patients with giardiasis which returned to normal after mepacrine treatment. Four of the six patients showed functional evidence of malabsorption which was more pronounced for carbohydrates than for fats. Jejunal disaccharide activity was depressed in one patient and became normal ten days after mepacrine therapy.

It can be deducted from the preceding studies and case reports that heavy intestinal parasite infections can contribute to deficiencies of protein, vitamin A, vitamin B_{12}, vitamin C, iron, lipids, and carbohydrates in marginally nourished persons. Carefully controlled experiments, preferably in a metabolic ward environment, are required to prove a causal relationship between a particular intestinal parasite and the disease syndrome for which it is thought to be responsible.

Public health personnel working with marginally nourished populations should be aware of the nutritional implications of heavy parasitism. An active parasitic control program should be maintained among such populations to keep the intensity of intestinal parasitism at a low level.

Dr. N. Ansari, Chief of the World Health Organization's Parasitic Disease Program, in a recent speech entitled "Parasites and Progress" (3) stressed the need for more effort in the field of research on parasitic diseases. Dr. Ansari concluded that the outcome of this effort will decide who will make the progress -- man or the parasites.

B. ENVIRONMENTAL RELATIONSHIPS BETWEEN INTESTINAL PARASITISM AND MALNUTRITION

Environmental relationships between intestinal parasites and malnutrition have been noticed by medical investigators in studying low income groups living under marginal conditions of sanitation and nutrition. Poor nutrition is usually found under the same conditions of poor personal and environmental sanitation that are conducive to the propogation of intestinal parasites (99).

Beaver (104), in analyzing prevalence data on ascariasis, trichuriasis, and hookworm infections, found there is a close relationship between socio-economic status and the intensity of these infections. The most advanced communities and the most favored members within them are almost invariably the least frequently and least heavily parasitized. In considering the prevalence of infection among members of any socio-economically advancing large community, Beaver stated that the reductions in the rate of infections in successive decades are directly proportional to the degree of socio-economic advancement. These generalizations hold true for disadvantaged groups within a highly advanced country such as the United States.

Owen and associates (55) made a pilot study in Mississippi prior to the National Nutrition Survey. A total of 585 preschool children were in the sample population. Twenty-five percent of these children from families with incomes under $500 per year were parasitized as compared with ten percent of the children from families with incomes over $500 per year. The difference in prevalence was due to infections with <u>Ascaris</u> and <u>Giardia</u>. Twice as many children in the lower income families suffered from deficiencies of hemoglobin, serum iron, vitamin C, and vitamin B_{12} than did their more affluent neighbors.

Unpublished data from the National Nutrition Survey in Louisiana show that of 1651 persons from predominatly lower socio-economic backgrounds examined for intestinal parasites, 5.27 percent were infected with Ascaris, 12.30 percent with Trichuris, 0.42 percent with hookworms, and 4.66 percent with Giardia. Preliminary reports on this survey (85) revealed the sample population was also suffering from deficiencies of hemoglobin, vitamin A, and vitamin C.

Lease et al.(41) surveyed 177 Negro children from poor families in South Carolina. It was reported that these children had deficiencies of hemoglobin and vitamin C and that 73 percent were infected with Ascaris lumbricoides, Trichuris trichiura, or both.

In none of these studies was an effort made to demonstrate a direct relationship between intestinal parasitism and malnutrition by comparing test and control groups of individuals, and no estimate of relative worm burden was reported in these studies.

C. COMPARISON OF THIS STUDY WITH PREVIOUS STUDIES

The author's study is unique in that biochemical nutritional measurements were available on large numbers of children who were also examined for intestinal parasite status. The availability of these data enabled statistical comparisons of the nutritional status of test and control groups of parasitized and nonparasitized children. The author was unable to find similar field studies reported in the literature.

Previous investigators (41, 55) of malnutrition and intestinal parasitism reported the presence of both biochemically detectable malnutrition and a high prevalence of intestinal parasites in low socio-economic groups. These studies left the reader to assume that there was a causal relationship between the two. No test and control group comparisons were made nor were any estimates of worm burdens reported. Estimates of worm burdens are essential in human parasitism to determine possible adverse effects on health and nutrition.

The author's study showed that although intestinal parasite prevalence was high in New Orleans children, the worm burden was relatively low. Of 387 children examined, only seven showed heavy or moderately heavy infections which might be expected to interfere with nutrition when diets were marginal. The study showed that large numbers of light helminth and subclinical protozoan infections did not affect the nutritional status of children whose collective nutritional status was substandard. Thus, although the prevalence of medically important intestinal parasites was high in the sample population, no medical significance could be attached to the statistics other than relating them to poor personal and environmental hygiene.

The reasoning of Schaefer and Johnson (68) may help to explain why no frank nutritional deficiency disease and so few heavily parasitized children were found in the sample population in New Orleans. In reporting preliminary results of the National Nutrition Survey, these authorities commented that the general health of malnourished people in the United States is better than those in the hunger areas abroad because Americans usually enjoy pure water, a safe food supply, excellent sewage disposal, and good medical care. Hunger tends to be obscured because the poor do not live in the filth of Oriental cities where exposure to stressful insults of a hostile environment might precipitate the severe syndromes of deficiency disease. The authors concluded that if individuals suffering from the same pattern and degree of malnutrition found in the early stages of the National Nutrition Survey were transplanted to a backward area, the added insults of a hostile environment might cause them to erupt promptly with physical signs of frank nutritional deficiency diseases.

The protein nutritional status of the sample population of the author's study was far better than that reported in metabolic ward studies of Tripathy and associates (80) wherein intestinal parasites were found to affect nutritional status adversely. Only two children were found to have a total serum protein below 5.5 grams percent at the beginning of the author's study; the mean value for the sample population was 7.46 grams percent.

The majority of the infections with medically important parasites were of a mild, subclinical nature rarely incriminated in specific nutritional deficiency disease. The availability of free medical care for low-income families at Charity Hospital in New Orleans may be a factor in controling the intensity of infections in the sample population as well as the rather common custom of treating children for worms at home with drugs purchased from local pharmacies.

The study was conducted under field conditions with limited control of patients as compared to a metabolic ward type study where control is possible. Lack of control over patients made valid comparisons between certain test and control groups difficult. Other uncontrolled factors were the duration of infection, the inability to treat other than a small number of infected individuals, and the inability to follow treated individuals. Another limiting factor was the lack of a large number of light, moderate, and heavy intestinal helminth infections in each category. The study would have been more meaningful if a larger number of heavy and moderately heavy Ascaris infections had been found in the sample population so that statistically valid comparisons could have been made between those with heavy Ascaris infection and those noninfected.

D. POSSIBLE SOLUTIONS TO THE PROBLEMS OF MALNUTRITION AND INTESTINAL PARASITISM IN THE UNITED STATES

The problem of malnutrition in the United States is being attacked by attempts to alleviate poverty, ignorance, and bureaucratic neglect. Federal food stamp programs, commodity distribution programs, and supplemental maternal and infant food programs are being expanded dramatically.

Mr. E. J. Heckman, Administrator of the United States Department of Agriculture Food and Nutrition Service, recently stated (87) that one-quarter billion dollars more will be requested by the Nixon Administration to expand the food stamp program. This will bring the total spent on this single program in 1971 to over two billion dollars. The number of participants will expand from 10.2 million in February 1971 to an estimated 11.5 million in December 1971.

Plans at the federal level have been formulated to expand the school feeding programs and to include breakfasts as well as lunches. Limitations have already been removed on the number of children served free school lunches; a simple Certificate of Need from the parent is all that is required. Participation in free lunches jumped from 70 to 700 of the 800 students enrolled in one of the schools included in this study (76). A nutritional education program for homemakers in the low socio-economic levels is being conducted by the Extension Service of the United States Department of Agriculture in which Home Nutrition Aides, trained locally, are being utilized. Food enrichment programs are also being studied by both governmental agencies and private institutions (68).

A solution to the problem of intestinal parasitism in the United States may be more difficult to find. For example, this study shows that there is a surprisingly large reservoir of medically important parasites in New Orleans preschool children from low income families. Although not proven to have a significant effect on the nutritional status of the sample population, this reservior of infection would be significant in the event of a natural or manmade disaster when normal controls over food, water, sewage, housing, and waste disposal are not in operation. Ten percent of the sample population harbored medically unimportant intestinal protozoa transmitted by means of anal-oral contamination which is an indication of poor personal hygiene.

There is more interest abroad than at home directed toward eliminating or reducing the prevalence of intestinal parasites. A national plan to eradicate intestinal parasites does not exist in the United States. Disagreement prevails on the medical significance of intestinal parasites and on the need for additional control measures. Testimony before the United States Senate Select Committee on Nutrition and Human Needs demonstrated that even high-ranking legislators responsible for appropriating billions of dollars for health and welfare programs were poorly informed on the subject of nutrition and intestinal parasites. The usually well-informed Senator Ellender of Louisiana (89) made the following comments in reference to Ascaris infection, "I do not know of any area in Louisiana where there are such worms. If there are, I would like to know it and visit it. I recall campaigns in Louisiana ... when we got rid of that."

Charles E. Fraser, President of Sea Pines Plantation Company, Hilton Head, South Carolina (89), made an extensive study of intestinal parasitism in the southeastern United States. Fraser estimated that over one million persons in the Southeast are infected with intestinal parasites. Physicians interviewed in his locality agreed that there was a higher correlation between malnutrition and income level than between malnutrition and intestinal parasites. Fraser found 224 articles on ascariasis published in the United States between 1961 and 1967 but commented that not one described efforts to control ascariasis on a wide scale. The same search revealed that during the same period of time 18 Russian articles were found relating to "Results of Five-Year Work in the Ukranian Soviet Socialistic Republic on Defestation of the Population for Ascariasis and Prospects for Eliminating the Disease."

Foreign governments seem to be more concerned with the problem of intestinal parasites possibly because of the greater intensities of infection and the relatively poor nutritional status of some of their populations. In Japan mass compaigns to eradicate the helminths have resulted in reducing prevalence from 74 percent in 1922-1926 to 14 percent in 1946 (107). Even if eradication of intestinal parasites were considered desirable or feasible in the United States, the demand on high priority medical resources would be prohibitive.

Fraser stated further (°9) that in his opinion control of ascariasis and trichuriasis has not been undertaken in this country because professionals disagree over the importance of these two infections and because demands for an effective program, sanitary facilities, hygiene education, and medical treatment appear to be overwhelming. He recommended in his concluding statement: (1) immediate studies to develop unambiguous data on the relationship of Ascaris and Trichuris infections and their intensities to malnutrition and health; (2) establishment of procedures for recording the prevalence of parasites throughout the United States; (3) making reports of foreign eradication efforts available to health officers in the United States; (4) widespread educational programs at private and governmental levels; (5) improved housing and sanitation in high-prevalence areas through the medium of the Federal Housing Administration; and (6) Tulane University or other groups be provided funds for demonstrating and testing ascariasis eradication methods.

Beaver (104), in his 1961 monograph prepared for the World Health Organization entitled Control of Soil-Transmitted Helminths, stated that the use of medicine in an attempt to eradicate *Trichuris* and hookworm had to await better drugs whereas it was feasible selectively to eliminate *Ascaris* by the use of piperazine. There have not, however, been any campaigns in the United States in attempts to do so.

In discussing approaches to the control of intestinal helminthiasis, Beaver stated that the control of intestinal helminths may be viewed as a stepwise procedure beginning with populations whose major health problems are related to such basic needs as food, housing, and sanitation and end when these needs are satisfied to the extent that transmission of infections meets natural barriers. As basic individual and community needs are provided, both the transmission and the effect of parasites diminish and eventually lose public health significance. Transitional stages where climate and soil conditions are highly favorable to transmission may pose enduring problems of intestinal parasitism and at times may be aggravated by social and economic maladjustments. A control program should aim at developing natural barriers to transmission and abating the adverse social and economic effects of the infections. The emphasis on sanitation, treatment, and the wearing of shoes has esthetic value but little lasting effect on the prevalence of soil-transmitted helminths.

Hope for new medicines or the long-searched-for broad spectrum anthelminthic has been enhanced recently by publication of the results of two human field trials of dichlorvos in Puerto Rico and Costa Rica (9, 58). The drug was found to be safe and effective against Ascaris, Trichuris, and hookworms in both trials. A single 12-milligram per kilogram of body weight dose eliminated 85 percent of the hookworms, 75 percent of the ascarides, and 90 percent of the trichurides. Unfortunately, attempts to obtain permission for clinical trials of this drug in the United States have been denied by the United States Food and Drug Administration.

Concentration on social and economic affluence has tended to obscure the plight of those citizens living in poverty and ignorance in the United States. It is reasonable to assume that sufficient light has been thrown on the subject of poverty and enough resources committed to its elimination that the prevalence of malnutrition and parasitism in this country will continue to decline.

The author agrees with the researchers cited, and in particular with Scrimshaw, Taylor, and Gordon (69) that more research is needed on the effect of parasitic diseases on the nutritional state of the invaded host. Available facts indicate that most of these infections have some adverse effects on nutritional status. These adverse effects are related to the close interplay between intensity of the infection and the degree of malnutrition of the host. This relationship has public health significance wherever substantial numbers of persons at risk have nutritionally inadequate diets. Infectious diseases in conjunction with reduced food intake and altered metabolism of protein and other specific nutrients are associated with the retardation of growth and maturation of young children. The need for more protein during convalescnece from an infectious disease is another limiting factor in the growth of those children whose usual diet is a borderline protein adequacy. Infections so consistently worsen nutritional status that they must be taken into account in all clinical problems and public health programs that involve persons whose diet are inadequate or whose nutritional statuses are suboptimal.

V. CONCLUSIONS

Based on the results of this study and other corroborating data presented, the author makes the following conclusions:

1. Although the sample population was substandard in hemoglobin, hematocrit and vitamin A values when compared with the National Nutrition Survey standards (54), the protein nutritional status was relatively good. Children at this level of nutrition can withstand heavy parasitic infections without apparent interference with their protein, lipid, and carbohydrate metabolism (80).

2. Although the overall prevalence of intestinal parasitism was high (31 percent) in the sample population, the majority of the children with medically important parasites (19 percent) had light helminthic infections or asymptomatic protozoan infections. Only seven of the children had heavy or moderately heavy helminthic infections which might be expected to interfere with nutritional status when dietary intake is marginal. The presence of both soil-transmitted and feces-transmitted parasites in these children reflects the conditions of poor personal and environmental sanitation under which they live.

3. The prevalence of *Entamoeba coli* (16 percent) and *Giardia lamblia* (11 percent) was considerably higher than that reported at Charity Hospital New Orleans. This might be explained by the fact that the sample population consisted of five-year-old children who would be more susceptible to feces-transmitted parasites.

The prevalence of pinworms (Enterobius vermicularis) (2.53 percent) was higher than that reported by Charity Hospital New Orleans which uses both the Scotch tape method and stool examinations. Since pinworms are only occasionally found in the feces (20), it is believed that the real prevalence of pinworms in the sample population would be much higher than the 2.53 percent found in this study by stool examination alone.

The one case of hookworm was found in a child of a family recently emigrated from Honduras; three other members of the family were also infected. This incident demonstrates that emigrants from underdeveloped countries can bring parasitic diseases into the United States under existing health regulations.

One case of rat tapeworm infection (Hymenolepis diminuta) was discovered. Accidental human infections by this animal parasite may result when food supplies are contaminated with arthropods (rat flea larvae, beetles, etc.) carrying the cysticercoid form of the parasite.

The prevalence of Entamoeba histolytica (0.68 percent) was comparable with that reported by Charity Hospital New Orleans and reflects the gradual decrease in its prevalence in New Orleans (30).

4. Using standard statistical methodology, the author was unable to demonstrate that a real difference existed between biochemical mean values of parasitized and non-parasitized groups in the six parameters used. Therefore, the test hypothesis -- that a relationship exists between

intestinal parasitism and malnutrition in New Orleans kindergarten children -- could not be supported. Although a limited number of statistically significant differences were noticed when comparing means of small numbers of parasitized individuals against means of nonparasitized individuals, the statistical validity and the nutritional significance of these associations were questionable.

It is necessary to have large numbers of parasitized individuals in each category of infection by species and by intensity of infection before statistically valid comparisons can be made with the techniques used in this study. These large numbers are difficult to obtain for a category such as heavy Ascaris infection when random methods of selecting sample populations are used in nutritional surveys. When large numbers of parasitized individuals were found in a single category (94 cases of nonclinical Giardia or 169 cases infected with medically important parasites), statistically valid conclusions could be drawn that there was no stastically significant differences between biochemical means of parasitized and nonparasitized groups.

5. A general conclusion can be made that in nutrition surveys of this type the parasitic infections must be numerous and severe in order to show statistical correlations with biochemical parameters.

6. The author would be remiss in not elaborating on the planning stages of any parasitological portion of a nutritional survey. A careful estimate of the daily number of stool samples to be examined should be made as well as the

personnel and logistics needed to accomplish the task. Methodology should include direct smear examinations as well as concentration techniques such as the zinc sulfate flotation examination. Stool samples should be saved until all examinations are completed if at all possible and a preserved sample kept for future reference. Repeated stool examinations on the same sample population is recommended if the maximum number of infected individuals is to be determined. Those samples positive for amoeba should be confirmed by means of an iron hematoxylin or similar stain. In nutritional surveys estimates of worm burdens are needed when comparisons are to be made between nutritional status of parasitized and non-parasitized individuals. Large numbers of light helminth infections may dilute out the biochemical values of the fewer number of heavily parasitized individuals. The direct smear egg count correlates well with the more time-consuming dilution technique (4, 5, 46, 104) and is recommended when a rough estimate of worm burden is needed for survey or clinical purposes.

7. The combination of heavy parasitism and marginal nutrition frequently seen in underdeveloped countries did not exist in the sample population. Biochemically detectable malnutrition and intestinal parasitism, however, were found to exist together in the New Orleans sample population as has been reported in other surveys from Louisiana, Mississippi, and South Carolina (41, 55).

VI. SUMMARY

Allegations were made and written into the record of the United States Senate Select Committee on Nutrition and Human Needs in early 1969 that certain intestinal parasites, notably *Ascaris* and *Trichuris*, were not only highly prevalent in the lower socio-economic population of the Southeastern United States but that there was a direct correlation between this parasitism and their "hunger" or, more specifically, to their biochemically detectable malnutrition.

The author studied the intestinal parasite status and the biochemical nutritional status of 887 Negro kindergarten children in seven New Orleans public schools to determine if a relationship existed between the two conditions. Biochemical parameters used for comparative purposes were hemoglobin, hematocrit, serum carotene, serum vitamin A, serum vitamin C, and total serum proteins. Approximately 24 percent of the sample population had unacceptable values of hemoglobin; six percent had unacceptable hematocrit values; and 13 percent had unacceptable serum vitamin A levels. The children did not exhibit clinical signs of nutritional deficiency disease.

The overall prevalence of intestinal helminths and intestinal protozoa was surprisingly high. Approximately 31 percent of the children harbored one or more intestinal parasites. Nineteen percent had asymptomatic infections with medically important parasites and 12 percent harbored medically unimportant species.

Only seven of the 169 children with medically

important species had heavy or moderately heavy infections with Ascaris lumbricoides or Trichuris trichiura. Although six of these children also had unacceptable hemoglobin, hematocrit, serum vitamin A and/or serum vitamin C values, a statistically valid causal relationship could not be established. Groups of children with light helminth and asymptomatic protozoan infections showed no significant differences in biochemical measurements as compared to nonparasitized controls. The author therefore did not find a statistically significant relationship to exist between intestinal parasitism and biochemically detectable malnutrition in the sample population of preschool Negro children from seven New Orleans public schools.

This study did confirm the fact that biochemically detectable malnutrition was present in New Orleans preschool Negro children and that environmental conditions contributing to this poor nutrition were also conducive to the propogation and transmission of intestinal parasites. The low intensity of parasitic infections in New Orleans preschool children and their relatively good protein nutritional status have worked to their advantage in preventing synergistically induced overt malnutrition. The classical combination of heavy parasitism and marginal nutritional status commonly seen in underdeveloped countries (69) fortunately did not exist in the sample population. The study shows that intestinal parasitism did not play a significant role in the etiology of malnutrition in the sample population of New Orleans preschool children from lower socio-economic backgrounds.

There are no long-range plans to eradicate intestinal parasites in the United States nor are there broad spectrum antihelminthics approved for use in such a project here. The solution to the problem of intestinal parasitism as well as malnutrition in the United States appears to be centered on the improvement of the diet, living conditions, and educational levels of those disadvantaged individuals living in the lower socio-economic strata of our American society (104).

TABLE I
PREVALENCE OF INTESTINAL HELMINTHS AND PROTOZOA
(Total Number of Children Examined - 887)

Medically Important	Children Infected	Percent Positive
Ascaris lumbricoides	20	2.25
Trichuris trichiura	47	5.27
*Enterobius vermicularis**	23	2.53
Hymenolepis diminuta	1	0.12
Hookworm	1	0.12
Giardia lamblia	94	10.53
Entamoeba histolytica	6	0.68
Mixed Infections	**Children Infected**	**Percent Positive**
Ascaris and *Trichuris*	3	0.34
Ascaris and *Giardia*	2	0.23
Ascaris and *E. histolytica*	1	0.12
Trichuris and Hookworms	1	0.12
Trichuris and *Giardia*	12	1.31
Giardia and *E. histolytica*	2	0.23
Medically Unimportant	**Children Infected**	**Percent Positive**
Entamoeba coli	134	15.95
Endolimax nana	52	5.77
Entamoeba hartmanni	3	0.34
Chilomastix mesnili	1	0.12

* Diagnosed by means of stool examination

TABLE II

BIOCHEMICAL MEASUREMENTS ON CHILDREN WITH HEAVY AND MODERATELY HEAVY INFECTIONS OF ASCARIS LUMBRICOIDES

HEAVY ASCARIS (200 OR MORE EGGS PER SMEAR)

I.D.#	Hemoglobin (gm%)		Hematocrit (%)		Serum Carotene (µg%)		Serum Vitamin A (µg%)		Serum Vitamin C (mg%)		Total Serum Protein (gm.%)	
	I	II	I	II	I	II	I	II	I	II	I	II
6031*	10.4	-	35	-	62	-	19	-	0.83	-	8.25	-
7047	10.8	11.1	37	37	147	115	24	39	0.36	-	7.61	-

MODERATELY HEAVY ASCARIS (BETWEEN 40 AND 200 EGGS PER SMEAR)

I.D.#	Hemoglobin (gm%)		Hematocrit (%)		Serum Carotene (µg%)		Serum Vitamin A (µg%)		Serum Vitamin C (mg%)		Total Serum Protein (mg%)	
	I	II	I	II	I	II	I	II	I	II	I	II
1559	10.8	-	36	-	-	-	-	-	-	-	-	-
2510	12.1	11.1	37	35	132	207	40	39	0.53	0.96	8.24	7.45
3062	9.8	10.4	33	33	85	140	17	31	-	0.43	6.80	7.00
6058	11.1	10.8	36	36	150	200	10	34	0.19	1.20	7.07	6.85
7025	12.1	10.4	39	35	165	140	24	29	0.43	0.57	7.90	7.40

Note: I - Preintervention
II - Postintervention

* This child also had moderately heavy Trichuris infection (14 ceggs per smear)

TABLE III
COMPARISON OF NONPARASITIZED CONTROL GROUP
WITH HEAVY ASCARIS INFECTED GROUP*

Preintervention	Nonparasitized			Heavy Ascaris			"t" Distribution
	#	$\bar{x}$	SD	#	$\bar{x}$	SD	
Hemoglobin (gm%)	587	11.50	0.88	7	11.01	0.27	4.52**
Hematocrit (%)	587	37.09	2.31	7	36.14	1.86	1.34
Serum Carotene (µg%)	521	117.87	39.58	6	123.50	40.80	-0.34
Serum Vitamin A (µg%)	521	31.28	8.36	6	22.33	10.09	2.16**
Serum Vitamin C (mg%)	483	0.78	0.50	5	0.47	0.24	2.83**
Total Serum Protein (gm%)	509	7.46	0.54	6	7.64	0.60	-0.73

Postintervention	Nonparasitized			Heavy Ascaris			"t" Distribution
	#	$\bar{x}$	SD	#	$\bar{x}$	SD	
Hemoglobin (gm%)	537	11.50	0.77	5	10.76	0.35	4.62**
Hematocrit (%)	537	37.14	2.18	5	35.20	1.48	2.90**
Serum Carotene (µg%)	524	145.64	48.58	5	160.40	40.72	-0.76
Serum Vitamin A (µg%)	524	34.17	10.27	5	34.40	4.56	-0.11
Serum Vitamin C (mg%)	500	0.93	0.36	4	0.79	0.35	0.80
Total Serum Protein (gm%)	511	6.96	0.54	4	7.18	0.30	-1.45

*This group includes two children with heavy Ascaris infection (200 or more Ascaris eggs per smear) and five children with moderately heavy Ascaris infection (between 40 and 200 Ascaris eggs per smear)

**Statistically significant at the .05 level

TABLE IV
COMPARISON OF NONPARASITIZED CONTROL GROUP
WITH ASCARIS INFECTED GROUP

Preintervention	Nonparasitized			*Ascaris* Infected			"t" Distribution
	#	$\bar{x}$	SD	#	$\bar{x}$	SD	
Hemoglobin (gm%)	587	11.50	0.88	20	11.35	0.96	0.69
Hematocrit (%)	587	37.09	2.31	20	36.60	2.01	1.07
Serum Carotene (μg%)	521	117.87	39.58	15	122.16	32.48	-0.50
Serum Vitamin A (μg%)	521	31.28	8.36	15	32.86	14.42	-0.42
Serum Vitamin C (mg%)	483	0.78	0.50	14	0.63	0.36	1.52
Total Serum Protein (gm%)	509	7.46	0.54	17	7.61	0.60	-1.02

Postintervention	Nonparasitized			*Ascaris* Infected			"t" Distribution
	#	$\bar{x}$	SD	#	$\bar{x}$	SD	
Hemoglobin (gm%)	537	11.50	0.77	17	11.44	0.75	0.32
Hematocrit (%)	537	37.14	2.18	17	37.24	2.08	-0.19
Serum Carotene (μg%)	524	145.64	45.58	17	165.06	40.75	-1.92
Serum Vitamin A (μg%)	524	34.17	10.27	17	35.19	7.50	-0.54
Serum Vitamin C (mg%)	500	0.93	0.36	15	1.03	0.43	-0.89
Total Serum Protein (gm%)	511	6.96	0.54	17	6.92	0.32	0.35

* This group includes twenty children infected with *Ascaris*, only one light infection was reported to have been treated.

TABLE V
COMPARISON OF NONPARASITIZED CONTROL GROUP
WITH GIARDIA INFECTED GROUP

Preintervention	Nonparasitized			Giardia Infected			"t" Distribution
	#	$\bar{x}$	SD	#	$\bar{x}$	SD	
Hemoglobin (gm%)	587	11.50	0.88	89	11.52	0.78	-0.22
Hematocrit (%)	587	37.09	2.31	89	37.10	2.36	-0.11
Serum Carotene (µg%)	521	117.87	39.58	81	114.61	37.77	0.71
Serum Vitamin A (µg%)	521	31.28	8.36	81	31.77	10.42	-0.11
Serum Vitamin C (mg%)	483	0.78	0.50	74	0.77	0.48	0.17
Total Serum Protein (gm%)	509	7.46	0.54	77	7.48	0.47	-0.34

Postintervention	Nonparasitized			Giardia Infected			"t" Distribution
	#	$\bar{x}$	SD	#	$\bar{x}$	SD	
Hemoglobin (gm%)	537	11.50	0.77	87	11.51	0.69	-0.12
Hematocrit (%)	537	37.14	2.18	87	37.00	2.02	0.59
Serum Carotene (µg%)	524	145.64	45.58	87	141.63	47.68	0.73
Serum Vitamin A (µg%)	524	34.17	10.27	87	33.81	8.29	0.36
Serum Vitamin C (mg%)	500	0.93	0.36	83	0.96	0.41	-0.63
Total Serum Protein (gm%)	511	6.96	0.54	82	7.03	0.47	-1.23

TABLE VI
COMPARISON OF GROUP WITH MEDICALLY IMPORTANT PARASITES*
AND GROUP WITH MEDICALLY UNIMPORTANT PARASITES**

Preintervention	Medically Important			Medically Unimportant			"t" Distribution
	#	$\bar{x}$	SD	#	$\bar{x}$	SD	
Hemoglobin (gm%)	161	11.53	0.84	89	11.42	0.95	0.94
Hematocrit (%)	161	37.05	2.33	98	36.74	2.44	1.00
Serum Carotene (μg%)	142	110.83	36.80	86	116.19	43.34	-0.95
Serum Vitamin A (μg%)	142	31.00	10.23	86	32.64	10.62	-1.15
Serum Vitamin C (mg%)	129	0.74	0.46	81	0.75	0.54	-0.14
Total Serum Protein (gm%)	143	7.50	0.49	85	7.36	0.64	1.74

Postintervention	Medically Important			Medically Unimportant			"t" Distribution
	#	$\bar{x}$	SD	#	$\bar{x}$	SD	
Hemoglobin (gm%)	151	11.47	0.68	95	11.31	0.74	1.70
Hematocrit (%)	151	36.99	2.04	95	36.71	2.05	1.04
Serum Carotene (μg%)	149	143.65	46.76	94	152.31	47.20	-1.39
Serum Vitamin A (μg%)	149	33.05	8.16	94	35.71	9.01	-2.32***
Serum Vitamin C (mg%)	138	0.98	0.40	85	0.99	0.36	-0.19
Total Serum Protein (gm%)	143	6.99	0.47	91	7.06	0.54	-1.01

* _Ascaris lumbricoides_, _Trichuris trichiura_, _Giardia lamblia_, _Hymenolepis diminuta_, _Enterobius vermicularis_, _Entamoeba histolytica_ and hookworm

** _Entamoeba coli_, _Entamoeba hartmanni_, _Endolimax nana_ and _Chilomastix mesnili_

*** Statistically significant at .05 level

TABLE VII
COMPARISON OF NONPARASITIZED CONTROL GROUP AND GROUP WITH MEDICALLY UNIMPORTANT PARASITES*

Preintervention	Nonparasitized			Medically Unimportant			"t" Distribution
	#	x̄	SD	#	x̄	SD	
Hemoglobin (gm%)	587	11.50	0.88	98	11.42	0.95	0.78
Hematocrit (%)	587	37.09	2.31	98	36.74	2.44	1.32
Serum Carotene (µg%)	521	117.87	39.58	86	116.19	43.34	0.34
Serum Vitamin A (µg%)	521	31.28	8.36	86	32.64	10.62	-0.84
Serum Vitamin C (mg%)	483	0.78	0.50	81	0.75	0.54	0.47
Total Serum Protein (gm%)	509	7.46	0.54	95	7.36	0.64	1.36

Postintervention	Nonparasitized			Medically Unimportant			"t" Distribution
	#	x̄	SD	#	x̄	SD	
Hemoglobin (gm%)	537	11.50	0.77	95	11.31	0.74	2.29**
Hematocrit (%)	537	37.14	2.18	95	36.71	2.05	1.87
Serum Carotene (µg%)	524	145.64	45.58	94	152.31	47.20	-1.27
Serum Vitamin A (µg%)	524	34.17	10.27	94	35.71	9.02	-1.49
Serum Vitamin C (mg%)	500	0.93	0.36	85	0.99	0.36	-1.42
Total Serum Protein (gm%)	511	6.96	0.54	91	7.06	0.54	-1.63

* Entamoeba coli, Entamoeba hartmanni, Endolimax nana and Chilomastix mesnili
** Statistically significant at .05 level

TABLE VIII
COMPARISON OF NONPARASITIZED GROUP AND
GROUP WITH MEDICALLY IMPORTANT PARASITES*

Preintervention	Nonparasitized			Parasitized			"t" Distribution
	#	$\bar{x}$	SD	#	$\bar{x}$	SD	
Hemoglobin (gm%)	587	11.50	0.88	161	11.53	0.94	-0.40
Hematocrit (%)	587	37.09	2.31	161	37.05	2.33	0.19
Serum Carotene (μg%)	521	117.87	39.58	142	110.83	36.80	1.95
Serum Vitamin A (μg%)	521	31.28	8.28	142	31.00	10.23	0.30
Serum Vitamin C (mg%)	483	0.78	0.50	129	0.74	0.46	0.86
Total Serum Protein (gm%)	509	7.46	0.54	143	7.50	0.49	-0.84

Postintervention	Nonparasitized			Parasitized			"t" Distribution
	#	$\bar{x}$	SD	#	$\bar{x}$	SD	
Hemoglobin (gm%)	537	11.50	0.77	151	11.47	0.68	0.46
Hematocrit (%)	537	37.14	2.18	151	36.99	2.04	0.79
Serum Carotene (μg%)	524	145.64	45.58	149	14[illegible].65	46.76	0.46
Serum Vitamin A (μg%)	524	34.17	10.27	149	33.05	8.16	1.39
Serum Vitamin C (mg%)	500	0.93	0.36	138	0.98	0.40	-1.32
Total Serum Protein (gm%)	511	6.96	0.54	143	6.99	0.47	0.65

* Ascaris lumbricoides, Trichuris trichiura, Giardia lamblia, Hymenolepis diminuta, Enterobius vermicularis, Entamoeba histolytica and hookworm

TABLE IX
PERCENTAGE DIFFERENCES - NONPARASITIZED GROUP VS GROUP WITH MEDICALLY IMPORTANT PARASITES *

	Number							
Hemoglobin (Grams Percent)	Number		% Deficient <10		% Low 10.0-10.9		% Acceptable ≥ 11.0	
	NP	P	NP	P	NP	P	NP	P
Preintervention	587	161	4.3	4.4	20.1	19.9	75.6	75.7
Postintervention	537	151	2.0	0.7	20.3	19.9	77.7	79.4
Hematocrit (Percent)	Number		% Deficient <30		% Low 30 - 33		% Acceptable ≥ 34.0	
	NP	P	NP	P	NP	P	NP	P
Preintervention	587	161	0.3	0	6.0	6.8	93.7	93.2
Postintervention	537	151	0.2	0	4.1	2.0	95.7	98.0
Serum Carotene (Micrograms Percent)	Number		% Deficient		% Low <40		% Acceptable ≥ 40	
	NP	P	NP	P	NP	P	NP	P
Preintervention	521	142	0	0	1.9	4.2	98.1	95.8
Postintervention	524	149	0	0	0.2	0.7	99.8	99.3
Serum Vitamin A (Micrograms Percent)	Number		% Deficient <20.0		% Low 20.0-29.9		% Acceptable ≥ 30.0	
	NP	P	NP	P	NP	P	NP	P
Preintervention	521	142	12.1	16.9	32.6	31.0	53.3	52.1
Postintervention	524	149	5.0	3.4	37.2	41.0	57.8	54.6
Vitamin C (Milligrams Percent)	Number		% Deficient <0.10		% Low 0.10-0.19		% Acceptable ≥ 0.2	
	NP	P	NP	P	NP	P	NP	P
Preintervention	483	129	0	0	1.7	0.8	98.3	99.2
Postintervention	500	138	0	0	0	0	100.0	100.0
Total Serum Proteins (Grams Percent)	Number		% Deficient		% Low < 5.5		% Acceptable ≥ 5.5	
	NP	P	NP	P	NP	P	NP	P
Preintervention	509	143	0	0	0.2	0	99.8	100.0
Postintervention	511	143	0	0	1.2	0	98.8	100.0

* Ascaris lumbricoides, Trichuris trichiura, Giardia lamblia, Hymenolepis diminuta, Enterobius vermicularis, Entamoeba histolytica and hookworm

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BIOGRAPHICAL SKETCH

Daniel Willis Hubbard was born in Bay Shore, Long Island, New York, on May 23, 1923. He received his elementary and secondary education in the public schools of New York State. After two years of preveterinary training at Hofstra College, Hempstead, New York, he entered the Veterinary School of the University of Pennsylvania in Philadelphia, Pennsylvania, where he received the degree of Doctor of Veterinary Medicine in 1945. After one and one-half years of general veterinary practice in New Jersey, he entered the United States Army Veterinary Corps. Military service included overseas assignments in Puerto Rico and Ethiopia, staff and faculty assignments at the Army Chemical School and the Army Veterinary School as well as attendance at the Army Command and General Staff College.

He retired from the United States Army on August 31, 1967, in the grade of Lieutenant Colonel and entered the Tulane University School of Public Health and Tropical Medicine, receiving the Master of Public Health degree in 1968. After participating in the Louisiana State University Fellowship in Tropical Medicine during the summer of 1968 in Central America and Mexico, he became a candidate for the Doctor of Public Health at the Tulane University School of Public Health and Tropical Medicine.

Dr. Hubbard subsequently participated in the National Nutrition Survey for Louisiana as Assistant Field Director and was assigned the additional responsibility for supervising collection and analysis of stool specimens for parasitological examinations. He also participated in the Tulane University Headstart Nutrition Surveys in 1969 and 1970 wherein he was responsible for collection and analysis of stool samples for parasitological examinations in addition to other responsibilities. He was Field Director of the West Virginia National Nutrition Survey during the summer of 1969.

Dr. Hubbard is a Diplomate of the American Board of Veterinary Public Health and is licensed to practice veterinary medicine in eight states of the United States and in Puerto Rico. He is a member of the Phi Zeta veterinary honorary society and the Delta Omega public health honorary society. Other affiliations include membership at the local, state, and national levels in the American Veterinary Medical Association, the American Public Health Association, and the American Society for Tropical Medicine and Hygiene.

He is married and has two children.