Data from the
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Series 11
Number 168

Selected Genetic Markers of Blood and Secretions

for Youths, 12-17 Years of Age

United States

Percentage distributions of nine genetic markers, including ABO blood type, secretor ability, haptoglobin type, transferrin type, and group specific component type, are presented and discussed by age, sex, race, geographic region, family income, and parental education for youths aged 12-17 years in the United States, 1966-70. Some comparisons are made with earlier published estimates.

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SELECTED GENETIC MARKERS OF BLOOD AND SECRETIONS FOR YOUTHS 12-17 YEARS OF AGE

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INTRODUCTION

This report presents the frequencies of certain selected genetically determined markers of the blood and secretions as distributed by race, sex, geographic region, income, and education.

Data source.—The data were collected during the third cycle of the Health Examination Survey, which was limited to a proportionately representative sample of noninstitutionalized youths aged 12-17 years in the U.S. population.

Cycle I of the Health Examination Survey was conducted from 1959 to 1962 to obtain information on the prevalence of certain chronic diseases and the distribution of various anthropometric and sensory characteristics in the civilian noninstitutionalized population of ages 18-79 in the continental United States. The general plan and operation of the survey and of Cycle I are described in two previous publications.[1,2]

Cycle II of the Health Examination Survey, conducted from July 1963 to December 1965, involved the selection and examination of a probability sample of noninstitutionalized children aged 6-11 years in the United States. During this program 96 percent of the 7,417 children selected for the sample were examined. The primary focus of Cycle II was on health factors related to growth and development as determined by a physician, a nurse, a dentist, and a psychologist and on a variety of somatic and physiologic measurements performed by specially trained technicians. The detailed plan and operation of Cycle II and the response results are described in Series 1, No. 5 of *Vital and Health Statistics.*[3]

Cycle III of the Health Examination Survey, conducted from March 1966 to March 1970, was essentially an agewise extension of Cycle II. The sample design of Cycle III was similar to that of Cycle II in that it utilized the same 40 sample areas and the same segments. It was more similar to Cycle II than to Cycle I in form, content, and style, and its major emphasis was on factors of "normal" growth and development rather than on chronic diseases. During Cycle II, two separate caravans were used simultaneously for the first 25 locations; for the remaining 15 locations, the two were consolidated into one caravan. During Cycle III, however, only one

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caravan was used for all 40 locations, which created a different itinerary or sequence of locations around the United States, even though the identical sites and even primary sampling units were used again. The average time interval between locations was about 3 years. The plan and operation of Cycle III are described in Series 1, No. 8 of *Vital and Health Statistics.*[4]

Genetic markers examined.—The genetic markers examined comprise red blood cell antigens of the ABO system and the Rh system (D, C, c, E, e, and combinations thereof); plasma proteins including haptoglobin phenotypes, transferrin phenotypes, and group specific component phenotypes; and in addition, a genetically determined marker of salivary secretions: ABH secretor ability.

Most of the results of the three cycles of the Health Examination Survey are published in Series 11 of *Vital and Health Statistics.*

BACKGROUND: RATIONALE AND REVIEW OF LITERATURE

Since E. B. Ford[5] first defined the term "polymorphism," there has been a growing recognition of the existence of numerous polymorphic genetic markers and their importance not only in delineating different genetic groups[6,7] but also in their relationship to differential disease susceptibility.[8-11] The differences in frequencies observed in various racial groups and geographic areas have been published in volumes of tables[12-14] and individual reports. These frequencies have been based on evaluations of numerous series of people, including mainly blood donors and large and small samples of diverse population groups from various countries. However, very few samples have been random or systematic, and none have been systematic representative samples of the U.S. population. Reliable statistics on genetic marker frequencies can be valuable not only as population descriptors, but also as a means for better understanding host factors in disease etiology and prognosis. This potential value was the incentive to incorporate the collection of such data into Cycle III.

NEED FOR POPULATION FREQUENCY DATA ON GENETIC MARKERS

Field studies are increasingly becoming the basic epidemiologic approach to the investigation of health problems. For field studies, as well as for the more strictly genetically oriented investigations in population genetics, accurate estimates of baseline population frequencies of simply inherited marker traits are essential. Moreover, these genetic parameters are very useful as epidemiologic parameters in studies that are primarily epidemiologic and not necessarily genetic. Genetic marker traits such as those of the blood components—red blood cell (RBC) antigens, plasma proteins, secretor ability, and so forth—characterize a population and show considerable variation with ethnic and racial composition. An important question is whether genetic markers are also correlated to either the epidemiologic agents being examined or those being controlled.

The need for representative, unbiased estimates of genetic marker frequencies of a U.S. population base may be considered in terms of (1) the purpose for which these data are required, that is, their function; and (2) the inadequacy of the frequency data presently available.

Applications of frequency distributions of genetic markers.—Genetic marker frequency data are needed for genetic studies that require estimates of mutation rates, selection, genetic drift, inbreeding, migration, racial intermixture, population admixture and consanguinity, as well as determination of zygosity in twin studies. Although such investigations examine primarily genetic problems, they provide demographic descriptors and important information on host factors applicable to health problems.

Although classical genetic studies are easily performed with laboratory organisms of isogenic stocks and inbred lines where gene fre-

quencies are known, investigations in human genetics depend on the relative reliability of available population frequency data, because the remaining genetic calculations are based on such data. Inaccuracy of population frequency data necessarily alters the validity of all statistics derived therefrom or compared to them.

Genetic marker frequencies are also needed for epidemiologic studies dealing with associations between blood groups and diseases, the role of genetic factors in differential susceptibility to various diseases, differential fertility, mortality, response to drugs (pharmacogenetics) and other extrinsic agents, as well as for studies attempting to evaluate the role of genetic factors and/or the interaction of environmental and genetic components.

Especially in chronic diseases, but even in acute and infectious diseases, there is increasing recognition of the importance of constitutional or host factors as agents that must be considered in addition to and along with environmental agents. Many of these so-called constitutional risk factors are basically genetic in nature, and thus the relative role of genetic factors in the etiology of disease concerns not only the human geneticist but also the epidemiologist.

Individuals with various genetically determined marker traits (often variants within the normal range) show differential susceptibility to specific diseases. Even some infectious diseases such as malaria, for which the causative organism as well as the vector have been identified, show differential manifestation in persons of different genotypes, for example, persons with hemoglobin variants S, C, E, K, and M.

Besides the clear-cut malaria-S hemoglobin relationship, many studies suggest a differential sucептibility to various chronic diseases among persons of different *red blood cell antigen types.*[6,11,15-24] Careful examination reveals that some of the reported associations between blood groups and chronic diseases are well established. However, some findings are still questioned because of the use of unsatisfactory controls. The inadequacy of blood donor series has been demonstrated in the observed significant differences among hospital donors, Red Cross donors, and "population" frequencies used for studies in the same community.[25] Yet investigators have been hampered by the lack of satisfactory population frequency data for comparison purposes.

Another use for reliable baseline genetic marker frequency data is in epidemiologic studies, even where the role of hereditary components per se is not under study, because genetic markers are valuable as indicators of sampling reliability. For example, case-control studies usually should include cases similar to controls in all characteristics except those under study or at least cases representative of the same universe. By comparing the respective frequencies of various marker traits in the cases and controls, these marker traits can be used as indicators to determine any differences between the two groups. Moreover, the cases and controls must be compared with each other as well as with the total population from which they are believed to be derived because the relative frequencies of genetic marker variants are dissimilar in different populations, that is, for different racial and ethnic groups, and even by geographic area for the same racial-ethnic group. Either cases or controls may show aberrant frequencies relative to the reference population; or both cases and controls, although similar to one another, may be different from the supposed reference population.

Thus genetic marker traits are not only genetic but also epidemiologic parameters and thereby serve a useful methodologic role in epidemiology.

Inadequacy of available frequency data.— Probably the most well-known and the best documented of the genetic marker traits are the ABO blood groups. In 1958, Mourant, Kopec, and Domaniewska-Sobczak published *The ABO Blood Groups. Comprehensive Tables and Maps of World Distribution,*[13] which was the best collection of frequencies available; and that volume subsequently was updated.[14] Yet none of the U.S. frequencies listed therein could be considered a representative sample of the United States or of any U.S. geographic region. In the 1958 edition,[13] the U.S. frequencies are a conglomeration of small samples from heterogeneous sources, some dating as far back as 1907. In addition to being small in numbers, the samples comprise mainly blood donors or groups with other specialized demographic characteristics

(see table A). Moreover, none of the frequencies listed are classified by sex or other commonly used epidemiologic categorizations, and, because they pertain to donors, the frequencies represent primarily male subjects. Although the updated tabulations in Mourant's 1976 edition[14] apply to more recently obtained samples, they involve the same problems of source selection and so forth.

The importance of current population-based statistics cannot be overemphasized. In addition to the fact that blood typing techniques were not as accurate in some of the early studies as they are today, Buckwalter and Knowler[26] found secular differences reaching statistical significance in samples taken in the same hospitals in Iowa over 17 different years. In another study of blood group frequencies of donors from two different donor organizations in the same city during the same time period (Baltimore, July-August 1963), the two samples yielded significantly different distributions for white donors.

Although donor samples have often been used for obtaining "population frequencies," especially in Great Britain and other European countries, for the United States the representativeness of such samples is open to question. This question exists even for the ABO blood groups. The frequency data on many other blood components depend on statistics from the British population, Norwegian samples, Milwaukee blacks (for S^u), or Seattle donors (for haptoglobins), representing the "best" statistics available.

In summary, although some genetic marker systems have been known for longer than 75 years—ABO blood types were discovered by Landsteiner[27] in 1900—no reliable frequency data exist on population samples for the U.S. population as a whole, for various U.S. geographic regions, or for subclassifications by age or sex. Many frequencies reported are derived from blood donor samples that often are not representative of the total population as just indicated.

GENETIC MARKER TRAITS

Erthrocyte antigens—ABO and Rh blood group systems.—The significance of the ABO and Rh systems with regard to health is well recognized. The ABO and Rh systems are the most important red blood cell (RBC) antigen systems in terms of transfusion, maternal-fetal effects, and likely associations between blood groups and diseases. In tissue matching for transplantation, the ABO system may be as important as the histocompatibility. Consequently, the ABO and Rh systems were selected for study. About 10-12 established systems of genetically determined RBC antigens exist, as well as the less well-known "private" or family systems, which involve low-frequency antigens, and the "public" systems, which involve high-frequency antigens. Although those systems also may be of medical importance, a large-scale survey of the public and private systems was not considered feasible because of their extreme relative frequencies—high and low, respectively—and the difficulty in obtaining antisera.

Plasma proteins.—The plasma proteins were described by Harris[28] as "an exceedingly complex mixture of many different protein species with diverse physiological functions."[28] With the development of new methods of analysis of protein mixtures, this heterogeneity has become more apparent, and certain components or fractions have demonstrated clear-cut genetically determined differences. Moreover, although some pathologic types do occur, many components show so-called normal variations that represent true polymorphisms, just as the ABO blood group system and other RBC antigen systems do. Many variants occur commonly in human populations, so that normal persons can be classified into one type or another according to the particular properties of the specific proteins involved. By means of simple classical electrophoresis either in free solution or in a supporting medium such as filter paper, agar, or starch grains, human plasma proteins can be fractionated into multiple groups.

Individuals possessing variants of a given protein fraction are grouped according to their characteristic phenotype with regard to that protein fraction, just as individuals are grouped with regard to their ABO types.

Haptoglobins.—Haptoglobins are plasma protein components that have the distinctive property of complexing and forming a stable compound with hemoglobin, that is, they are

Table A. Number and percent distribution of specified population by blood type, according to race and area: ABO system, test with anti-A and anti-B antisera

Area and race	Population	Author	Number	Blood type			
				O	A	B	AB
				Percent distribution			
UNITED STATES							
Colorado, Denver (s) RH.	Donors	Charney 1969	3648	47.1	40.4	8.9	3.7
Connecticut, New Haven (s) ABH-Seer.	Students (male)	Niederman et al. 1962	1000	43.1	42.2	11.0	3.7
Indiana, Adams County	'Amish'	Jackson et al. 1968	892	15.6	64.6	11.4	8.4
Indiana, Adams and Wells Counties	'Swiss'	Jackson et al. 1968	619	60.6	31.5	5.8	2.1
Iowa	White donors	Buckwalter et al. 1958	6313	45.8	41.6	9.0	3.6
Iowa, Iowa City (s) S.,C.	Donors (about 2% Negroes)	Buckwalter & Knowler 1958	49979	44.8	42.3	9.4	3.5
Michigan, Jackson County	White Protestant couples with non-Slavonic surnames	Reed & Ahronheim 1959	1116	46.3	41.7	8.4	3.6
Missouri, St. Louis	White donors	Sievers 1959	32945	45.3	41.3	9.9	3.5
New York	Volunteer donors	Osborne & de George 1962	4738	42.8	38.6	13.4	5.2
New York	Non-Jewish donors (from surnames)	Macmahon & Folusiak 1958	548	51.3	33.6	11.3	3.8
Ohio, Holmes County	'Amish'	McKusick et al. 1967	1027	34.0	53.9	6.0	6.0
Pennsylvania, Allegheny County (s)A.,S.	Largely white	Kaplan et al. 1964	3871	41.0	41.2	12.6	5.2
Pennsylvania, Franklin County	'Dunkers'	Glass et al. 1952	228	35.5	59.2	3.1	2.2
Pennsylvania, Pittsburgh (s)Schools	White school-children	Kaplan et al. 1964	1578	38.6	39.9	15.8	5.6
Pennsylvania, Pittsburgh	White donors (males)	Kaplan et al. 1964	1959	42.9	37.9	12.9	6.3
Texas	'Mexicans' (from surnames)	King et al. 1955	1597	60.2	28.3	9.0	2.4
Utah, Salt Lake City	Student donors	Mayeda 1966	247	44.9	43.7	9.3	2.0
UNITED STATES WHITES ABROAD							
Japan		Furuhata et al. 1954	400	38.5	42.0	13.8	5.8
UNITED STATES NEGROES							
Alabama, Birmingham	Children	Casey et al. 1968	610	49.5	26.9	20.0	3.6
Florida, Miami	Donors	Butts 1955	502	48.6	24.3	23.1	3.8
Iowa	Donors	Buckwalter et al. 1958	6722	49.1	26.5	20.1	4.3
Missouri, St. Louis	Donors	Sievers 1959	1395	51.1	25.3	19.3	4.3
UNITED STATES NEGROES ABROAD							
Japan		Furuhata et al. 1954	100	49.0	34.0	15.0	2.0
UNITED STATES CITIZENS ABROAD							
Turkey	Navy	Mizan et al. 1963	253	41.9	43.5	9.1	5.5

SOURCE: Table 1.1 in reference 14.

hemoglobin binding. In conventional electrophoresis, they form a part of the alpha$_2$ fraction. When plasma or sera from normal individuals of European ancestry are subjected to starch gel electrophoresis, three distinct types (1-1, 2-1, and 2-2) can be recognized as a result of genetically controlled differences in this part of the alpha fraction.

The relationship of the various types to differential disease susceptibility remains to be elucidated, but the clear-cut geographic and population differences suggest that there may be interesting associations. Quantitative variation in haptoglobin levels in disease states is well known, and possible interactions with qualitative variation have been suggested. Although the absence of haptoglobins occurs as a temporary pathologic state in certain hemolytic conditions (ahaptoglobinemia), the absence of haptoglobins is also found in a certain percent of apparently healthy individuals in all African Negro populations and in the black American population. This finding suggests the possible existence of a "silent" allele in these populations.

The observation of temporary haptoglobinemia and other evidence suggest the importance of haptoglobins in health and disease, but these findings still remain to be clarified. The physiologic role of haptoglobin is of interest; Giblett[29] suggested that, in addition to being a hemoglobin binder, haptoglobin might have other properties, such as the binding of some other protein or proteins, possibly hormones, enzymes, or toxins.

Furthermore, the haptoglobins vary quantitatively with various disease states. Regarding levels of haptoglobins, Giblett[29] noted:

> "The normal haptoglobin level, expressed in terms of the milligrams of hemoglobin bound per 100 ml. of serum, is about 50 to 150 milligrams per ml. This level is usually increased in diseases associated with an inflammatory process or tissue necrosis. Thus haptoglobin quantitation is not a specific diagnostic aid, having about the same significance as the erythrocyte sedimentation level.
>
> "Laurell and Nyman[30] in Sweden and Allison ap Rees[31] in England pointed out that in diseases associated with increased red cell destruction, the haptoglobin level is either decreased or entirely absent."[29]

Moreover, there is good evidence of an interaction between quantitative and qualitative variation in both normal and pathologic states, but the nature of this interaction remains to be resolved. The relative quantitative relationship may be 1-1 > 2-1 > 2-2, and quantitative differences as well as qualitative differences may be under genetic control.[30]

Transferrins.—The transferrins are another series of genetically determined protein variants discovered by the application of starch gel electrophoresis to the study of human plasma. Transferrin is the iron-binding globulin that forms a part of the beta fraction in conventional electrophoresis, and thus this component was referred to as "beta-globulin" in many of the earlier discussions.

In a majority of racial groups yet studied, only one transferrin, C, is present, although two transferrins can be demonstrated in the serum of some individuals.

So far, more than nine types of transferrins differing in their electrophoretic mobility have been distinguished. Transferrins moving more slowly than C toward the anode at pH 8.6, found in the American black population and in Australian aborigines, were named "D." Type CD occurs in as much as 10 percent of some Negro populations. Transferrins moving more rapidly than C were named "B" and have been found in Caucasians, particularly the Canadian groups studied.

As for the role of transferrins in health and disease, many interesting possibilities and unanswered questions remain. Although the transferrins bind iron, there is no confirmed association with iron diseases. Moreover, the rates of iron utilization were very much the same for the different phenotypes, so that no differences were detected in the transport and utilization of iron bound to those transferrins tested. Certain bacteriostatic properties have been reported for transferrins, a fact that raises the question of possible selective value of transferrin variants in infectious diseases.

Group specific component (Gc) types.—Another group of protein variants for which alleles appear to determine the formation of

qualitatively distinct forms are the electrophoretically distinct types of particular alpha$_1$ globulin[32] known as Group specific component (often referred to as the Gc types). Gc types were first described in 1959 by Hirschfeld.[33] By slight modification of an earlier immunoelectrophoretic technique, he observed qualitative differences in alpha$_2$ globulins of normal human serum, independent of haptoglobins. The phenotypes are also detectable by starch gel electrophoresis using a modified technique designed by Bearn.[34] Normal sera are classified into three different phenotypes: Gc 1-1, Gc 2-1, or Gc 2-2. A few rare variants have been observed.

The physiologic functions of Gc types are not yet known, but, as with other genetically determined components of the blood and body fluids, their existence and the presence of variants probably are meaningful in health and disease.

ABH secretor ability.—The ABH antigens found on erythrocytes are present in alcohol soluble form on almost all cells of the body, except possibly nervous tissue. Moreover, about 70-80 percent of Caucasians secrete these antigens in water soluble form into the body fluids—saliva, seminal fluid, milk, and so forth. These individuals are called secretors. As first demonstrated by Schiff and Sasaki[35] in 1932, persons who are either homozygous or heterozygous for the secretor gene (whose locus is completely independent of the ABO locus) are secretors. Thus the ability of the ABO alleles to express themselves in the saliva and body fluids depends on the secretor locus, and the ABO locus merely determines which of the ABH antigens are to be secreted.

The importance of the secretor characteristic in differential susceptibility to duodenal ulcer is well documented.[20-22] Other suggested relationships, such as with rheumatic heart disease, are controversial.[36-38] Recently, increased risk of airway obstruction has been reported for nonsecretors as compared with secretors.[39]

The frequency of secretor ability varies in different populations, having been estimated at 75 percent for the U.S. white population, 61 percent for the U.S. black population, 100 percent for American Indians, and 86 percent for Finnish and Danish populations.

In conclusion, the potential usefulness of genetic marker statistics for epidemiologic and genetic research, as well as for public health purposes, could be documented at great length; but for simplicity, three most apparent reasons have been considered briefly:

(1) The needed population baseline frequencies (in a normal healthy population sample) are not otherwise available.

(2) Such frequencies are essential to certain types of population genetic studies and most valuable in many other genetic and epidemiologic investigations as population descriptors.

(3) Growing evidence suggests that so-called normal variants in blood components and other genetic markers may be associated directly or indirectly with differential disease susceptibility and response to environmental agents (including drugs), so that providing baseline frequencies to assist further research may help to define high-risk groups and clarify the evolution of disease states in healthy individuals.

METHOD

At each of the 40 preselected locations (see appendix I for survey design) throughout the United States, the youths were brought to the centrally located mobile examination center for an examination that lasted about 3½ hours. Six youths were examined in the morning and six in the afternoon. Except during vacations, they were transported to and from school and/or home.

After entering the examination center, each youth's oral temperature was taken, and a cursory screening for acute illness was made. If

illness was detected, the youth was sent home and reexamined later. The examinees changed into gymnasium-type shorts, cotton sweat socks, a terry cloth robe; and, for the girls, a light sleeveless top. All six then proceeded to different stages of the examination, each one following a different route. The 3½-hour examination was divided into six 35-minute periods, each consisting of one or more detailed examinations at a designated station. At the end of each period, the youths rotated to another station so that at the end of 3½ hours each youth had been given essentially the same examinations by the same examiners, but in a different sequence. Four examination time periods were allocated to examinations by a pediatrician, a dentist, and a psychologist (two periods), and the other two were allocated to a group of examinations performed by highly trained technicians. This last group of examinations consisted of X-rays of the chest and hand-wrist, hearing and vision tests, measures of respiratory function, a 12-lead electrocardiogram, a submaximal exercise tolerance test on a treadmill with chest leads to a continuous electrocardiogram, a battery of body measurements, grip strength measurement, examination of blood and (on girls only) urine cultures for bacteria, a school questionnaire, and a privately administered health behavior and attitude questionnaire.

SAMPLE COLLECTION AND SHIPMENT

The ABH secretor types were determined from the saliva sample collected immediately after the dental examinations from all subjects who did not have actively bleeding gums. No attempt was made to promote more than normal secretion, nor was the subject allowed to eat or drink during the examination period prior to the collection of the saliva sample. After collecting at least 2 ml of saliva, 2 drops of 0.2 percent merthiolate was added to the sample for each 1 ml of sputum collected. The sample was capped and then frozen at −20° C until shipment.

A venipuncture was performed by the physician at the beginning of the physical examination with the assistance of the nurse. Blood samples for a variety of chemical and laboratory genetic determinations were drawn from the anticubital fossa while the subject was supine. The whole blood for the genetic marker determinations was collected in a 15-ml vacutainer containing 2 ml of ACD Solution A to prevent coagulation, and then refrigerated.

The saliva samples were packed in dry ice and sent to Dr. Wilma Bias of the Johns Hopkins Immunogenetics Laboratory (then located at the Baltimore City Hospitals) for analysis. The blood samples were packed in regular ice and sent to the same destination.

LABORATORY PROCEDURES

ABO and Rh types were determined by standard saline tube agglutination with licensed blood-banding reagents. The indirect Coombs test was performed on all D-negative cells to test for presence of the D^u variant. Reverse grouping using the subjects' plasmas and known group A and B red cells was performed to confirm ABO typing.

Haptoglobin, transferrin, and Gc groups were typed after vertical polyacrylamide gel electrophoresis by using a modification of the method described by Peacock et al.[40] A 7-percent gel was used with the buffer system of Kitchin.[41] Five microliters of an approximately 0.1-g/ml solution of hemoglobin was added to each 250-μl serum sample. Fifteen microliters of each sample was inserted in the gel slots, and electrophoresis was performed for 5 hours at 10 V/cm. After electrophoresis, the gel was washed in 1 M acetic acid for 15 minutes, then stained in a 10-percent guaiacol solution for 20 minutes to resolve the haptoglobin bands. This solution was prepared by adding 20 ml of guaiacol to a mixture of 90 ml of glacial acetic acid, 55 ml of distilled water, and 35 ml of 5 N sodium hydroxide. Immediately before staining, 18 ml of 5 percent hydrogen peroxide was added to the solution. After haptoglobin types were determined, the guaiacol solution was aspirated off the gel; the gel was washed in two changes of distilled water and stained for 45 minutes with 1 percent amido black in 10 percent acetic acid. The gel was destained in 10 percent acetic acid until the background was

clear. Transferrin and Gc groups were then determined.

For secretor testing, at least 2 ml of saliva was collected from each subject, 0.05 ml of aqueous 4 percent merthiolate was added as a preservative, and the sample was frozen at -20° C. Before testing, the samples were thawed, boiled for 10 minutes, and centrifuged. The clear supernatant was tested for A, B, or H substance by a semiquantitative agglutination inhibitions test in which 0.05 ml of serial dilutions of the heat-inactivated saliva was incubated for 5 minutes with 0.05 ml of a standard dilution of anti-H (*Ulex europaeus* seed extract) or anti-A, or anti-B antisera. Erythrocytes of the appropriate blood group were added, the tubes were centrifuged for 15 seconds at 3,000 rpm, and the results were graded from 0 to 4+ agglutination. Zero agglutination indicated positive secretor status.

Hemoglobin quantitation was performed on the ACD blood sample.[42] A small portion of the blood sample was centrifuged at 15,000 rpm, and 10 μl of the packed cells was blown into 5 ml of dilute ammonium hydroxide (4 ml/l). The solution was mixed thoroughly to hemolyze the cells and saturate the hemolysate with oxygen. Then the solution was read in a Perkin-Elmer spectrophotometer at 540 mμ. The reading on the density scale multiplied by the molecular extinction coefficient of hemoglobin at 540 mμ (14,800) multiplied by the molecular weight (16,700) multiplied by the dilution factor (500) gives milligrams of hemoglobin per milliliter of packed cells. Grams percent hemoglobin of the whole blood was obtained by dividing milligrams per milliliter by 10 and multiplying by the hematocrit.

$D_{540}/14{,}800 \times 16{,}700 \times 500$ = hemoglobin, mg/ml

mg/ml/1,000 X 100 X hct = whole blood hemoglobin, g%

The ACD solution used as anticoagulant is slightly hypotonic, and the red cells absorb water. This absorption results in a decrease in the mean corpuscular hemoglobin concentration (MCHC). The average MCHC of blood stored in the ACD solution for 7 days is 25.3 as compared with a normal value of 32 (*Technical Manual of the American Association of Blood Banks*[43]). To obtain normal estimates, the value obtained for milligrams per milliliter of packed cells should be increased by about 20 percent.

RESULTS

The weighted frequency distributions by race for ABO, Rh, haptoglobin, transferrin, and group specific component types are presented in tabular form and discussed briefly. Frequencies are presented for white and black youths, tabulated by categories of sex and age, geographic region, family income, and education of parent or guardian. Because genetic marker frequencies vary markedly by race, all data were examined separately for white and black groups, rather than combined. The small number of individuals in the sample belonging to other racial groups (e.g., Orientals or American Indians) precludes presentation of sets of tabulations for those groups separately, and the recognized differences in genetic marker frequencies preclude pooling with data for white or black youths. Consequently, the data from "other races" were not considered.

ABO BLOOD TYPES

For samples upon which satisfactory ABO determinations could be carried out, six ABO categories are designated: O, A_1, A_2, B, A_1B, and A_2B; the A type was subclassified into A_1 and A_2.

Race.—As might be expected from published series[14,26,44-75] (see tables A and B), U.S. black youths have a very markedly higher frequency of B type, more than twice that of U.S. white youths (21.2 versus 10.2 percent, respectively), a slightly higher frequency of O (47.5 versus 44.3 percent, respectively), a markedly lower frequency of A (23.4 versus 35.2 percent, respectively, for A_1 and 3.4 versus 6.9 percent, respectively, for A_2) (table 1, figure 1).

Sex and age.—Among white youths aged 12 through 17 years, no significant differences

Table B. Number and percent distribution of specified population by blood type, according to race and area: ABO system, test with anti-A, anti-A_1, and anti-B antisera

Area and race	Population	Author	Number	Blood type					
				O	A_1	A_2	B	A_1B	A_2B
				Percent distribution					
UNITED STATES									
California, San Francisco Bay	Whites	Reed 1968	8962	45.4	31.9	8.7	10.7	2.5	0.8
California, San Francisco Bay	'Mexicans'	Reed 1968	335	55.5	22.1	5.1	13.1	3.9	0.3
Georgia, Bullock and Evans Counties	Whites	Cooper et al. 1963	333	51.7	29.1	11.7	6.0	1.2	0.3
Iowa (s) S., secretion	Controls	Newman et al. 1961	1261	44.6	33.6	7.0	11.4	2.5	0.9
Iowa, Iowa City	Controls	Buckwalter et al. 1962	1355	43.5	34.8	6.5	11.5	2.8	1.0
Massachusetts, Boston (s) S., Rh, MNS, P Le.K	Hospital staff	Sanger & Race 1950-51	94	53.2	36.2	9.6	1.0	0.0	0.0
Massachusetts, Boston	Whites	Dublin et al. 1964	605	46.4	28.6	8.6	12.6	2.6	1.2
Michigan, Tecumseh	Of West European extraction	Shreffler et al. 1971	8965	43.7	34.0	9.6	9.0	2.6	1.1
New York City	Whites	Miller et al. 1951	5000	43.8	30.4	8.6	12.6	3.4	1.2
Pennsylvania, Lancaster County	'Amish'	McKusick et al. 1967	215	10.7	65.1	8.8	4.7	7.0	3.7
Tennessee, Hancock County and Virginia, Lee County	'Melungeons'	Pollitzer & Brown, W. H. 1969	177	35.6	23.0	27.3	7.3	2.3	4.5
Washington, Seattle (s)S., allergies	Whites	Vanarsdel & Motulsky, 1959	5657	42.4	34.6	8.9	10.6	2.5	1.0
West Virginia	Whites	Juberg 1970	1412	45.9	31.4	9.9	9.1	2.7	1.0
Negroes									
California, San Francisco Bay		Reed 1968	3146	49.0	19.2	8.5	19.2	2.7	1.5
Georgia, Bullock and Evans Counties		Cooper et al. 1963	300	54.0	16.7	8.0	19.3	0.3	1.7
Georgia, Sapelo Island		Robinson et al. 1967	78	64.1	12.8	9.0	11.5	0.0	2.6
North Carolina	'Coloured' (non-Indian)	Pollitzer et al. 1966	111	65.8	24.3	4.5	2.7	1.8	0.9
South Carolina, Charleston	Gullah	Pollitzer 1958	514	49.8	13.0	8.9	24.7	1.0	2.5
South Carolina, James Island	Gullah	Pollitzer et al. 1964	151	53.0	18.5	7.3	17.9	0.7	2.6
West Virginia		Juberg 1970	133	54.9	22.3	4.8	15.8	2.3	0.0

SOURCE: Table 1.2 in reference 14.

appeared between males and females or by age: The ABO distribution appeared quite similar for males and females of pooled ages and also did not show any discernible age patterns (table 1). The highest type O frequencies were found in 14-year-old males (46.7 percent) and 13-year-old females (47.5 percent) and the lowest in 15-year-old females (41.0 percent), results that are neither very different from the 44.3 percent for all white male youths or 43.6 percent for all white female youths. The highest type A_1 frequencies appeared in 15-year-old males and 15-year-old females (37.7 and 38.4 percent, respectively). Again this result was not very different from the totals (34.3 and 36.0 percent, respectively) and did not appear to indicate an age-related trend, as the lowest frequency (30.5 percent) occurred in 16-year-old males. Although the highest type A_2 frequency was found in the oldest males (9.4 percent) and

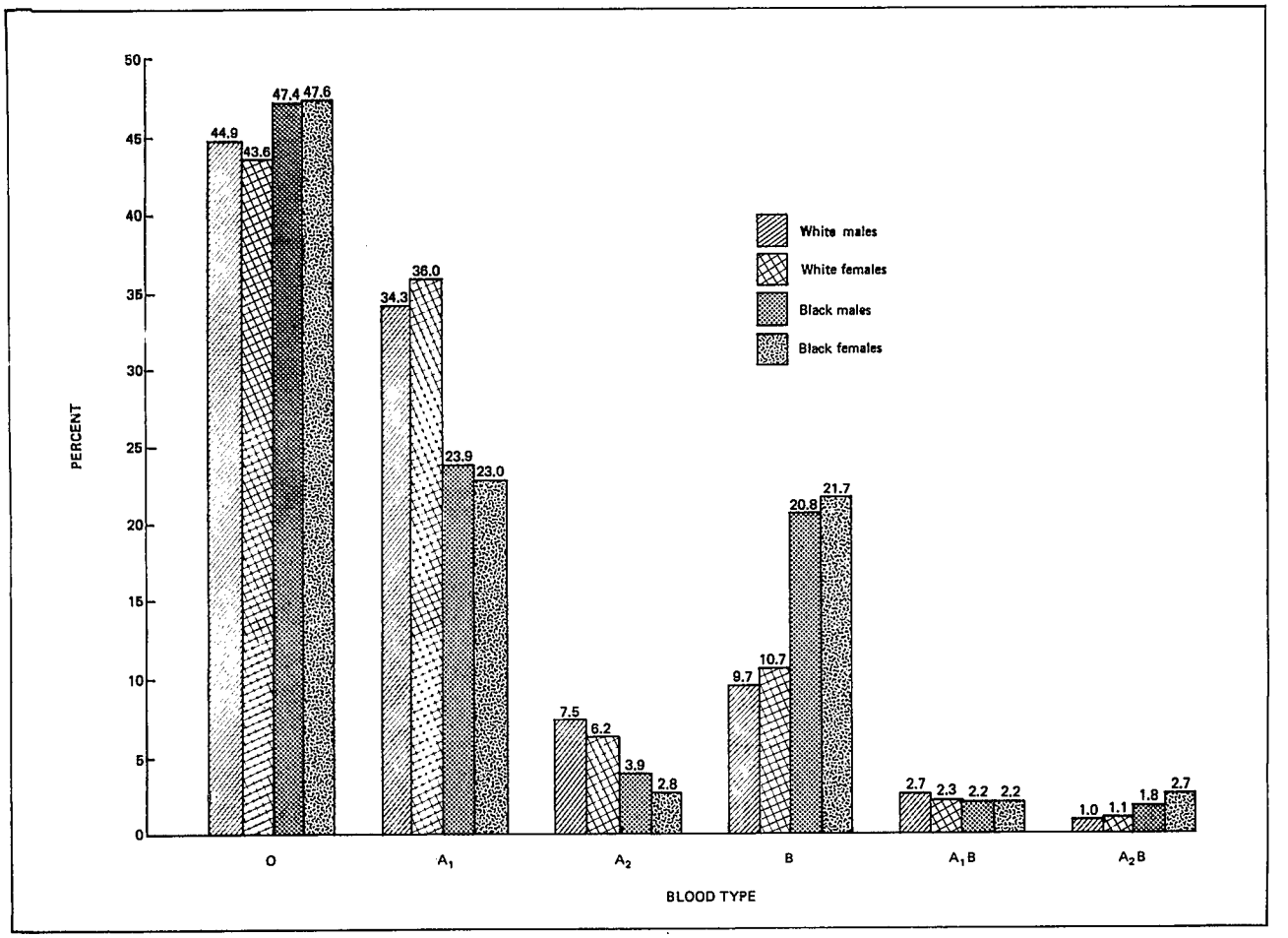

Figure 1. Percent of youths 12-17 years old, by ABO blood type, race, and sex: United States, 1966-70

the lowest was found in males in the youngest group (5.3 percent), this trend was not observed for females, since 16-year-old females had the lowest frequency (4.6 percent). The frequency of type B varied from a low of 8.7 percent in 12-year-old males to a high of 11.5 percent in 15-year-old females.

Among black youths, the ABO distributions of males of pooled ages and females of pooled ages were very similar to each other. The highest frequency of type O occurred in 17-year-old females (54.7 percent), and a low frequency of O occurred in 15-year-old females (37.5 percent). The highest A_1 frequency (31.0 percent) and the highest A_2 frequency (6.6 percent) occurred in 14-year-old males, and the highest B frequencies occurred in 15-year-old females (28.6 percent) and males (25.1 percent).

Geographic region.—Among white youths, regional differences are not marked (table 2). Relatively, the value for type O was high (47.4 percent) and that for type B was low (8.3 percent) in the West Region ($p < 0.10$ for both, when compared with the corresponding percentages for all white youths); in the Midwest, the frequency of type B was high (11.5 percent) and that for A was also slightly above average (35.8 percent for A_1 plus 7.3 percent for A_2), but neither difference was statistically significant ($p > 0.10$). The A values are not surprising in view of the well-recognized high frequency of A in Scandinavian populations who are more heavily represented in the northern Midwest (Minnesota, Wisconsin, etc.). The total U.S. estimates for white youths—44.3 percent for O, 42.1 percent for $A_1 + A_2$, and 10.2 percent for

B—appear consistent with those expected for white populations of European descent.

Black youths showed much wider regional variation, possibly associated with differences in degree of racial intermixture among emigrants from the South. Although not directly correlated with distance of migration, the West showed the broadest deviation from the South. The high frequency of type O in the South (49.4 percent) and Northeast (50.6 percent) and the high values for B (24.8 percent) in the South (twice that of the West) were much closer to African frequencies than were the 39.6 percent for O or the 12.4 percent for B in the West, which appear to be quite low. The A_1 level of 34.3 percent in the West was comparable with that of white youths across the United States and almost twice the 17.8 percent for black youths in the South ($p < 0.10$). The extremely high A_1B value (6.3 percent), giving a total 9.3 percent AB for black youths in the West, although not statistically significant ($p > 0.10$), could be associated with transition and intermixture. Previous estimates[14] are quite consistent with the observed total U.S. sample estimates for the black population, 21.2 percent for B and 47.5 percent for O, although the observed 26.8 percent for A suggests that previous estimates are too high.

Family income.—At the extreme categories, family income and frequency of type O showed an inverse relationship among white youths: Those in the lowest income class (less than $1,000) had an O frequency of 58.3 percent, and those in the income group of $15,000 or more had an O frequency of 39.5 percent (table 2) ($p < 0.05$). Although very marked in white youths, the deviation between the end groups was not so distinct in black youths (48.8 percent in the lowest income group and 29.2 percent in the highest group), and the highest O frequency (50.7 percent) occurred in the $3,000-$4,999 category, not very different from the overall frequency of 47.5 percent. Among white youths, although the frequencies in the $3,000-$14,999 categories were similar to each other, the extreme values were very different from the estimate of 44.3 percent for total U.S. white youths. Concomitantly, the A_1 frequency tended to be higher in the highest income categories, although the deviation around the "total" estimate (35.2 percent) was not great. The patterns were similar with A_2. In black youths, however, the difference in A_1 frequency between the lowest income group (17.0 percent) and the highest income group (38.2 percent) was quite striking: The latter value was not only as high as the overall estimate for white youths, but it was as high as the highest frequency for the white youths.

Education of parent or guardian.—Among white youths, although the highest frequency of type O (50.3 percent) appeared in those whose parent or guardian had the least education and the lowest frequency (40.2 percent) in those whose parent had 13-15 years of schooling (some college), the trend was not consistent, because those whose parent had graduate/professional education had higher O values (table 2). Consistent patterns were not discernible in the other blood types. Although the lowest A_1 frequency (30.1 percent) appeared with 5-7 years of education, similar frequencies (32.7 and 34.0 percent) occurred at college graduate and at less than 5 years levels, respectively. The highest value (38.2 percent) was not very different in frequency nor in the associated educational level (13-15 years).

Similarly, among black youths no consistent trends were observed to suggest a relationship between ABO blood type and years of education of parent or guardian. The highest frequency of type O (57.4 percent was found in those whose parent had only 8 years of schooling, but the next highest (57.0 percent) appeared at the level of 17 years and over, and the lowest frequency of O (42.9 percent) was observed in the category adjacent to that with the highest frequency of O—those with some high school but not high school graduates. Likewise, A_1 frequencies showed no consistent pattern: The lowest (9.7 percent) and the highest (33.7 percent) occurred in contiguous groups. A similarly erratic pattern appeared in the frequency of the B blood type. Clearly, no consistent patterns of association between ABO type and level of parental education among white or black youths exist.

Rh TYPES

The alternate Fisher-Race nomenclature for the Rh system (Dd, Cc, Ee) was used for data

coding because it did not require the use of subscripts or superscripts and was likely to result in fewer transcription errors by data handlers. Accordingly, for simplicity, that nomenclature is also used to describe the results. Tabulations are presented for Rh D, Rh Cc, Rh Ee, and a summary code for Rh types is given in table IV of appendix III.

Rh D

Race.—Consistent with published data,[14] the frequency of the Rh D negative type (D−1) was much higher among white youths (15.0 percent) than among black youths (6.0 percent) ($p < 0.001$), and thus concomitantly the frequency of D+ was higher among the black group (93.7 percent) than among the white group (84.8 percent) (table 3, figure 2). Interestingly, the frequency of the D^u phenotype was almost as high in white as in black youths (0.2 and 0.3 percent, respectively), although D^u has often been associated with African or non-Caucasian ancestry.

Sex and age.—The Rh D frequencies for white males and white females were very similar, and no age trends were discernible (table 3). Black males and females were also similar to each other with a slightly lower frequency of D− among females than among males for black as well as for white youths. As in the white group, no age trends were detectable in black youths, and the high frequencies of D− in 17-year-old black males (16.1 percent) and 15-year-old black females (10.4 percent) are likely due to chance variation.

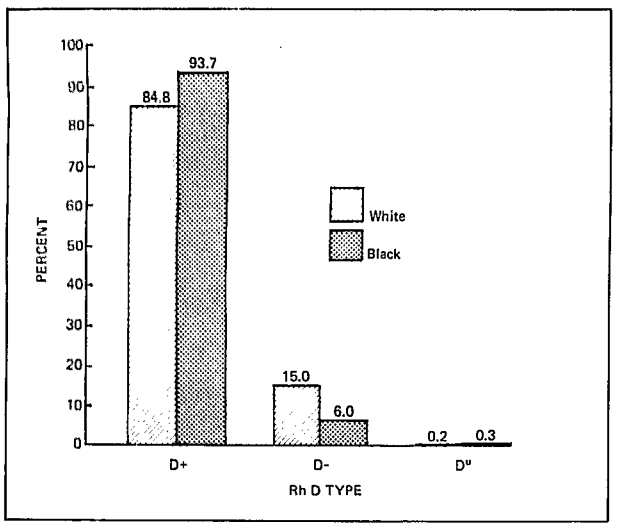

Figure 2. Percent of youths 12-17 years old, by Rh D type and race: United States, 1966-70

Geographic region.—The highest rates of D+ (85.9 percent) and the lowest of D− (14.1 percent) among white youths occurred in the Midwest Region. The highest frequency of D+ in black youths appeared in the South (94.9 percent) (table 4). Although it was expected that the highest D^u rates among black youths would occur in the South (0.4 percent) and Northeast (0.6 percent), it was surprising that white youths of the South (0.4 percent) had the same rates as black youths (0.4 percent) and white youths of the Northeast and West had rates of 0.3 and 0.2 percent, respectively.

Family income.—The lack of relationship between the Rh D type and family income among black youths is shown by the occurrence of the lowest (2.9 percent) and the highest (9.2 percent) frequencies of D− in adjacent groups: The lowest income category (less than $1,000) and the next to lowest ($1,000-$2,999), respectively (table 4). Moreover, the only two recordable frequencies of D^u for black youths appeared in the $3,000-$4,999 category (0.7 percent) and the "unknown" income category (1.9 percent). For white youths, the data were no more informative: The highest frequency of D− (17.0 percent) occurred in those in the less than $1,000 category, and the lowest (12.9 percent) occurred in the $3,000-$4,999 category.

Education of parent or guardian.—No consistent trends were discernible with regard to educational levels (table 4). Among white youths the highest frequencies of D+ occurred among those whose parent or guardian had the least education (89.6 and 90.1 percent) and among those whose parent or guardian had the most education (87.9 percent); the highest frequencies of D− appeared among those whose parent or guardian had elementary but no high school education (17.5 percent) and among those whose parent or guardian had attended college for 4 years (16.5 percent). The latter group also had the highest frequency of D^u (0.5 percent). The D+ and D− frequencies in black, as in white youths, showed no discernible trends.

Rh Cc

Race.—The marked contrast in Cc frequency between black and white youths is shown by the distribution of C homozygotes and c homozygotes. More than 70 percent of black youths are of the cc genotype and only 1.7 percent are of the CC genotype; less than one-third (32.0 percent) of the white youths are of the cc type and more than 17 percent are of the CC type. Thus only about 27 percent of black youths but 68 percent of white youths carry a C allele, that is, they show a C phenotype (either CC or Cc) (table 5, figure 3) ($p < 0.001$).

Sex and age.—No differences between males and females in the frequency of distribution of CC, Cc, and cc genotypes were observed in either white or black youths (table 5). The marked differences were in the relatively low frequency of C-bearing phenotypes and very high frequency of c-bearing phenotypes in black as compared with white youths (17.8 percent for CC and 32.0 percent for cc for the white group versus 1.7 percent for CC and 72.7 percent for cc for the black group). Although in white males there was a suggestion of a trend with age—the highest CC value appeared in 12-year-olds and the lowest CC in 17-year-olds—this trend was not observed for females nor was there any corresponding pattern for cc. In black youths the frequencies appeared almost random with no discernible systematic relationship to age.

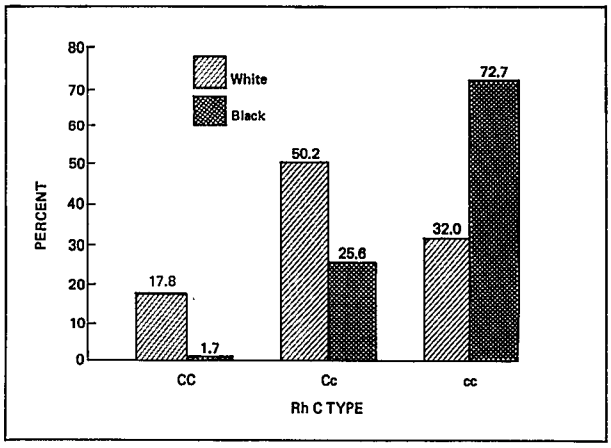

Figure 3. Percent of youths 12-17 years old, by Rh C type and race: United States, 1966-70

Geographic region.—The West Region showed the lowest frequency of cc genotypes for white youths (30.0 versus 32.0 percent mean) or black youths (65.8 versus 72.7 percent mean) (tables 5 and 6). The lowest frequency of the CC genotype for white youths occurred in the South (16.6 versus 17.8 percent total); surprisingly this result was not true for black youths, for whom the lowest CC frequency occurred in the Northeast (0.6 versus 1.7 percent average).

Family income.—Among white youths the highest frequency of CC (20.7 percent) and the next to the highest frequency of cc (32.9 percent) appeared in the $1,000-$2,999 income bracket, the same income class in which among black youths a very high frequency of CC (2.7 percent) and the next to lowest frequency of cc (68.2 percent) appeared (table 6). The values were, however, quite divergent and no patterns can be detected.

Education of parent or guardian.—Neither in white nor in black youths did any systematic patterns of association between years of education of parent or guardian and Cc frequency appear (table 6). Among white youths a low (25.8 percent) and a high (37.8 percent) cc frequency appeared in adjacent categories of educational level (5-7 and 8 years, respectively). The result was similar among black youths: cc values of 53.5 percent for those with 17 years or more of parental education and 80.9 percent for those with 16 years of parental education.

Rh Ee

Race.—White youths had a higher frequency of E and a very slightly lower frequency of e (indicated by their distribution of 3.1 percent for EE, 26.9 percent Ee, and 70.0 percent for ee) as compared with black youths (1.2 percent, 17.1, and 81.6 percent, respectively) (table 7, figure 4).

Sex and age.—As with the Cc frequencies, with the EE, Ee, and ee phenotypes, very similar distributions appeared among white males and females, with a just slightly lower frequency of EE and higher frequency of ee among males than among females (table 7). In the black group, the male and female frequency distributions also were almost identical to each other.

No age trends were discernible in white or black youths. The lowest EE frequencies among white males occurred in the youngest and oldest ages examined (1.5 percent for those 12 years old and 1.7 percent for those 17 years old), and the other frequencies fluctuated erratically. The frequencies among black youths also were erratic—the lowest ee frequency (72.5 percent) occurred in 16-year-old black males, the highest (87.9 percent) in 15-year-old black females with no systematic relationship to age.

Geographic region.—No marked regional patterns were noted for either black or white youths (table 8). However, among black youths, the highest frequency of E carriers (EE or Ee) occurred in the West Region (0.6 percent EE plus 26.5 percent Ee) and in the Midwest (2.0 percent EE plus 25.0 percent Ee), although black youths of the South and Northeast Regions had a low frequency of E bearers. These findings suggest that the black emigrants to the West have more white admixture than those who remained in the East.

Family income.—Among white youths, the frequency curve for EE and ee by family income appears almost bimodal; the lowest EE (2.9 and 2.4 percent) and the highest ee (72.8 and 72.6 percent) frequencies occurred in the $5,000-$6,999 and $7,000-$9,999 categories, respectively. Among black youths the highest EE value (5.4 percent) and next to lowest ee value (70.8 percent) occurred in the $10,000-$14,999 income class (table 8).

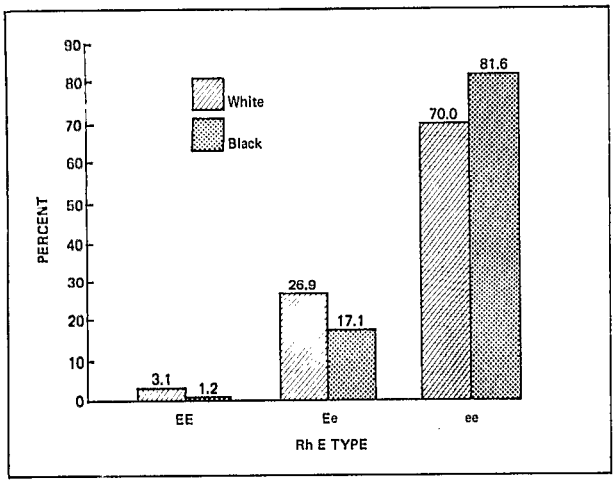

Figure 4. Percent of youths 12-17 years old, by Rh E type and race: United States, 1966-70

Education of parent or guardian.—As with Cc, Ee frequencies did not display trends of association with educational level of parent or guardian—outlying values were scattered for both white and black youths (table 8). In the white group, low frequencies of ee occurred in the lowest and highest educational levels (66.1 and 62.6 percent, respectively), and the highest frequency occurred just two groups from the latter. Among black youths the lowest frequency of EE (1.0 percent) occurred among those whose parent or guardian had attained but had not completed high school, and the lowest ee frequency occurred in the group with parent or guardian a college graduate (16 years of education).

Rh Summary Classifications and Combined Classes

The classification of the Rh genotype combinations is given in appendix table IV. Some categories involved such rare combinations that no individuals were observed in those categories. The actual numerical distribution of the sample by Rh genotype is given in table V. For the purpose of computing estimates of the population distribution, three cells were combined with larger cells: (1) The one subject in cell 9 (having D, C, c, and E antigens) was combined with those in the 4 cell (having D, C, c, and E antigens) and, in addition, e antigen not possessed by the added member); (2) the five subjects in cell 35 (having D^u, c, and e antigens) were combined with those in cell 5 (having D, c, and e antigens); and (3) the four subjects in cell 36 (having D^u, c, E, and e antigens) were joined with those in cell 6 (having D, c, E, and e antigens). The intraset differences in the last two sets involving pooling were that one class had D antigen and the other had D^u.

Race.—Among white youths clearly the most frequent antigenic complex (2) included the D, C, c, and e reactions (35.4 percent), which in the black group was somewhat less frequent (22.7 percent), being second to the 5 + 35 antigenic complex involving D, C, c, E, and e reactions (51.6 percent) (table 9, figure 5).

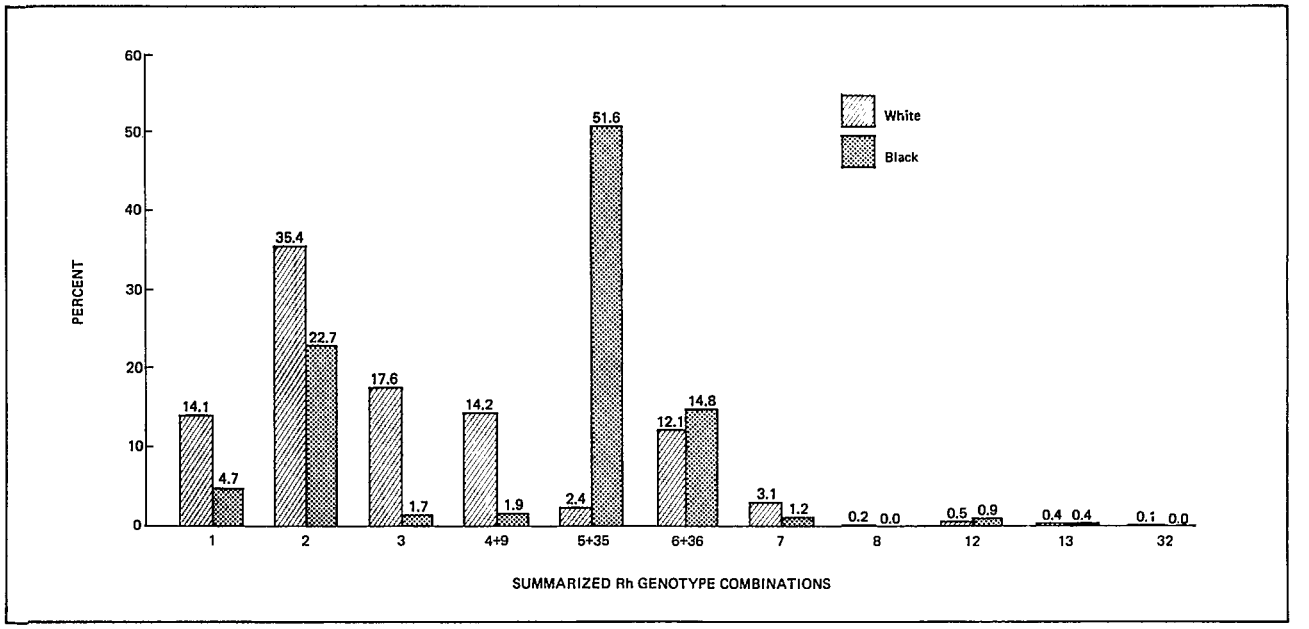

Figure 5. Percent of youths 12-17 years old, by summarized Rh genotype combinations and race: United States, 1966-70

In the white group, the second most frequent genotypic combination appeared in the 3 category with D, C, E, and e antigenic reactions (17.6 percent). The next two in order were category 4 (with antigenic specificity D, C, c, E, and e) plus 9 (with D^u specificity instead of D) (14.2 percent) and category 1 "true Rh negative" cde/cde homozygous, at a similar frequency of 14.1 percent. The only other category in white youths with a frequency greater than 10 percent was 6 (including D, C, E, and e antigens) with category 36 added (containing D^u instead of D)—totaling 12.1 percent. Other categories not having any D specificity added to less than 1 percent (category 12 at 0.5 percent and category 13 at 0.4 percent). Both negative for D specificity, category 12, has C, c, and e specificity and category 13 has c, E, and e specificity.

In the black group, besides categories 5 + 35 and 2 (which make up more than 74 percent of the total types among black youths), only one other had a frequency above 10 percent: Category 6 (having antigenic specificity D, c, E, and e which was combined with category 36, the latter having D^u instead of D specificity) had a frequency of 14.8 percent.

Sex and age.—White males and females were quite similar in distribution of Rh genotypes (table 9). Among males, there appeared to be a slightly higher frequency of "true negative" category 1 (15.1 compared with 13.0 percent for females) with slightly lower frequencies of 4 + 9 (13.7 versus 14.6 percent) and 5 + 35 (1.8 versus 2.9 percent). No real patterns occurred with age. In males of the 2 category, lower frequencies were apparent at younger ages and higher frequencies at older ages. The reverse was true in the 6 + 36 category; 12-year-old males had a frequency of 12.6 percent, and 17-year-old males had a frequency of 9.7 percent compared with the overall male frequency of 12.0 percent. None of the other categories of white males or females appeared to vary systematically, however.

In black youths also, there appeared to be a very similar Rh distribution for males and females with possibly a slightly higher frequency of the Rh negative (1) category among males than among females (5.6 versus 3.7 percent), a lower frequency of the 2 category among males (21.1 versus 24.3 percent for females), and a higher frequency of the 6 + 36 category among males (15.6 versus 14.1 percent). Age trends are suggested in the 4 + 9 category of males with an increase from 1.6 percent in the 12-year-old group to 3.5 percent in the 17-year-old group,

and in the 5 + 35 category, which showed a decline from 58.6 percent in 13-year-old males to 43.2 percent in 17-year-old males, although the 12-year-olds had a mid-low level. No discernible trends with age appeared in black females.

Geographic region.—Regional variation was not marked for either white or black youths. Among white youths, a somewhat elevated frequency of true Rh negatives was found in the South Region (15.8 compared with 14.1 percent overall) (table 10). The 2 frequency was high in the Midwest (37.6 compared with 35.4 percent overall). However, none of these differences is significant.

Among black youths, the most noteworthy deviation was the low frequency of the 5 + 35 category in the West (37.4 percent) and the high frequency in the South (57.6 percent), probably attributable to differences in racial admixture in the black population in the two regions as suggested by the marked difference in overall frequency of that Rh combination in black and white youths (51.6 and 2.4 percent, respectively). The relatively elevated frequency of the 2 category among black youths in the West Region (29.3 percent) may similarly be a reflection of more racial admixture in the West. The most puzzling deviation is the high frequency of category 6 + 36 in the West (22.0 percent) compared with the overall frequency of 14.8 percent among black youths and overall frequency of 12.1 percent among white youths.

Family income.—No systematic trend of association of Rh genotype frequencies and family income was observed among either white or black youths (table 10). In the white group, the lowest frequency of the true Rh negatives occurred in the lowest income group, and higher frequencies occurred in higher income groups, although the pattern was not entirely consistent. A high frequency of the 3 type in the next to lowest income category (20.7 percent compared with an overall 17.6 percent) and a high frequency in the 4 + 9 category in the lowest income group (16.8 versus 14.2 percent overall) may be due to spurious variation.

Among the black population, high frequencies of the 3 and 4 + 9 types (13.2 versus 1.7 percent overall and 6.0 versus 1.9 percent) plus a low frequency in the 5 + 35 category (36.4 compared with 51.6 percent overall) shown in the highest income group may indicate more racial intermixture as these values deviate in the direction of frequencies found in the white population. On the other hand, the very high 26.2 percent in the 6 + 36 category in the top income group is very different from the overall frequencies among both black and white youths (14.8 and 12.1 percent, respectively), and suggests that many of the observed deviations in small samples are spurious: A total of 15 black youths was observed in the sample in the group with income of $15,000 or more, extrapolated in the weighted distribution to 41,870 individuals in the U.S. population.

Education of parent or guardian.—As with income, no systematic trends appeared to suggest an association between Rh type and number of years of education of parent or guardian (table 10). Among white youths, a high frequency of the 4 + 9 category in the lowest educational levels (19.1 versus 14.2 percent of overall) is difficult to explain, and other sporadic elevations and deviations apparently do not represent any meaningful patterns. Noteworthy and puzzling, however, is the very high frequency of the 6 + 36 category (20.7 versus 12.1 percent overall) in the highest educational level both because a similarly very high and deviant frequency also occurred among black youths (in the 6 + 36 category) at the highest educational level (23.4 versus 14.8 percent overall). This deviation parallels that noted in the highest income level in black youths, even more markedly deviating with income than among white youths. (In white youths, the 6 + 36 frequency in the highest income level was 13.9 percent, only slightly above the overall 12.1 percent.) Although these findings with regard to the 6 + 36 category are interesting, the extremely high frequency of 2 (46.5 percent compared with an overall 22.7 percent in black youths and an overall 35.4 percent in white youths) among black youths with a parent or guardian in the highest education class suggests possible erratic sampling phenomena.

ABH SECRETOR ABILITY

Table C shows percent of secretors compared with nonsecretors in selected population

Table C. Number and percent distribution of specified population by secretory ability, according to race and area: ABH secretion and Lewis systems, saliva tested for ABH secretion

Area	Population	Author	Number	Secretory ability	
				Secretors	Non-secretors
				Percent distribution	
AMERICA					
NORTH AMERICA					
UNITED STATES					
Connecticut, New Haven (s) ABO	Students (male)	Niederman et al. 1962	1000	77.3	22.7
Iowa (s)S., A_1A_2BO	Controls	Newman et al. 1961	1261	77.0	23.0
Massachusetts, Boston (s) Le Le	White controls	Dublin et al. 1964	594	73.6	26.4
Michigan, Tecumseh	Whites of West European extraction	Shreffler et al. 1971	8664	74.6	25.4
Washington, Seattle (s) S., ABO, allergies	Whites	Vanarsdel & Motulsky 1959	3144	75.9	24.1
Wisconsin (s) Le and Le secr.	Parents (White)	Greenwalt 1961	146	80.8	19.2
Negroes					
(s) Le Le, Le secr.		Miller et al. 1954	111	72.1	27.9
New York, Harlem		Schiff 1940	178	61.2	38.8
South Carolina, Charleston (s) Le secr.	Family material	Cepellini et al. 1959	236	75.4	24.6

SOURCE: Table 7.1 in reference 14.

groups and the literature available on the subject.[14]

Race.—Despite the overall differences in secretor frequencies and proportion with unsatisfactory samples (i.e., insufficient sputum or sputum contaminated by blood, usually from the gums), the patterns among white and black youths considered separately were very consistent (table 11, figure 6).

Sex and age.—White males and white females showed very similar frequencies of secretors (75.8 and 75.5 percent, respectively) and of unsatisfactory samples (2.3 and 1.8 percent, respectively), and nonsecretors were 21.4 and 22.2 percent of the respective totals. No trends appeared with age when ages 12-17 years were examined (table 11).

As among white youths, black males and females were similar to each other, although males showed a slightly higher frequency of unsatisfactory samples (12.1 percent) compared with 8.8 percent for females. Nonsecretor frequencies were 21.5 percent for males and 24.5 percent for females. Again no consistent age patterns were observed.

Geographic region.—Only 2.0 percent of white youths but 10.4 percent of black youths gave unsatisfactory saliva samples, and the largest proportion of the latter (15.1 percent) was in the South Region (table 12). Among white youths, the highest frequency of unsatisfactory samples also was in the South (2.8 percent). The large proportion of missing data thus makes it difficult to extrapolate total percent distributions. In total estimates, white youths showed a higher frequency of secretors than black youths did (75.7 versus 66.0 percent, respectively); and this difference is consistent for all regions except the West (75.4 percent for white youths and 76.0 percent for black youths).

The highest frequency of nonsecretors was found among black youths of the Northeast

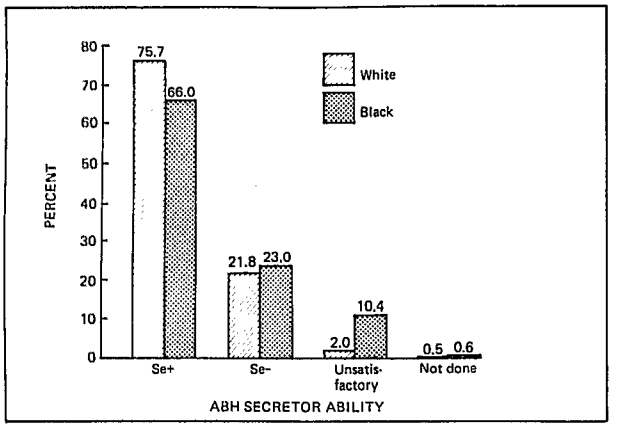

Figure 6. Percent of youths 12-17 years old, by ABH secretor ability and race: United States, 1966-70

Region (29.4 percent); the lowest frequency of nonsecretors occurred among white youths of the Northeast (20.2 percent) as compared with an overall nonsecretor rate of 22.0 percent (21.8 percent for all white youths and 23.0 percent for all black youths).

Because of the sizable proportion of unsatisfactory samples, it is difficult to compare percents of nonsecretors by region. In the South and West Regions white youths had a higher proportion of nonsecretors; in the Northeast Region black youths had a higher prevalence of nonsecretors.

Family income.—Among white youths (except for the lowest income group), a clear inverse relationship exists between family income level and proportion of unsatisfactory saliva samples (from 4.3 percent for those with family incomes of $1,000-$2,999 to 1.0 percent for those with family incomes of $15,000 or more) (table 12). Not only was the proportion of unsatisfactory samples among black youths much higher, but the pattern did not appear related to income levels: 12.8 percent for those with family incomes of $15,000 or more and only 1.7 percent for those with family incomes of $10,000-$14,999. Further emphasizing the lack of consistent pattern is the occurrence of the highest frequency of nonsecretors among black youths (31.5 percent) in the $10,000-$14,999 income group; among white youths the largest proportion of nonsecretors was observed in the next to lowest income group.

Education of parent or guardian.—Among white youths, the frequency of unsatisfactory samples is inversely related to education of parent or guardian—the highest frequency (6.6 percent) occurred among those youths whose parent or guardian had 5-7 years of education and the lowest value (0.5 percent) occurred among those whose parent had 17 years or more of education. Among black youths, however, not only is the frequency of unsatisfactory samples higher but the pattern is erratic: 15.6 percent for those whose parent or guardian had 5-7 years of education and 14.5 percent for those whose parent had some high school education.

No other consistent patterns of association are observed between the secretor frequencies and education levels. Whereas the highest frequency of nonsecretors (38.2 percent) was found among black youths with 8 years of education of parent or guardian, the highest nonsecretor frequency in white youths (24.7 percent) occurred in the highest education level.

PLASMA PROTEINS

Haptoglobin Types

Table D presents the distribution of and available literature on haptoglobin (Hp) types in selected U.S. populations.[14]

Race.—Black youths showed twice as high a frequency of 1-1 types as white youths did (32.2 versus 16.4 percent, respectively) but less than half as many 2-2 phenotypes (13.3 versus 32.8 percent, respectively) (table 13, figure 7). Although the frequency of 2-1 individuals was not strikingly different among white (46.8 percent) and black (39.4 percent) youths, black youths had a much higher frequency of "other" types, that is, other than 1-1, 2-1, or 2-2 (12.1 percent as compared with only 1.9 percent for white youths) ($p < 0.001$). Thus, type 2 appeared to occur much more frequently in white youths than in black youths (about 80 percent for white youths as compared with about 53 percent for black youths) ($p < 0.001$); type 1 was more prevalent in black individuals (72 percent for black youths versus 63 percent for white youths).

Table D. Number and percent distribution of specified population by haptoglobin type according to race and area: Haptoglobin system, Hp1 not subtyped

Area and race	Population	Author	Number	Haptoglobin type			
				Hp1-1	Hp2-1	Hp2-2	Other
				Percent distribution			
UNITED STATES							
	'Hutterites' (parents)	Kirk 1971	548	26.6	46.5	26.8	
Georgia, Bullock and Evans Counties	Whites	Cooper et al. 1963	145	18.6	44.1	35.9	
Illinois, Chicago	Whites	Shih & Hsia 1969	101	17.8	50.5	31.7	
Maryland, Bethesda	Whites (mostly males)	Queen & Peacock 1966	192	12.5	44.3	43.2	
Michigan, Ann Arbor	Whites	Sutton et al. 1959	68	13.2	58.8	27.9	
Michigan, Ann Arbor	Males	Bayani-Sioson et al. 1962	161	14.3	47.8	37.9	
Michigan, Tecumseh	Whites of West European origin	Shreffler et al. 1971	7649	17.1	48.8	33.7	0.4
Michigan, Tecumseh	Parents	Kirk 1971	2718	17.9	47.2	34.9	
Washington, Seattle	White donors	Giblett & Brooks 1963	409	13.2	50.4	36.4	
Tennessee, Hancock County, Virginia, Lee County	'Melungeons'	Pollitzer & Brown, W.H. 1969	111	14.4	46.8	36.9	
Negroes							
California		Harris et al. 1959	51	41.2	27.5	19.6	11.8
Georgia, Bullock and Evans Counties		Cooper et al. 1963	167	28.7	36.5	25.1	9.6
Georgia, Sapelo Island		Parker & Bearn 1961	38	55.3	36.8	5.3	2.6
Illinois, Chicago		Shih & Hsia 1969	101	29.7	46.5	23.8	
Michigan, Ann Arbor		Sutton et al. 1959	48	35.4	35.4	18.8	10.4
Ohio, Cleveland, Washington, Seattle	Parents selected for sickle cell Hemoglobin in at least one	Giblett & Steinberg 1970	178	25.3	39.3	17.4	18.0
New York City		Parker & Bearn 1961	100	36.0	35.0	19.0	10.0
Texas, Austin		Sutton & Karp 1964	249	29.7	34.5	20.1	15.7
Washington, Seattle	Donors	Giblett & Brooks 1963	1657	28.5	38.7	18.5	14.3

SOURCE: Table 36.1 in reference 14.

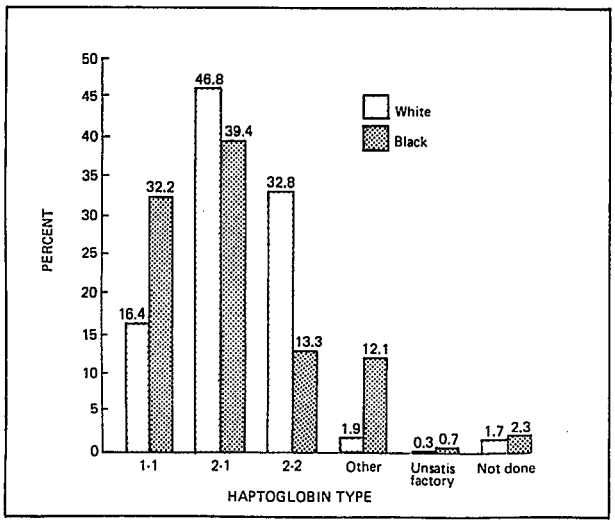

Figure 7. Percent of youths 12-17 years old, by haptoglobin type and race: United States, 1966-70

Sex and age.—Among white youths, the haptoglobin phenotype frequencies for males and females were strikingly similar: 16.4 percent for 1-1, 47.3 percent for 2-1, and 32.1 percent for 2-2 in males as compared with 16.5, 46.3, and 33.6 percent, respectively, for white females. Among black youths, the distribution of phenotypes for males and females was not quite as similar. Black youths showed much higher rates of 1-1: 34.9 percent for males and 29.6 percent for females with opposite deviations for 2-1 (35.5 percent for males and 43.2 percent for females) and 2-2 (11.0 percent for males and 15.4 percent for females). Thus the Hp phenotype frequencies for black youths were very different from those for white youths; the 1-1 type was about half that for white individuals and 2-2 was twice or three times that observed in white youths.

Among white youths, an inverse relationship between the frequency of 1-1 and age in males was observed, as well as an increase in 2-1 and 2-2 frequency with age, but the pattern was not so regular in females; nor did any other suggested associations with age appear in white or black youths. The most marked variations were the persistent black-white differences in phenotype frequency: twice as high a frequency of 1-1 in black as in white youths (32.2 versus 16.4 percent, respectively) and less than half the frequency of 2-2 (13.3 versus 32.8 percent, respectively). The absence of a male-female difference in white youths with suggested deviation in black youths may just represent random variation due to the smaller sample size of the latter.

Geographic region.—By region, the haptoglobin phenotypes were remarkably similar for white youths, 1-1 possibly being slightly lower in the Northeast and South Regions (table 14). Among black youths, however, the regional variation was much more discernible. Black youths of the Midwest and Northeast Regions had 1-1 frequencies of 37.5 and 34.9 percent, respectively; those in the West had a frequency of 20.8 percent for 1-1, closer to the white frequency of 16.4 percent than to the black of 32.2 percent; their 2-2 frequency (20.3 percent) in the West was much higher than the frequency for all black youths (13.3 percent) but lower than that for all white youths (32.8 percent). However, black youths in the West showed the same high frequency (12.7 percent) of "other" types as noted for all black youths.

Family income.—No discernible trends suggesting any relationship between haptoglobin phenotypes and family income, either in white or black youths, were noted (table 14). A few deviant cells appeared but whether these indicate associations or were the results of random variation is not evident. Among white youths, the highest frequency of 1-1 occurred in the income group $1,000-$2,999 (20.8 percent), and the lowest frequency (14.9 percent) appeared in the adjacent income group $3,000-$4,999. The pattern of extreme frequencies in adjacent income groups was similarly noted with 2-2 (26.1 percent in the $1,000-$2,999 group and 34.0 percent—the penultimate frequency—in the next income bracket, $3,000-$4,999).

Furthermore, among black youths the findings show no apparent associations between haptoglobin phenotypes and family income. In the group $15,000 or more, the 1-1 phenotype frequency (42.7 percent) was quite high but in the group directly below it, the frequency was quite low (19.1 percent). Moreover, in the $15,000 or more group the 2-1 heterozygote frequency (18.8 percent) was very low. Because no systematic patterns appear, this variation probably is random.

Education of parent or guardian.—Among white youths no clear-cut association appeared between Hp type and educational level of parent or guardian (table 14). The highest frequency of 1-1 (21.3 percent) appeared in those with the least parental schooling (less than 5 years) and the lowest (14.5 percent) among those with 12 years of parental schooling; considerable variation occurs in-between, and no real pattern is discernible. Among black youths, the 2-2 phenotype was highest in those with more than 4 years of parental education beyond the high school level (52.9 percent in the category 17 years or more and 21.5 percent at the level of 16 years). However, the lowest frequency (8.6 percent) occurred in the 12-year category. Phenotype 1-1 showed an even more erratic pattern. Thus in black as in white youths, Hp phenotype and level of parental education evidently are not correlated.

Transferrin Types

The distribution of transferrins in selected populations and related available literature are presented in tables E and F.

The usual transferrin phenotype is CC, which is reported to occur in more than 95 percent of white youths and more than 90 percent of black youths. The frequency of variants is so low, especially in the white group, that patterns and trends are difficult to observe. The observations, however, are presented in tables 15 and 16.

Race.—The racial differences in variant type and frequency are noteworthy. Type B is the main variant occurring in white persons and D is the main variant in the black population.

Table E. Number and percent distribution of specified population by transferrin type, according to area: Transferrin system, not more than one variant distinguished in each of classes B and D

Area	Population	Author	Number	Transferrin type				
				C	BC	DC	B	D
				Percent distribution				
AMERICA								
NORTH AMERICA								
UNITED STATES								
Arizona, between Ajo and Tucson	Papago	Brown & Johnson 1970	541	96.3	3.3		0.4	
Arizona, Gila Valley	Pima (full blood)	Maison et al. 1968	247	93.5	6.5			
Florida	Seminole	Pollitzer et al. 1970	375	100.0				
New York, Cattaraugus Reservation	Seneca	Doeblin et al. 1968	112	100.0				
New Mexico	Zuni	Brown & Johnson 1970	654	80.9	18.5		0.6	
Illinois, Chicago	Whites	Shih & Hsia 1969	101	100.0				
Michigan, Tecumseh	Whites (of West European origin)	Shreffler et al. 1971	7654	98.8	1.1	0.1		
South-East	Negroes (donors)	Roop et al. 1968	418	95.5		4.5		
Georgia, Bullock and Evans Counties	Negroes	Cooper et al. 1963	133	90.2		9.8		
Georgia, Sapelo Island	Negroes	Parker & Bearn 1961	38	73.7		26.3		
Illinois, Chicago	Negroes	Shih & Hsia 1969	101	92.1		7.9		
New York City	Negroes	Parker & Bearn 1961	99	89.9		9.1		1.0

SOURCE: Table 37.1 in reference 14.

Table F. Number and percent distribution of specified population by transferrin type, according to area: Transferrin system, more than one B or more than one D variant present

		AMERICA				POLYNESIA
Place		UNITED STATES		MEXICO		HAWAIIAN ISLANDS
		Southeast	Georgia, Bullock and Evans Counties	Veracruz, Tamiahua		
Population		Whites		Males	Nahua (s) G., T.	Mixed and miscellaneous (s)
	Authors	Roop et al. 1968	Cooper et al. 1963	Lisker et al. 1969	Lisker et al. 1967	Beckman et al. 1964
Number		2221	107	109	355	684
Percent	C	98.8	96.3	95.4	96.6	97.4
	BC	0.8	0.9	1.8	3.4	0.3
	DC	0.5	1.9	2.8		2.3
	Other	0.0	0.9			

SOURCE: Table 37.2 in reference 14.

As the variant alleles are very rare, no homozygotes even for D in black persons or B in white persons would be expected to be observed in numbers adequate for extrapolation to the population. Therefore, as an index of variation associated with various characteristics—age, sex, family income, and education of parent or guardian—BC frequency in white youths and DC frequency in black youths are used (table 15, figure 8).

Sex and age.—White males and females have very similar frequency distributions of transferrin types (table 15). Among white males, 96.7 percent were of the usual or CC type, 1.4 percent carried a B variant and were BC type, and 0.6 percent were of DC type, that is, carrying the D variant, which is more common in black persons. White females showed a similar distribution, the slightly lower frequencies of CC (95.4 percent), BC (1.2 percent), and DC (0.4 percent) types deriving primarily from the additional 1.7 percent with no blood sample (2.3 percent for females compared with 1.2 percent for males) or with unsatisfactory samples (0.7 percent for females versus 0.1 percent for males). "Other" variants in white youths were observed in males (at a very low frequency of 0.1 percent) but not in females.

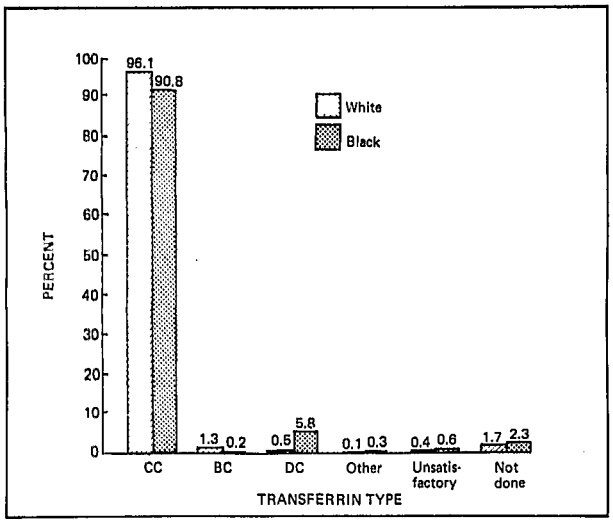

Figure 8. Percent of youths 12-17 years old, by transferrin type and race: United States, 1966-70

No systematic age patterns appeared. In white males, a low frequency of BC variants occurred in the 14- and 15-year-olds (0.9 percent and 0.6 percent, respectively, compared with an overall frequency of 1.4 percent for white males aged 12-17 years) and a high frequency of DC in 15-year-olds (1.1 percent compared with an overall frequency of 0.6 percent for those aged 12-17 years). In white females, a low frequency of BC was noted in 12- and 13-year-olds (0.4 and 0.9 percent, respectively, compared with an overall frequency of 1.2 percent for white females aged 12-17 years).

The frequency distribution of transferrin types was very similar for black males and black females. However, although the very slight male-female difference in unsatisfactory (i.e., hemolyzed) samples and absence of samples was negligible, it could account for the slight deviation in frequency of CC types, 91.7 percent for males and 90.0 percent for females. For males, 2.1 percent had missing samples, and of those obtained 0.2 percent were listed as unsatisfactory; for females, 2.6 percent did not have samples, and of those obtained 1.0 percent were unsatisfactory.

With frequencies of 91.7 percent for CC, no BC, 5.8 percent for DC, and 0.2 percent for "other" types in black males and 90.0 percent for CC, 0.3 percent for BC, 5.7 percent for DC, and 0.4 percent for "other" types in black females, any slight deviations are obviously within the bounds of random variation. No real age trends were discernible. A high frequency of DC in 12-year-old males (10.1 percent) is almost twice the overall black male frequency of 5.8 percent; 2.8 percent in 17-year-olds is only one-half the overall frequency; nevertheless, considerable variation occurred in ages 13 through 16, a result that does not fall into a systematic trend of decline with age. No noteworthy patterns occurred in females. Only females had any BC variants (12- and 14-year-olds). "Other" variants appeared in 14-year-old males and 12- and 17-year-old females.

Geographic region.—In white youths, the highest frequency of BC (2.0 percent) was found in the Midwest Region and the lowest was found in the Northeast (0.7 percent), as compared with an overall 1.3 percent for white youths (table

16). That the high frequency in the Midwest may be real and possibly a function of ethnic distribution of white population in that region is suggested by the finding that the only region of the United States with detected—or detectable—BC frequencies in black youths (1.0 percent) was the Midwest. This finding possibly indicates that the B variant is more frequent in that region in some ethnic groups. Possibly, then, its occurrence in black youths in that area—and that area primarily—results from racial admixture perhaps occurring at the usual levels there. Nevertheless, in that area of high B this result would be reflected in its appearance in the black group of the region also. On the other hand, the lowest frequency of DC in white youths was found in the Midwest (0.3 as compared with 0.5 percent overall for all white youths. This result suggests little black intermixture there, whereas black youths in the Midwest had relatively high DC frequencies (6.5 compared with 5.8 percent overall for black youths). Mixture would not be expected to be unidirectional! That the highest frequency of DC in white youths was observed in the South (0.7 percent) is not as surprising, because the highest black frequency of DC is in the South (6.8 percent). The combination of a somewhat high DC frequency in white youths occurring in the West (0.5 percent) with the very lowest DC frequency in black youths occurring in the West (3.3 percent) is not surprising in that the genetic marker patterns throughout suggest much racial admixture in black persons in the West, and thus likely more ongoing racial mixture there than in other regions. This situation tends to push the black frequencies closer to those of the white population and vice versa, although the latter would be less readily discernible because of differences in the population sizes involved. To add to the puzzling findings in the Midwest is the observation that the highest frequency of "other" variants for black or white youths occurred in black youths of the Midwest (0.6 percent).

Family income.—No really systematic associations between transferrin variant types and family income can be detected (table 16). In white youths, a possible higher frequency of BC variants with higher income appeared. In the lowest income group (less than $1,000 per year), no variants were noted, and in the highest income group, 1.4 percent were BC, compared with an overall frequency of 1.3 percent, although the highest frequency (1.4 percent) also occurred in the $7,000-$9,999 group. Except for the two lowest income categories, the reverse seems to happen with regard to DC variant: The highest frequency appeared in the $3,000-$4,999 range (1.0 percent, twice the overall 0.5 percent) and the lowest (0.1 percent) in the highest income bracket in white youths.

Among black youths, the frequencies of variants were more erratic. The only bracket showing any BC (1.0 percent) was the $5,000-$6,999 group, which is the bracket having the highest frequency of DC (9.0 compared with 5.8 percent overall frequency), although relatively high frequencies of DC (6.4 percent) were found in the two lower income categories. Concomitantly, 6.1 percent DC was observed in the top income bracket with only 1.7 percent observed in the next to highest income bracket. Clearly, in black youths no association exists between family income and frequency of transferrin variants.

Education of parent or guardian.—The findings with regard to education of parent or guardian and transferrins are not only not indicative of systematic associations but also are somewhat inconsistent with the observations concerning family income, emphasizing the likely spurious nature of the transferrin relationship. Although education and income tend to be associated with one another, this association did not appear with regard to the frequency of BC variants in white youths where there was a suggested trend toward association of higher BC frequency with higher income. With regard to education, except for the category of less than 5 years, where no BC variants were observed, the lowest BC frequencies (0.5 and 0.9 percent) appeared in the two categories with the most years of education: 16 years and 17 years or more, respectively. The highest BC frequencies (1.8 and 2.3 percent) occurred in categories 13-15 and 8 years, respectively, of parental education reported. DC frequencies among white youths were similarly erratic and inconsistent: The highest DC frequency among white youths (1.0 percent) appeared in the group with 8 years

of parental education, but those reporting 16 years had a DC frequency of 0.1 percent, and those in the highest educational category did not show any DC phenotypes at all. The overall frequency for white youths was 0.5 percent.

Among black youths, the highest frequency of DC (6.4 compared with 5.8 percent overall) appeared in the group whose parents had only elementary (8 years) education (with the exception of 22.0 percent for the group with 16 years of parental education, doubtless a sampling problem[f]). Among those educational categories for which frequencies could be computed, the lowest frequency of DC in black youths (4.9 percent) occurred in the categories of less than 5 years and 12 years of schooling. Only one category, 13-15 years of parental education, showed any BC variants (3.1 percent).

Group Specific Component Types

Table G presents the distribution of group specific component (Gc) types in selected populations and related available literature.[14,67,99,100]

[f]Only 11 black youths had a parent with 16 years of education, and 2 were DC variants; thus the weighted frequency was 22.0 percent, whereas the frequency was 5.0 percent in the preceding category of 13-15 years and 0 percent in the next highest and top category 17 years or more.

Race.—Group specific component, like the other genetically determined serum proteins, shows racial differences in allele frequencies (table 17, figure 9). About 94 percent of black youths and slightly fewer white youths (about 90 percent) carry a 1 allele ($p < 0.001$). More than 75 percent of black youths (75.5 percent) were 1-1 homozygotes, but two-thirds as many, only slightly more than 50 percent, of white youths were ($p < 0.001$). More than twice as many white youths (38.5 percent) as black youths (18.6 percent) were 2-1 heterozygotes;

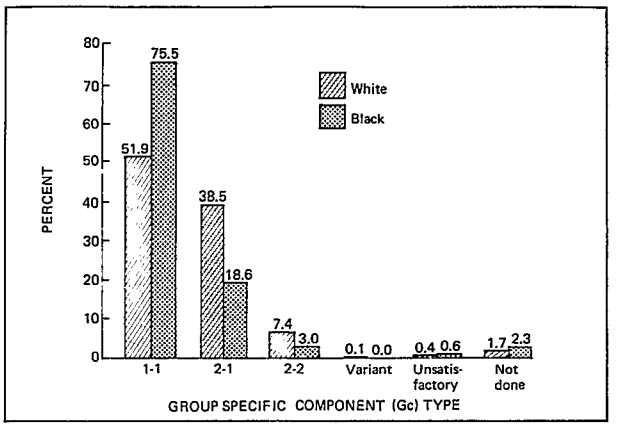

Figure 9. Percent of youths 12-17 years old, by group specific component type and race: United States, 1966-70

Table G. Number and percent distribution of specified population by Gc type, according to area: Gc system, common types only present

Area	Population	Author	Number	Gc type		
				1-1	2-1	2-2
				Percent distribution		
AMERICA						
NORTH AMERICA						
UNITED STATES						
Massachusetts, Boston (s)S.	Controls	Murray, R.F. & Robinson 1968	407	57.5	35.9	6.6
Michigan, Tecumseh	Whites of West European origin	Shreffler et al. 1971	7658	51.1	41.0	8.0
New York City	Whites	Cleve & Bearn 1961	122	51.6	40.2	8.2
New York City	Negroes	Cleve & Bearn 1961	144	80.6	17.4	2.1

SOURCE: Table 38.1 in reference 14.

7.4 percent in the white group were 2-2 homozygotes and 0.1 percent were other variants as compared with only 3.0 percent in the black group who were the 2-2 type and none who were detected as other types. About 2 percent of white youths and 3 percent of black youths had no blood samples available for determinations or produced unsatisfactory samples (among white youths, 1.7 percent without blood samples and 0.4 percent with unsatisfactory samples compared with 2.3 percent without blood samples and 0.6 percent with unsatisfactory samples among black youths).

Sex and age.—The frequency patterns of group specific component for white male and female youths were extremely similar to each other (table 17). The slightly lower frequencies for the females derive from the slightly higher frequency of absent samples (2.3 versus 1.2 percent), unsatisfactory samples (0.7 versus 0.1 percent), and other phenotypes (0.1 percent versus none detected) in females as compared with males.

No systematic trends in Gc frequencies appeared with age in either white males or white females aged 12-17. The low frequency of 1-1 in 12-year-old males (50.3 percent) and the high frequency in 17-year-olds (56.4 percent) suggests a pattern of increase with increasing age, but it does not follow completely in males and was not observed at all in females. A high frequency of 2-2 phenotype was found in 14-year-old males (8.5 percent) and 15-year-old females (9.2 percent). Highest frequencies of 2-1 heterozygotes in younger males, especially those aged 13 (40.3 percent) and also those aged 12 and 15, may be sporadic despite low frequencies in 17-year-olds (36.2 percent).

Among black youths, as in white, the male and female frequency distributions are almost identical to each other, and again the very minor deviations likely come from the slightly higher frequency of missing and/or unsatisfactory samples among females than among males (3.6 versus 2.3 percent).

Again no systematic differences occurred with age. High frequencies of 1-1 occurred in 14- and 15-year-old females (81.4 and 82.7 percent, respectively) and 15-year-old males (82.9 percent), but these are not part of any real trend with age in males or females (the other frequencies wavered around the overall values). High frequencies of 2-2 in 16-year-old females (4.5 percent) were outstripped by 16-year-old males (9.4 percent) adjacent to very low values for 15-year-old males (0.8 percent) and also low values for 15-year-old females (1.5 percent). Whether the highs and lows in both sexes are sporadic and coincidental or indicate selection for a single year (possibly due to some infection, epidemic, or subclinical manifestation) is not clear, but certainly they do not coincide with age trends functioning over longer spans.

Geographic region.—Among white youths, the lowest frequency of 1-1 types occurred in the South Region (49.3 percent) and the highest in the West (53.6 percent) compared with an overall white frequency of 51.9 percent (table 18). White youths from the South showed the highest frequency of 2-1 heterozygotes (41.2 compared with 38.5 percent overall white frequency) and the lowest frequency of 2-2 homozygotes (6.0 compared with 7.4 percent overall white frequency).

Regional frequencies in the black group are as puzzling as those in the white group and are not as consistent as the red blood cell antigen frequencies in suggesting more racial intermixture in the black population in the West than in the South or Northeast. Overall, black youths had much higher frequencies of 1-1 phenotype than white youths did (75.5 versus 51.9 percent, respectively), yet the highest frequency of 1-1 in black youths occurred in the Midwest (79.3 percent) and not in the South, which surprisingly had the lowest 1-1 frequency of the black group in any region (73.8 percent). This finding, however, is not inconsistent with the low frequency of 1-1 in white youths in the South (49.3 percent) and may be related to racial intermixture with southern white persons who come from European ethnic stocks with a low frequency of the 1 allele. Another possibility, of course, is geographic selection pressures against the 1 allele.

Still another puzzling observation is the very low frequency of 2-2 among black youths in the West Region (1.8 percent), which, instead of falling between the overall frequencies for white (7.4 percent) and black (3.0 percent) youths, is

even more divergent from white frequencies than those of black youths from other regions. Only the high heterozygote (2-1) frequency among black youths in the West (20.8 percent), higher than for other black youths and in the direction of the overall white frequency of 38.5 percent, shows the suggestions of more racial intermixture in the black population in the West noted in the discussion of red blood cell frequencies.

Family income.—No real trends of family income in relation to group specific component phenotype are discernible. Very high and very low frequencies of specific phenotypes were observed in adjacent income brackets (table 18).

Among white youths, the highest frequency of 1-1 (55.4 percent) was found in the lowest income group (less than $1,000); the next income level ($1,000-$2,999) showed the lowest 1-1 frequency (46.8 percent; the highest income level ($15,000 or more) had a frequency (48.4 percent) similar to that in the next to the lowest income bracket. Similarly, in regard to 2-1 heterozygotes, whereas the lowest income level had the lowest frequency (34.9 percent), the next income bracket had next to the highest frequency (41.9 percent), not very different from the highest 2-1 frequency (42.4 percent) found in the highest income bracket. A rather high frequency of 2-2 was found in the next to lowest income bracket (9.0 percent) compared with an overall white frequency of 7.4 percent.

The frequency of 2-2 in black youths was highest in the income bracket listed as "unknown" (4.7 percent), approaching the 7.4 percent overall white frequency and not very different from the overall black frequency of 3.0 percent. In phenotypes of black, as in white youths, very different frequencies appeared in adjacent income brackets: The highest 1-1 phenotype frequency (87.3 percent) occurred in the highest income bracket, and the next to lowest 1-1 frequency (70.0 percent) occurred in the adjacent next to highest income bracket. The 2-1 frequency among black youths ranged from 12.7 to 28.1 percent, as compared with an overall black frequency of 18.6 percent; these frequency extremes occurred in adjacent categories.

Education of parent or guardian.—Educational levels of parent or guardian and Gc genotype frequency associations appeared just as erratic as associations with family income. In the white group, the highest frequency of 2-1 heterozygotes occurred among those with parental elementary school educational levels (5-7 years) and those whose parent had completed elementary school (8 years): 42.7 and 41.2 percent, respectively, compared with the overall white frequency of 38.5 percent. The highest frequency of 2-2 appeared for those with parental education of 8 years (10.4 compared with 7.4 percent overall white), and the highest frequency of 1-1 for those with less than 5 years of school (57.4 compared with 51.9 percent overall white). These frequencies are not very deviant and are not associated with extremes of educational level.

In the black group, the highest (4.8 percent) and lowest (0.8 percent) 2-2 frequencies occurred in adjacent educational levels of 9-11 and 8 years, respectively. Similar erratic patterns occurred in 1-1 frequencies. On the other hand, for 2-1 heterozygosity, the highest frequency (46.9 percent compared with an overall black frequency of 18.6 percent and an overall white frequency of 38.5 percent) occurred in the highest parental educational level (17 years or more), and although the trend was not completely consistent, lower frequencies occurred at lower educational levels and higher frequencies occurred at higher educational levels.

DISCUSSION

Frequency distributions.—Although detailed tabulations of phenotype frequencies are presented in this report, no allele frequencies were computed. Calculation of allele frequencies from these data would not be meaningful. All such calculations are based on the Hardy-Weinberg

principle and thus assume random mating, that is, a panmictic population. Clearly, this method is not applicable for a population as heterogeneous and geographically dispersed as that of the total United States. Moreover, the overall U.S. frequencies of various markers and also the frequencies estimated for individual regions present a working comparison base rather than an absolute set of frequencies for any study series. Comparison series matched on ethnic group and region would be required for examination in specific studies.

Tables A and B present blood type data adapted from Mourant et al.[14] The Mourant data exhibit a high degree of regional and—in some cases—ethnic specificity, but in general these percents compare quite well with those of the Health Examination Survey (HES), when crossed by race. Comparisons based on other demographic factors (e.g., geographic region) are much less illuminating due to the difficulty in winnowing precise and comparable definitions from the Mourant data. However, the HES data present a stable and reliable picture of the distribution of this variable in the United States.

Similar conclusions can be reached concerning the other variables discussed. Of particular interest for comparison purposes is the Tecumseh, Mich., study reported by Shreffler et al.[44] This study, which had a sample size varying around 8,000, discovered distributions for transferrin, haptoglobin, secretor ability, and group specific component that agree to within a few percent in every cell (when only white persons are considered) with the geographically broader but numerically smaller HES. Less agreement was observed between HES black data and data for black persons collated by Mourant, but no consistent difference is detectable; the larger differences are likely due to greater variability associated with much smaller sample sizes.

Variation in frequencies.—The only consistent and noteworthy differences in genetic marker frequencies observed are the differences between white and black youths. These findings were expected because racial, ethnic, and geographic differences in genetic markers are well documented. Some suggested regional differences appear, although they are less clear. Although one might speculate as to possible ecological/geographical/environmental selective factors that might be responsible for some of the regional variation, quantitative differences in racial admixture in migrants probably are responsible. For example, other reports[45] suggested that the California black population (migrants to the west coast) is less inbred than is the South Carolina black population.

No patterns of variation in genetic marker frequencies in relationship to age, sex, family income, or education of parent or guardian are discernible. Therefore, any slight deviations that might appear to be associated with those biologic, demographic, or socioeconomic factors likely derive from racial/ethnic stratification in the subsets rather than any primary effect. The absence of any consistent trends tends to reaffirm that at least within the age range of 12 through 17, no significant selective survival is associated with the markers studied (ABO and Rh blood types; ABH secretor status; or haptoglobin, transferrin, or Gc types). Sex differences in blood group frequencies have never been established; the findings reported from studies of blood groups and sex ratio have at best been equivocal.[46,47] The role of ABO and Rh incompatibility singly and their interaction, although examined extensively, have not suggested sex differences or selection occurring during the second decade of life.[46,48] The sociodemographic variables, where suggestive of possible associations, cannot be disengaged from confounding factors that could be responsible.

In conclusion, of the factors examined (race, sex, age, geographic region, family income, and education of parent or guardian), only race appears to be associated with distinct differences in genetic marker frequencies. Regional and other observed variations in marker frequencies may be related to differences in racial/ethnic composition and admixture. In view of the increasing literature on associations between genetic markers and diseases, the racial/ethnic composition and comparability of groups being examined must be considered in evaluating the impact of environmental or other agents on health status and prognosis.

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LIST OF DETAILED TABLES

Table 1. Percent distribution of youths 12-17 years old by blood type, according to race, sex, and age: United States, 1966-70

Race, sex, and age	Blood type					
	O	A_1	A_2	B	A_1B	A_2B
WHITE						
Both sexes	Percent distribution					
12-17 years	44.3	35.2	6.9	10.2	2.5	1.1
12 years	44.5	36.0	5.3	10.0	2.8	1.3
13 years	45.4	34.5	7.5	9.8	2.1	0.7
14 years	44.9	34.9	7.1	10.4	2.4	0.3
15 years	41.3	38.0	6.3	10.8	2.0	1.5
16 years	45.5	34.1	6.6	9.9	3.0	0.9
17 years	43.8	33.2	8.6	10.2	2.6	1.6
Male						
12-17 years	44.9	34.3	7.5	9.7	2.7	1.0
12 years	46.1	35.2	5.3	8.7	3.2	1.5
13 years	43.5	35.7	8.6	8.8	2.8	0.7
14 years	46.7	34.7	6.8	10.3	1.5	-
15 years	41.7	37.7	6.8	10.1	2.5	1.3
16 years	45.9	30.5	8.4	10.6	3.6	1.1
17 years	45.5	31.8	9.4	9.5	2.4	1.4
Female						
12-17 years	43.6	36.0	6.2	10.7	2.3	1.1
12 years	42.9	36.9	5.4	11.4	2.4	1.1
13 years	47.5	33.2	6.3	10.9	1.4	0.7
14 years	43.1	35.0	7.4	10.4	3.4	0.7
15 years	41.0	38.4	5.8	11.5	1.6	1.8
16 years	45.1	37.9	4.6	9.2	2.4	0.8
17 years	42.0	34.7	7.8	10.9	2.8	1.8
BLACK						
Both sexes						
12-17 years	47.5	23.4	3.4	21.2	2.2	2.3
12 years	51.4	21.4	2.6	21.1	2.2	1.4
13 years	50.4	23.1	2.7	20.3	1.2	2.3
14 years	42.6	27.0	5.5	21.2	2.6	1.0
15 years	40.8	19.7	2.2	26.8	4.3	6.2
16 years	46.3	27.3	2.7	20.4	1.1	2.1
17 years	53.2	22.2	4.6	17.5	1.7	0.8
Male						
12-17 years	47.4	23.9	3.9	20.8	2.2	1.8
12 years	49.3	23.3	2.1	22.8	2.5	-
13 years	50.6	19.9	4.1	22.1	1.0	2.3
14 years	39.1	31.0	6.6	20.0	3.3	-
15 years	43.9	18.2	3.0	25.1	2.6	7.1
16 years	50.6	24.7	3.3	19.2	2.2	-
17 years	51.7	26.2	4.6	14.5	1.3	1.6
Female						
12-17 years	47.6	23.0	2.8	21.7	2.2	2.7
12 years	53.5	19.4	3.0	19.4	1.9	2.7
13 years	50.3	26.2	1.4	18.5	1.5	2.2
14 years	46.1	23.2	4.4	22.4	1.8	2.0
15 years	37.5	21.2	1.4	28.6	6.1	5.2
16 years	42.1	30.0	2.1	21.6	-	4.2
17 years	54.7	18.4	4.7	20.2	2.0	-

Table 2. Percent distribution of youths 12-17 years old by blood type, according to race, geographic region, income, and education: United States, 1966-70

Race, region, income, and education	Blood type					
	O	A_1	A_2	B	A_1B	A_2B
WHITE						
Region	Percent distribution					
Northeast	43.0	35.6	6.0	11.4	2.9	1.1
Midwest	41.0	35.8	7.3	11.5	3.2	1.2
South	46.3	33.4	8.1	9.3	1.6	1.2
West	47.4	35.3	6.2	8.3	1.9	0.8
Income						
Less than $1,000	58.3	30.8	7.4	3.5	-	-
$1,000-$2,999	47.6	33.6	6.4	10.4	1.3	0.7
$3,000-$4,999	46.0	36.3	6.0	8.7	1.9	1.1
$5,000-$6,999	43.5	33.6	6.8	11.8	3.7	0.6
$7,000-$9,999	44.4	35.0	6.2	10.5	2.5	1.3
$10,000-$14,999	45.6	33.9	6.8	10.5	1.9	1.4
$15,000 or more	39.5	39.6	8.9	9.5	1.8	0.7
Unknown	40.8	35.8	8.0	8.9	5.5	1.0
Education						
Less than 5 years	50.3	34.0	7.4	8.4	-	-
5-7 years	49.5	30.1	6.4	12.0	1.1	0.9
8 years	45.2	34.4	6.0	10.3	2.0	2.1
9-11 years	47.3	35.1	6.3	8.1	2.8	0.4
12 years	43.2	35.3	7.2	10.4	2.6	1.3
13-15 years	40.2	38.2	7.5	10.1	2.5	1.4
16 years	43.0	32.7	6.9	13.1	3.2	1.2
17 years or more	43.1	37.0	6.6	10.2	2.9	0.2
Unknown	51.3	36.9	5.2	4.4	2.1	-
BLACK						
Region						
Northeast	50.6	27.2	1.9	18.1	0.5	1.8
Midwest	44.8	25.9	3.2	22.1	3.4	0.6
South	49.4	17.8	3.8	24.8	1.3	2.8
West	39.6	34.3	4.4	12.4	6.3	3.0
Income						
Less than $1,000	48.8	17.0	3.1	26.5	2.9	1.6
$1,000-$2,999	47.4	21.3	4.1	21.4	3.2	2.7
$3,000-$4,999	50.7	24.3	3.3	18.0	1.5	2.2
$5,000-$6,999	42.7	30.6	4.4	19.0	2.2	1.1
$7,000-$9,999	48.6	16.7	3.7	27.3	1.3	2.5
$10,000-$14,999	47.2	20.3	1.9	24.1	3.5	2.9
$15,000 or more	29.2	38.2	-	20.0	6.5	6.1
Unknown	48.8	27.1	-	21.6	-	2.6
Education						
Less than 5 years	48.8	16.9	4.6	23.6	2.4	3.7
5-7 years	51.2	18.1	2.2	23.2	1.4	4.0
8 years	57.4	20.8	-	18.6	3.3	-
9-11 years	42.9	28.5	4.6	21.1	1.0	2.0
12 years	46.9	21.3	2.2	22.3	4.4	2.8
13-15 years	50.8	23.6	8.0	16.3	-	1.4
16 years	50.5	33.7	-	10.3	5.5	-
17 years or more	57.0	9.7	10.4	22.8	-	-
Unknown	53.5	22.3	-	21.2	3.0	-

Table 3. Percent distribution of youths 12-17 years old by Rh D type, according to race, sex, and age: United States, 1966-70

Race, sex, and age	Rh D type		
	D+	D–	D^u
WHITE			
Both sexes	Percent distribution		
12-17 years	84.8	15.0	0.2
12 years	84.6	15.3	0.1
13 years	84.6	15.1	0.3
14 years	83.5	16.4	0.1
15 years	85.5	14.4	0.1
16 years	85.8	13.8	0.4
17 years	84.7	15.0	0.2
Male			
12-17 years	83.7	16.1	0.3
12 years	83.9	16.0	0.2
13 years	85.2	14.4	0.4
14 years	81.6	18.2	0.2
15 years	84.4	15.6	-
16 years	83.4	16.2	0.5
17 years	83.6	16.0	0.4
Female			
12-17 years	85 9	13.9	0.1
12 years	85.4	14.6	-
13 years	84.0	15.8	0.2
14 years	85.5	14.5	-
15 years	86.6	13.2	0.2
16 years	88.4	11.2	0.3
17 years	85.9	14.1	-
BLACK			
Both sexes			
12-17 years	93.7	6.0	0.3
12 years	93.1	5.8	1.2
13 years	91.8	8.2	-
14 years	95.3	4.3	0.5
15 years	93.1	6.9	-
16 years	98.6	1.4	-
17 years	90.4	9.6	-
Male			
12-17 years	92.4	7.2	0.4
12 years	89.9	9.1	1.0
13 years	92.3	7.7	-
14 years	93.6	5.5	0.9
15 years	96.4	3.6	-
16 years	98.4	1.6	-
17 years	83.9	16.1	-
Female			
12-17 years	94.9	4.9	0.2
12 years	96.3	2.3	1.3
13 years	91.4	8.6	-
14 years	96.9	3.1	-
15 years	89.6	10.4	-
16 years	98.9	1.1	-
17 years	96.4	3.6	-

Table 4. Percent distribution of youths 12-17 years old by Rh D type, according to race, geographic region, income, and education: United States, 1966-70

Race, region, income, and education	Rh D type		
	D+	D–	D^u
	Percent distribution		
WHITE			
Region			
Northeast	85.0	14.7	0.3
Midwest	85.9	14.1	-
South	82.9	16.7	0.4
West	84.6	15.2	0.2
Income			
Less than $1,000	83.0	17.0	-
$1,000-$2,999	86.3	13.4	0.3
$3,000-$4,999	86.9	12.9	0.1
$5,000-$6,999	84.5	15.3	0.2
$7,000-$9,999	83.6	16.1	0.4
$10,000-$14,999	84.7	15.1	0.2
$15,000 or more	84.7	15.2	0.1
Unknown	85.3	14.7	-
Education			
Less than 5 years	89.6	10.4	-
5-7 years	90.1	9.9	-
8 years	82.5	17.5	-
9-11 years	83.9	16.1	0.1
12 years	84.6	15.0	0.3
13-15 years	84.0	15.9	0.1
16 years	83.0	16.5	0.5
17 years or more	87.9	12.1	-
Unknown	85.6	14.4	-
BLACK			
Region			
Northeast	91.1	8.3	0.6
Midwest	93.6	6.4	-
South	94.9	4.7	0.4
West	93.2	6.8	-
Income			
Less than $1,000	97.1	2.9	-
$1,000-$2,999	90.8	9.2	-
$3,000-$4,999	94.1	5.2	0.7
$5,000-$6,999	91.5	8.5	-
$7,000-$9,999	95.6	4.4	-
$10,000-$14,999	96.3	3.7	-
$15,000 or more	100.0	-	-
Unknown	97.1	1.0	1.9
Education			
Less than 5 years	94.8	5.2	-
5-7 years	93.2	5.9	0.9
8 years	93.0	5.9	1.0
9-11 years	91.4	8.4	0.3
12 years	95.6	4.4	-
13-15 years	94.4	5.6	-
16 years	100.0	-	-
17 years or more	100.0	-	-
Unknown	100.0	-	-

Table 5. Percent distribution of youths 12-17 years old by Rh C type, according to race, sex, and age: United States, 1966-70

Race, sex, and age	Rh C type		
	CC	Cc	cc
	Percent distribution		
WHITE			
Both sexes			
12-17 years	17.8	50.2	32.0
12 years	19.4	49.2	31.4
13 years	18.5	48.7	32.8
14 years	15.6	50.8	33.5
15 years	17.5	50.0	32.5
16 years	19.3	49.9	30.8
17 years	16.4	52.8	30.9
Male			
12-17 years	17.8	50.0	32.2
12 years	20.9	48.2	30.9
13 years	20.3	47.4	32.3
14 years	15.6	48.4	35.9
15 years	16.3	52.1	31.6
16 years	18.7	48.7	32.6
17 years	14.5	55.9	29.6
Female			
12-17 years	17.8	50.4	31.8
12 years	17.9	50.1	31.9
13 years	16.5	50.2	33.3
14 years	15.6	53.4	31.0
15 years	18.7	47.9	33.4
16 years	19.9	51.1	28.9
17 years	18.3	49.5	32.2
BLACK			
Both sexes			
12-17 years	1.7	25.6	72.7
12 years	1.5	31.1	67.4
13 years	3.7	19.6	76.7
14 years	1.7	26.1	72.2
15 years	1.1	25.7	73.2
16 years	1.6	21.4	77.1
17 years	0.7	28.9	70.4
Male			
12-17 years	1.9	24.3	73.8
12 years	1.9	30.8	67.3
13 years	4.1	16.1	79.8
14 years	1.0	23.2	75.8
15 years	2.1	22.0	75.9
16 years	2.0	23.9	74.1
17 years	-	29.9	70.1
Female			
12-17 years	1.6	26.8	71.7
12 years	1.1	31.4	67.5
13 years	3.4	23.0	73.6
14 years	2.3	29.0	68.6
15 years	-	29.6	70.4
16 years	1.1	18.8	80.0
17 years	1.3	27.9	70.7

Table 6. Percent distribution of youths 12-17 years old by Rh C type, according to race, geographic region, income, and education: United States, 1966-70

Race, region, income, and education	Rh C type		
	CC	Cc	cc
	Percent distribution		
WHITE			
Region			
Northeast	18.0	49.5	32.5
Midwest	17.5	51.0	31.5
South	16.6	48.4	35.0
West	18.8	51.2	30.0
Income			
Less than $1,000	14.4	54.6	30.9
$1,000-$2,999	20.7	46.4	32.9
$3,000-$4,999	17.0	51.9	31.2
$5,000-$6,999	18.3	53.6	28.1
$7,000-$9,999	18.1	49.7	32.3
$10,000-$14,999	17.2	50.2	32.6
$15,000 or more	17.0	47.1	36.0
Unknown	17.6	50.9	31.5
Education			
Less than 5 years	20.7	53.2	26.1
5-7 years	19.6	54.6	25.8
8 years	14.5	47.7	37.8
9-11 years	19.1	49.8	31.1
12 years	18.4	49.7	31.9
13-15 years	16.3	54.5	29.2
16 years	18.1	47.9	34.0
17 years or more	15.6	47.4	37.0
Unknown	13.4	49.4	37.2
BLACK			
Region			
Northeast	0.6	24.4	75.0
Midwest	2.6	26.2	71.1
South	1.8	24.0	74.2
West	2.2	32.0	65.8
Income			
Less than $1,000	1.4	17.7	80.9
$1,000-$2,999	2.7	29.1	68.2
$3,000-$4,999	0.8	24.4	74.8
$5,000-$6,999	3.5	23.7	72.8
$7,000-$9,999	-	30.9	69.1
$10,000-$14,999	-	25.3	74.7
$15,000 or more	13.2	24.2	62.6
Unknown	-	23.0	77.0
Education			
Less than 5 years	-	12.2	87.8
5-7 years	1.6	24.0	74.4
8 years	1.6	23.7	74.8
9-11 years	1.6	23.7	74.7
12 years	2.3	29.9	67.8
13-15 years	5.4	40.8	53.7
16 years	-	19.1	80.9
17 years or more	-	46.5	53.5
Unknown	-	26.9	73.1

Table 7. Percent distribution of youths 12-17 years old by Rh E type, according to race, sex, and age: United States, 1966-70

Race, sex, and age	Rh E type		
	EE	Ee	ee
	Percent distribution		
WHITE			
Both sexes			
12-17 years	3.1	26.9	70.0
12 years	2.3	27.9	69.8
13 years	3.9	26.6	69.4
14 years	2.4	27.6	70.0
15 years	4.1	25.7	70.2
16 years	3.4	26.3	70.3
17 years	2.4	27.1	70.5
Male			
12-17 years	2.8	26.4	70.8
12 years	1.5	28.8	69.7
13 years	4.0	27.2	68.8
14 years	2.8	25.4	71.8
15 years	4.0	25.4	70.6
16 years	2.6	26.1	71.3
17 years	1.7	25.5	72.8
Female			
12-17 years	3.4	27.4	69.2
12 years	3.1	27.0	70.0
13 years	3.8	26.1	70.1
14 years	1.9	30.0	68.1
15 years	4.3	26.0	69.7
16 years	4.2	26.5	69.3
17 years	3.2	28.7	68.1
BLACK			
Both sexes			
12-17 years	1.2	17.1	81.6
12 years	1.6	14.9	83.5
13 years	0.6	17.2	82.3
14 years	2.0	14.7	83.3
15 years	2.1	14.0	83.8
16 years	1.0	26.6	72.3
17 years	-	16.2	83.8
Male			
12-17 years	1.4	17.5	81.0
12 years	2.4	15.1	82.5
13 years	1.2	13.6	85.2
14 years	1.9	15.7	82.4
15 years	2.6	17.4	79.9
16 years	-	27.5	72.5
17 years	-	17.2	82.8
Female			
12-17 years	1.0	16.8	82.2
12 years	0.8	14.7	84.6
13 years	-	20.6	79.4
14 years	2.0	13.8	84.1
15 years	1.6	10.5	87.9
16 years	2.1	25.8	72.2
17 years	-	15.4	84.6

Table 8. Percent distribution of youths 12-17 years old by Rh E type, according to race, geographic region, income, and education: United States, 1966-70

Race, region, income, and education	Rh E type		
	EE	Ee	ee
	Percent distribution		
WHITE			
Region			
Northeast	3.1	25.4	71.4
Midwest	3.0	25.9	71.1
South	3.7	26.6	69.6
West	2.7	29.4	67.9
Income			
Less than $1,000	6.1	30.0	63.9
$1,000-$2,999	4.5	29.9	65.5
$3,000-$4,999	3.4	27.2	69.4
$5,000-$6,999	2.9	24.4	72.8
$7,000-$9,999	2.4	25.0	72.6
$10,000-$14,999	3.6	28.1	68.3
$15,000 or more	2.9	27.5	69.7
Unknown	2.3	30.3	67.4
Education			
Less than 5 years	1.8	32.1	66.1
5-7 years	3.6	30.6	65.7
8 years	4.9	29.1	65.9
9-11 years	2.5	25.0	72.5
12 years	3.6	25.0	71.3
13-15 years	1.8	23.9	74.2
16 years	3.8	28.7	67.5
17 years or more	1.3	36.0	62.6
Unknown	0.8	31.7	67.5
BLACK			
Region			
Northeast	1.3	13.6	85.1
Midwest	2.0	25.0	73.0
South	1.1	13.2	85.7
West	0.6	26.5	72.9
Income			
Less than $1,000	-	16.6	83.4
$1,000-$2,999	1.9	13.5	84.6
$3,000-$4,999	1.2	13.7	85.2
$5,000-$6,999	0.5	20.3	79.2
$7,000-$9,999	0.7	27.0	72.4
$10,000-$14,999	5.4	23.8	70.8
$15,000 or more	-	32.2	67.8
Unknown	-	11.9	88.1
Education			
Less than 5 years	4.0	18.1	77.9
5-7 years	2.4	9.4	88.3
8 years	-	16.2	83.8
9-11 years	1.0	19.0	80.1
12 years	1.2	17.8	81.0
13-15 years	-	18.7	81.3
16 years	-	32.2	67.8
17 years or more	-	23.4	76.6
Unknown	-	8.7	91.3

Table 9. Percent distribution of youths 12-17 years old by summarized Rh genotype combinations, according to race, sex, and age: United States, 1966-70

Race, sex, and age	Rh genotype combinations										
	1	2	3	4+9[1]	5+35[1]	6+36[1]	7	8	12	13	32
WHITE											
Both sexes	Percent distribution										
12-17 years	14.1	35.4	17.6	14.2	2.4	12.1	3.1	0.2	0.5	0.4	0.1
12 years	14.4	33.5	19.4	14.9	1.9	12.6	2.3	0.1	0.6	0.2	0.1
13 years	13.9	34.3	18.3	13.6	2.1	12.5	3.8	0.2	0.7	0.5	0.1
14 years	15.5	37.0	15.2	13.4	1.9	13.3	2.4	0.5	0.5	0.4	-
15 years	13.5	36.1	17.4	13.4	2.7	11.6	4.1	0.1	0.4	0.5	0.1
16 years	12.9	35.3	18.9	14.2	2.7	11.2	3.4	0.4	0.3	0.5	0.1
17 years	14.3	36.5	16.2	15.6	2.9	10.9	2.4	0.2	0.4	0.4	0.2
Male											
12-17 years	15.1	35.6	17.5	13.7	1.8	12.0	2.8	0.3	0.5	0.4	0.1
12 years	15.0	31.5	20.7	15.8	1.5	12.6	1.5	0.2	0.8	0.2	0.2
13 years	13.2	32.3	20.0	13.9	2.2	12.6	4.0	0.3	0.8	0.3	0.3
14 years	17.4	37.0	15.3	10.8	1.4	14.2	2.8	0.3	0.6	0.2	-
15 years	14.4	37.5	16.3	14.1	2.0	10.5	4.0	-	0.5	0.8	-
16 years	15.4	36.1	18.1	12.7	1.7	12.1	2.6	0.6	-	0.8	-
17 years	15.6	40.0	14.3	15.3	2.4	9.7	1.7	0.2	0.2	0.2	0.4
Female											
12-17 years	13.0	35.2	17.6	14.6	2.9	12.1	3.4	0.2	0.5	0.4	0.1
12 years	13.8	35.6	17.9	14.1	2.2	12.6	3.1	-	0.5	0.3	-
13 years	14.6	36.3	16.5	13.2	2.0	12.4	3.7	-	0.7	0.6	-
14 years	13.5	36.9	15.0	16.1	2.4	12.5	1.9	0.6	0.4	0.7	-
15 years	12.6	34.7	18.5	12.8	3.5	12.8	4.3	0.2	0.3	0.3	0.2
16 years	10.4	34.5	19.7	15.8	3.8	10.4	4.2	0.2	0.7	0.1	0.2
17 years	12.9	32.9	18.1	16.0	3.5	12.1	3.2	0.2	0.7	0.5	-
BLACK											
Both sexes											
12-17 years	4.7	22.7	1.7	1.9	51.6	14.8	1.2	-	0.9	0.4	-
12 years	4.1	27.4	1.5	2.0	48.9	12.9	1.6	-	1.7	-	-
13 years	6.0	18.5	3.7	0.5	53.4	15.1	0.6	-	0.6	1.6	-
14 years	3.3	22.9	1.7	2.3	54.4	12.5	2.0	-	1.0	-	-
15 years	5.5	23.6	1.1	0.7	52.2	13.3	2.1	-	1.4	-	-
16 years	1.4	17.9	1.6	3.4	51.5	23.2	1.0	-	-	-	-
17 years	7.8	25.6	0.7	2.5	48.9	12.7	-	-	0.8	1.0	-
Male											
12-17 years	5.6	21.1	1.9	1.8	51.0	15.6	1.4	-	1.5	0.2	-
12 years	5.7	25.8	1.9	1.6	45.7	13.5	2.4	-	3.4	-	-
13 years	6.5	14.8	4.1	-	58.6	13.6	1.2	-	1.3	-	-
14 years	4.7	19.8	1.0	2.6	56.1	13.0	1.9	-	0.8	-	-
15 years	2.3	20.7	2.1	-	53.5	17.4	2.6	-	1.3	-	-
16 years	1.6	20.6	2.0	3.3	48.3	24.2	-	-	-	-	-
17 years	13.2	24.8	-	3.5	43.2	12.5	-	-	1.7	1.2	-
Female											
12-17 years	3.7	24.3	1.6	2.0	52.1	14.1	1.0	-	0.4	0.7	-
12 years	2.3	29.0	1.1	2.4	52.1	12.2	0.8	-	-	-	-
13 years	5.5	22.1	3.4	1.0	48.4	16.6	-	-	-	3.1	-
14 years	2.0	26.0	2.3	1.9	52.7	11.9	2.0	-	1.2	-	-
15 years	8.9	26.5	-	1.5	50.9	9.0	1.6	-	1.5	-	-
16 years	1.1	15.3	1.1	3.5	54.6	22.2	2.1	-	-	-	-
17 years	2.7	26.3	1.3	1.6	54.3	12.9	-	-	-	0.9	-

[1]See the Results section of the test for the rationale behind these mergers.

Table 10. Percent distribution of youths 12-17 years old by summarized Rh genotype combinations, according to race, geographic region, income, and education: United States, 1966-70

Race, region, income, and education	Rh genotype combinations										
	1	2	3	4+9[1]	5+35[1]	6+36[1]	7	8	12	13	32
WHITE											
Region	Percent distribution										
Northeast	13.7	35.9	18.0	12.8	3.1	12.1	3.1	0.1	0.6	0.4	0.3
Midwest	13.0	37.6	17.3	12.7	2.6	12.6	3.0	0.3	0.7	0.3	-
South	15.8	34.0	16.6	14.1	2.9	11.9	3.7	-	0.2	0.7	0.1
West	14.4	33.6	18.3	17.0	1.1	11.5	2.6	0.5	0.5	0.3	0.1
Income											
Less than $1,000	10.0	33.1	14.4	16.8	1.7	11.0	6.1	-	4.8	2.2	-
$1,000-$2,999	11.5	30.1	20.7	16.1	3.0	11.9	4.5	-	-	1.9	0.3
$3,000-$4,999	12.6	37.4	16.9	14.4	2.5	12.4	3.4	0.1	-	0.3	0.1
$5,000-$6,999	14.1	38.1	17.9	14.6	1.8	9.0	2.8	0.4	0.8	0.4	0.1
$7,000-$9,999	15.3	36.0	17.8	12.8	2.7	11.7	2.4	0.3	0.6	0.1	0.2
$10,000-$14,999	13.9	34.8	17.1	14.5	1.7	13.1	3.6	0.1	0.8	0.4	0.1
$15,000 or more	15.0	34.1	16.5	12.9	4.0	13.9	2.9	0.4	-	0.2	-
Unknown	14.7	34.2	17.6	16.7	0.9	13.6	2.3	-	-	-	-
Education											
Less than 5 years	8.0	33.2	20.7	19.1	3.3	11.4	1.8	-	0.9	1.6	-
5-7 years	9.4	34.2	19.3	20.4	2.8	9.7	3.4	0.3	-	0.5	-
8 years	16.1	32.1	14.4	14.9	2.7	13.3	4.9	0.2	0.7	0.7	-
9-11 years	15.3	35.7	18.7	13.5	2.3	10.8	2.5	0.4	0.5	0.3	0.1
12 years	14.2	36.4	18.0	12.7	2.1	11.5	3.6	0.4	0.4	0.4	0.2
13-15 years	14.6	40.1	16.3	13.5	2.3	9.9	1.8	-	0.8	0.5	0.1
16 years	15.9	31.2	18.1	16.2	1.8	12.4	3.8	-	0.5	0.2	-
17 years or more	11.5	32.2	15.6	15.0	3.1	20.7	1.3	-	0.2	0.4	-
Unknown	12.1	34.6	13.4	12.6	5.1	19.1	0.8	-	2.2	-	-
BLACK											
Region											
Northeast	6.8	21.9	0.6	1.1	54.4	12.5	1.3	-	1.5	-	-
Midwest	5.7	21.3	2.6	4.2	42.6	20.8	2.0	-	0.7	-	-
South	3.8	21.8	1.8	1.4	57.6	11.6	1.1	-	0.8	0.1	-
West	3.1	29.3	2.2	1.8	37.4	22.0	0.6	-	1.0	2.7	-
Income											
Less than $1,000	2.9	17.7	1.4	-	61.4	16.6	-	-	-	-	-
$1,000-$2,999	7.4	25.6	2.7	1.7	47.1	11.8	1.9	-	1.8	-	-
$3,000-$4,999	4.7	22.3	0.8	1.6	56.9	12.0	1.2	-	0.5	-	-
$5,000-$6,999	5.0	19.3	3.5	2.8	49.8	15.5	0.5	-	1.6	2.0	-
$7,000-$9,999	2.4	26.3	-	3.4	42.6	22.7	0.7	-	1.2	0.8	-
$10,000-$14,999	3.7	25.3	-	-	41.8	23.8	5.4	-	-	-	-
$15,000 or more	-	18.1	13.2	6.0	36.4	26.2	-	-	-	-	-
Unknown	1.0	21.5	-	1.5	65.5	10.5	-	-	-	-	-
Education											
Less than 5 years	3.7	9.7	-	0.9	63.0	17.2	4.0	-	1.6	-	-
5-7 years	5.0	22.3	1.6	0.7	58.4	8.6	2.4	-	0.9	-	-
8 years	5.0	21.0	1.6	2.6	56.2	12.6	-	-	-	0.9	-
9-11 years	6.7	20.9	1.6	1.9	49.9	16.4	1.0	-	0.9	0.7	-
12 years	2.8	27.0	2.3	1.3	47.4	16.5	1.2	-	1.6	-	-
13-15 years	3.9	33.8	5.4	7.0	38.1	10.0	-	-	-	1.7	-
16 years	-	15.4	-	3.7	52.4	28.5	-	-	-	-	-
17 years or more	-	46.5	-	-	30.0	23.4	-	-	-	-	-
Unknown	-	24.3	-	2.6	67.0	6.1	-	-	-	-	-

[1]See the Results section of the text for the rationale behind these mergers.

Table 11. Percent distribution of youths 12-17 years old by ABH secretor ability, according to race, sex, and age: United States, 1966-70

Race, sex, and age	ABH secretor ability			
	Se+	Se-	Unsatisfactory sample	Test not done
	Percent distribution			
WHITE				
Both sexes				
12-17 years	75.7	21.8	2.0	0.5
12 years	78.5	19.8	1.5	0.1
13 years	76.8	21.3	1.6	0.3
14 years	72.3	24.8	2.3	0.6
15 years	76.1	21.4	2.3	0.3
16 years	75.8	21.7	1.9	0.6
17 years	74.3	22.0	2.8	0.9
Male				
12-17 years	75.8	21.4	2.3	0.5
12 years	77.6	20.6	1.6	0.3
13 years	78.1	19.5	1.9	0.4
14 years	72.3	24.4	2.1	1.2
15 years	78.1	18.9	2.8	0.1
16 years	75.8	22.3	1.9	-
17 years	72.7	22.8	3.4	1.0
Female				
12-17 years	75.5	22.2	1.8	0.4
12 years	79.5	19.1	1.4	-
13 years	75.4	23.1	1.3	0.2
14 years	72.3	25.3	2.4	-
15 years	74.0	23.9	1.7	0.4
16 years	75.7	21.0	2.0	1.3
17 years	75.9	21.1	2.1	0.9
BLACK				
Both sexes				
12-17 years	66.0	23.0	10.4	0.6
12 years	66.8	25.8	6.3	1.0
13 years	70.9	23.1	5.4	0.6
14 years	66.9	19.9	12.3	0.9
15 years	60.9	28.0	10.7	0.4
16 years	68.7	21.7	9.1	0.5
17 years	60.8	19.0	20.1	-
Male				
12-17 years	65.8	21.5	12.1	0.6
12 years	68.0	25.2	6.1	0.7
13 years	71.5	22.9	4.4	1.2
14 years	67.9	16.4	14.9	0.9
15 years	57.9	27.6	13.7	0.8
16 years	65.7	22.9	11.3	-
17 years	62.7	12.8	24.5	-
Female				
12-17 years	66.2	24.5	8.8	0.6
12 years	65.5	26.5	6.6	1.3
13 years	70.3	23.3	6.3	-
14 years	66.0	23.3	9.8	0.9
15 years	64.1	28.4	7.6	-
16 years	71.5	20.5	7.0	1.1
17 years	59.0	25.0	16.0	-

Table 12. Percent distribution of youths 12-17 years old by ABH secretor ability, according to race, geographic region, income, and education: United States, 1966-70

Race, region, income, and education	ABH secretor ability			
	Se+	Se–	Unsatisfactory sample	Test not done
WHITE				
Region	Percent distribution			
Northeast	76.2	20.2	2.6	1.1
Midwest	78.0	20.3	1.3	0.4
South	71.9	24.9	2.8	0.3
West	75.4	22.5	1.9	0.2
Income				
Less than $1,000	76.3	22.5	1.2	-
$1,000-$2,999	68.3	26.6	4.3	0.8
$3,000-$4,999	76.7	19.7	3.2	0.4
$5,000-$6,999	76.4	21.0	2.2	0.5
$7,000-$9,999	75.4	22.1	1.9	0.5
$10,000-$14,999	76.9	21.3	1.4	0.5
$15,000 or more	76.0	22.6	1.0	0.3
Unknown	77.2	20.8	1.5	0.4
Education				
Less than 5 years	74.1	20.6	5.3	-
5-7 years	71.7	21.0	6.6	0.8
8 years	72.2	22.7	4.8	0.4
9-11 years	73.3	23.5	2.3	0.9
12 years	77.5	21.1	1.2	0.3
13-15 years	78.1	20.0	1.2	0.8
16 years	76.0	22.6	1.3	0.1
17 years or more	74.3	24.7	0.5	0.6
Unknown	73.8	20.8	5.5	-
BLACK				
Region				
Northeast	62.1	29.4	7.4	1.1
Midwest	72.1	20.9	7.1	-
South	62.8	21.4	15.1	0.7
West	76.0	21.0	3.1	-
Income				
Less than $1,000	70.5	18.8	9.6	1.1
$1,000-$2,999	62.8	24.0	12.3	1.0
$3,000-$4,999	65.1	22.8	12.1	-
$5,000-$6,999	71.8	15.8	11.6	0.9
$7,000-$9,999	69.5	24.2	6.3	-
$10,000-$14,999	66.8	31.5	1.7	-
$15,000 or more	67.4	19.8	12.8	-
Unknown	55.3	34.5	8.4	1.8
Education				
Less than 5 years	62.4	22.9	13.5	1.1
5-7 years	58.2	26.2	15.6	-
8 years	49.2	38.2	11.7	0.9
9-11 years	71.5	17.7	10.0	0.8
12 years	67.5	26.0	6.6	-
13-15 years	66.4	16.5	14.5	2.6
16 years	74.6	14.4	11.1	-
17 years or more	82.7	17.3	-	-
Unknown	57.5	33.2	9.2	-

Table 13. Percent distribution of youths 12-17 years old by haptoglobin type, according to race, sex, and age: United States, 1966-70

Race, sex, and age	Haptoglobin type					
	1-1	2-1	2-2	Other	Unsatisfactory sample	Test not done
WHITE						
Both sexes	Percent distribution					
12-17 years	16.4	46.8	32.8	1.9	0.3	1.7
12 years	17.4	43.7	32.9	2.9	0.4	2.7
13 years	17.5	46.2	30.8	3.0	0.5	2.0
14 years	17.6	45.5	33.5	1.7	0.3	1.3
15 years	15.9	50.1	31.6	1.4	0.1	0.8
16 years	14.8	46.7	34.8	1.3	0.2	2.1
17 years	15.1	49.0	33.5	0.6	0.3	1.3
Male						
12-17 years	16.4	47.3	32.1	2.9	0.1	1.2
12 years	18.0	44.0	30.9	4.6	0.2	2.4
13 years	18.9	44.2	30.4	4.9	0.3	1.2
14 years	16.8	46.9	33.3	2.1	0.2	0.8
15 years	14.8	50.5	31.7	2.4	-	0.6
16 years	16.3	47.0	33.1	2.2	0.2	1.2
17 years	13.2	51.9	33.5	0.6	-	0.8
Female						
12-17 years	16.5	46.3	33.6	0.8	0.5	2.3
12 years	16.9	43.3	35.1	1.1	0.5	3.1
13 years	16.0	48.2	31.2	1.0	0.7	2.8
14 years	18.4	44.1	33.8	1.4	0.5	1.9
15 years	17.1	49.7	31.5	0.5	0.2	1.0
16 years	13.4	46.3	36.4	0.4	0.3	3.1
17 years	17.2	46.1	33.6	0.6	0.6	1.9
BLACK						
Both sexes						
12-17 years	32.2	39.4	13.3	12.1	0.7	2.3
12 years	33.0	39.0	9.7	15.6	1.2	1.5
13 years	33.6	40.3	14.5	6.9	0.7	4.1
14 years	32.3	36.1	13.5	15.1	1.2	2.0
15 years	31.0	45.8	13.3	7.8	-	2.0
16 years	30.0	39.8	11.4	14.6	1.1	3.0
17 years	33.3	35.4	17.7	12.3	-	1.4
Male						
12-17 years	34.9	35.5	11.0	16.1	0.4	2.1
12 years	33.6	31.5	9.0	23.0	1.1	1.8
13 years	37.2	37.0	11.5	10.4	-	3.9
14 years	35.9	32.8	8.9	19.9	1.2	1.2
15 years	32.9	41.9	13.4	10.5	-	1.3
16 years	35.3	38.6	9.0	15.5	-	1.6
17 years	34.4	31.5	15.0	16.3	-	2.8
Female						
12-17 years	29.6	43.2	15.4	8.2	1.0	2.6
12 years	32.4	46.7	10.5	8.0	1.3	1.1
13 years	30.1	43.4	17.3	3.5	1.3	4.3
14 years	28.7	39.2	17.8	10.4	1.1	2.8
15 years	29.1	49.8	13.2	5.1	-	2.8
16 years	24.9	41.0	13.7	13.9	2.1	4.4
17 years	32.2	39.1	20.2	8.5	-	-

Table 14. Percent distribution of youths 12-17 years old by haptoglobin type, according to race, geographic region, income, and education: United States, 1966-70

Race, region, income, and education	Haptoglobin type					
	1-1	2-1	2-2	Other	Unsatisfactory sample	Test not done
WHITE						
Region	Percent distribution					
Northeast	15.0	46.0	35.0	1.6	0.8	1.6
Midwest	17.9	47.0	32.5	1.7	0.2	0.8
South	15.2	46.4	32.1	2.7	0.4	3.1
West	17.1	47.5	32.0	1.6	-	1.8
Income						
Less than $1,000	16.3	45.3	34.0	2.8	-	1.6
$1,000-$2,999	20.8	47.5	26.1	3.3	0.2	2.1
$3,000-$4,999	14.9	47.1	34.0	1.6	0.3	2.2
$5,000-$6,999	17.6	46.1	32.8	1.3	0.7	1.4
$7,000-$9,999	14.9	48.1	33.4	1.4	0.2	1.9
$10,000-$14,999	16.2	45.8	34.7	1.8	0.1	1.4
$15,000 or more	16.9	46.6	31.8	2.4	0.4	1.9
Unknown	17.2	46.0	32.6	2.6	0.5	1.1
Education						
Less than 5 years	21.3	43.9	29.5	3.0	-	2.4
5-7 years	20.9	44.2	30.8	1.4	0.5	2.2
8 years	19.5	45.7	31.8	1.8	-	1.1
9-11 years	16.2	46.8	33.9	1.3	0.1	1.7
12 years	14.5	48.1	32.9	2.1	0.3	2.1
13-15 years	19.1	47.8	30.2	0.9	0.5	1.5
16 years	15.6	46.3	34.1	2.5	0.6	1.0
17 years or more	15.3	43.5	37.2	2.5	0.3	1.2
Unknown	18.0	44.2	31.9	4.1	0.8	1.0
BLACK						
Region						
Northeast	34.9	40.2	12.5	8.0	0.5	3.9
Midwest	37.5	37.3	9.5	14.4	0.7	0.6
South	32.3	38.7	13.0	12.9	1.0	2.1
West	20.8	43.1	20.3	12.7	-	3.0
Income						
Less than $1,000	33.3	37.8	17.8	4.0	5.1	2.1
$1,000-$2,999	30.7	36.4	13.7	14.2	0.3	4.6
$3,000-$4,999	31.6	43.5	10.1	12.9	0.4	1.5
$5,000-$6,999	31.8	39.0	15.2	13.3	0.7	-
$7,000-$9,999	38.2	43.6	8.8	7.1	-	2.3
$10,000-$14,999	19.1	45.7	18.1	15.2	-	1.9
$15,000 or more	42.7	18.8	18.7	19.9	-	-
Unknown	38.6	28.6	16.3	12.1	-	4.4
Education						
Less than 5 years	28.3	45.9	9.4	10.0	3.4	3.0
5-7 years	34.5	42.5	13.1	8.4	-	1.5
8 years	37.0	32.2	13.5	16.3	-	1.0
9-11 years	28.6	40.2	14.2	13.4	0.9	2.8
12 years	38.7	40.5	8.6	9.4	0.5	2.3
13-15 years	22.2	41.0	17.4	14.2	-	5.1
16 years	36.8	17.0	21.5	24.7	-	-
17 years or more	-	9.7	52.9	37.4	-	-
Unknown	45.7	30.7	18.5	5.1	-	-

Table 15. Percent distribution of youths 12-17 years old by transferrin type, according to race, sex, and age: United States, 1966-70

Race, sex, and age	Transferrin type					
	CC	BC	DC	Other	Unsatisfactory sample	Test not done
	Percent distribution					
WHITE						
Both sexes						
12-17 years	96.1	1.3	0.5	0.1	0.4	1.7
12 years	95.6	0.8	0.6	-	0.3	2.7
13 years	95.7	1.3	0.1	-	0.8	2.0
14 years	96.9	1.0	0.4	0.1	0.3	1.3
15 years	96.9	1.3	0.8	0.1	0.2	0.8
16 years	95.3	1.7	0.6	0.1	0.2	2.1
17 years	96.2	1.5	0.4	0.1	0.5	1.3
Male						
12-17 years	96.7	1.4	0.6	0.1	0.1	1.2
12 years	95.9	1.2	0.5	-	-	2.4
13 years	96.6	1.7	0.2	-	0.3	1.2
14 years	97.6	0.9	0.6	0.1	-	0.8
15 years	97.5	0.6	1.1	0.2	-	0.6
16 years	95.8	2.2	0.5	0.1	0.2	1.2
17 years	96.9	1.6	0.6	0.2	-	0.8
Female						
12-17 years	95.4	1.2	0.4	-	0.7	2.3
12 years	95.3	0.4	0.7	-	0.5	3.1
13 years	94.8	0.9	0.1	-	1.4	2.8
14 years	96.1	1.2	0.3	-	0.5	1.9
15 years	96.2	2.0	0.4	-	0.4	1.0
16 years	94.7	1.2	0.7	-	0.3	3.1
17 years	95.5	1.5	0.2	-	0.9	1.9
BLACK						
Both sexes						
12-17 years	90.8	0.2	5.8	0.3	0.6	2.3
12 years	90.1	0.5	6.8	0.4	0.7	1.5
13 years	89.0	-	6.2	-	0.7	4.1
14 years	89.4	0.4	6.5	0.5	1.2	2.0
15 years	92.8	-	5.2	-	-	2.0
16 years	90.4	-	5.5	-	1.1	3.0
17 years	93.9	-	4.1	0.7	-	1.4
Male						
12-17 years	91.7	-	5.8	0.2	0.2	2.1
12 years	88.1	-	10.1	-	-	1.8
13 years	90.7	-	5.5	-	-	3.9
14 years	87.4	-	9.2	0.9	1.2	1.2
15 years	95.8	-	2.9	-	-	1.3
16 years	95.1	-	3.3	-	-	1.6
17 years	94.3	-	2.8	-	-	2.8
Female						
12-17 years	90.0	0.3	5.7	0.4	1.0	2.6
12 years	92.2	1.0	3.5	0.9	1.3	1.1
13 years	87.4	-	6.9	-	1.3	4.3
14 years	91.4	0.9	3.9	-	1.1	2.8
15 years	89.6	-	7.6	-	-	2.8
16 years	85.9	-	7.6	-	2.1	4.4
17 years	93.4	-	5.3	1.3	-	-

Table 16. Percent distribution of youths 12-17 years old by transferrin type, according to race, geographic region, income, and education: United States, 1966-70

Race, region, income, and education	Transferrin type					
	CC	BC	DC	Other	Unsatisfactory sample	Test not done
	Percent distribution					
WHITE						
Region						
Northeast	95.9	0.7	0.5	0.2	1.2	1.6
Midwest	96.7	2.0	0.3	-	0.2	0.8
South	94.7	1.1	0.7	0.1	0.3	3.1
West	96.6	1.1	0.5	-	-	1.8
Income						
Less than $1,000	98.4	-	-	-	-	1.6
$1,000-$2,999	96.3	1.0	0.5	-	0.2	2.1
$3,000-$4,999	95.3	1.1	1.0	-	0.4	2.2
$5,000-$6,999	95.9	1.3	0.5	-	0.8	1.4
$7,000-$9,999	95.8	1.4	0.5	0.2	0.1	1.9
$10,000-$14,999	96.6	1.1	0.4	-	0.5	1.4
$15,000 or more	96.3	1.4	0.1	0.1	0.2	1.9
Unknown	96.1	1.9	0.4	-	0.5	1.1
Education						
Less than 5 years	97.6	-	-	-	-	2.4
5-7 years	95.6	0.9	0.8	-	0.5	2.2
8 years	95.6	2.3	1.0	-	-	1.1
9-11 years	96.2	1.4	0.5	0.1	0.1	1.7
12 years	95.8	1.0	0.4	0.1	0.6	2.1
13-15 years	95.2	1.8	0.9	-	0.6	1.5
16 years	98.0	0.5	0.1	0.2	0.3	1.0
17 years or more	98.0	0.9	-	-	-	1.2
Unknown	90.9	7.3	-	-	0.8	1.0
BLACK						
Region						
Northeast	91.7	-	4.4	-	-	3.9
Midwest	90.6	1.0	6.5	0.6	0.7	0.6
South	89.7	-	6.8	0.3	1.0	2.1
West	93.7	-	3.3	-	-	3.0
Income						
Less than $1,000	91.9	-	0.9	-	5.1	2.1
$1,000-$2,999	88.3	-	6.4	0.3	0.3	4.6
$3,000-$4,999	92.1	-	6.4	-	-	1.5
$5,000-$6,999	88.7	1.0	9.0	0.5	0.7	-
$7,000-$9,999	95.3	-	2.4	-	-	2.3
$10,000-$14,999	94.5	-	1.7	1.9	-	1.9
$15,000 or more	93.9	-	6.1	-	-	-
Unknown	88.3	-	7.3	-	-	4.4
Education						
Less than 5 years	88.7	-	4.9	-	3.4	3.0
5-7 years	91.7	-	6.2	0.6	-	1.5
8 years	91.6	-	6.4	1.0	-	1.0
9-11 years	90.4	-	6.3	-	0.6	2.8
12 years	91.9	-	4.9	0.4	0.5	2.3
13-15 years	86.8	3.1	5.0	-	-	5.1
16 years	78.0	-	22.0	-	-	-
17 years or more	100.0	-	-	-	-	-
Unknown	100.0	-	-	-	-	-

Table 17. Percent distribution of youths 12-17 years old by group specific component (Gc) type, according to race, sex, and age: United States, 1966-70

Race, sex, and age	Group specific component (Gc) type					
	1-1	2-1	2-2	Variant	Unsatisfactory sample	Test not done
WHITE						
Both sexes	Percent distribution					
12-17 years	51.9	38.5	7.4	0.1	0.4	1.7
12 years	51.7	38.9	6.4	0.1	0.3	2.7
13 years	50.1	39.4	7.8	-	0.7	2.7
14 years	52.3	37.2	8.7	-	0.4	1.3
15 years	51.4	38.7	8.6	0.1	0.3	0.8
16 years	51.1	40.0	6.4	0.2	0.2	2.1
17 years	55.2	36.8	6.4	-	0.3	1.3
Male						
12-17 years	52.6	38.6	7.6	-	0.1	1.2
12 years	50.3	39.6	7.8	-	-	2.4
13 years	50.5	40.3	7.7	-	0.3	1.2
14 years	53.4	37.2	8.5	-	0.2	0.8
15 years	51.6	39.7	8.1	-	-	0.6
16 years	53.9	38.2	6.6	-	0.2	1.2
17 years	56.4	36.2	6.6	-	-	0.8
Female						
12-17 years	51.2	38.5	7.2	0.1	0.7	2.3
12 years	53.1	38.2	4.9	0.2	0.5	3.1
13 years	49.7	38.4	7.9	-	1.2	2.8
14 years	51.3	37.3	8.9	-	0.7	1.9
15 years	51.1	37.8	9.2	0.3	0.6	1.0
16 years	48.1	41.9	6.2	0.4	0.3	3.1
17 years	54.0	37.3	6.1	-	0.6	1.9
BLACK						
Both sexes						
12-17 years	75.5	18.6	3.0	-	0.6	2.3
12 years	75.8	19.0	3.1	-	0.7	1.5
13 years	71.3	21.5	2.4	-	0.7	4.1
14 years	80.1	15.7	1.1	-	1.2	2.0
15 years	82.8	14.0	1.1	-	-	2.0
16 years	68.2	20.8	6.9	-	1.1	3.0
17 years	74.9	20.3	3.5	-	-	1.4
Male						
12-17 years	75.1	19.0	3.6	-	0.2	2.1
12 years	76.6	18.2	3.3	-	-	1.8
13 years	70.4	22.1	3.6	-	-	3.9
14 years	78.7	17.9	1.0	-	1.2	1.2
15 years	82.9	15.0	0.8	-	-	1.3
16 years	64.1	24.9	9.4	-	-	1.6
17 years	77.8	15.7	3.6	-	-	2.8
Female						
12-17 years	75.9	18.2	2.4	-	1.0	2.6
12 years	74.9	19.8	2.9	-	1.3	1.1
13 years	72.2	20.9	1.3	-	1.3	4.3
14 years	81.4	13.6	1.1	-	1.1	2.8
15 years	82.7	13.0	1.5	-	-	2.8
16 years	72.1	16.9	4.5	-	2.1	4.4
17 years	72.0	24.6	3.4	-	-	-

Table 18. Percent distribution of youths 12-17 years old by group specific component (Gc) type, according to race, geographic region, income, and education: United States, 1966-70

Race, region, income, and education	Group specific component (Gc) type					
	1-1	2-1	2-2	Variant	Unsatisfactory sample	Test not done
	Percent distribution					
WHITE						
Region						
Northeast	51.7	37.5	8.1	-	1.0	1.6
Midwest	52.3	39.1	7.5	0.2	0.2	0.8
South	49.3	41.2	6.0	0.1	0.3	3.1
West	53.6	36.8	7.6	-	0.2	1.8
Income						
Less than $1,000	55.4	34.9	8.1	-	-	1.6
$1,000-$2,999	46.8	41.9	9.0	-	0.2	2.1
$3,000-$4,999	53.8	35.8	7.7	-	0.5	2.2
$5,000-$6,999	51.5	38.7	7.5	0.2	0.7	1.4
$7,000-$9,999	53.9	36.8	7.0	0.2	0.2	1.9
$10,000-$14,999	53.2	37.7	7.2	-	0.5	1.4
$15,000 or more	48.4	42.4	7.1	-	0.2	1.9
Unknown	50.2	41.5	6.7	-	0.5	1.1
Education						
Less than 5 years	57.4	31.6	8.7	-	-	2.4
5-7 years	48.6	42.7	5.3	0.7	0.5	2.2
8 years	47.3	41.2	10.4	-	-	1.1
9-11 years	54.3	36.7	7.2	-	0.1	1.7
12 years	52.6	37.6	7.1	0.0	0.5	2.1
13-15 years	50.6	39.2	7.8	0.1	0.7	1.5
16 years	52.5	40.4	5.7	-	0.5	1.0
17 years or more	49.0	41.0	8.8	-	-	1.2
Unknown	55.3	36.0	6.9	-	0.8	1.0
BLACK						
Region						
Northeast	77.0	15.6	3.5	-	-	3.9
Midwest	79.3	17.2	2.2	-	0.7	0.6
South	73.8	19.7	3.4	-	1.0	2.1
West	74.4	20.8	1.8	-	-	3.0
Income						
Less than $1,000	68.3	21.9	2.7	-	5.1	2.1
$1,000-$2,999	74.1	17.3	3.7	-	0.3	4.6
$3,000-$4,999	79.6	15.9	2.9	-	-	1.5
$5,000-$6,999	76.3	20.0	3.0	-	0.7	-
$7,000-$9,999	72.1	23.1	2.5	-	-	2.3
$10,000-$14,999	70.0	28.1	-	-	-	1.9
$15,000 or more	87.3	12.7	-	-	-	-
Unknown	78.5	12.4	4.7	-	-	4.4
Education						
Less than 5 years	72.7	20.9	-	-	3.4	3.0
5-7 years	80.6	15.0	2.9	-	-	1.5
8 years	74.6	23.6	0.8	-	-	1.0
9-11 years	75.9	15.9	4.8	-	0.6	2.8
12 years	75.9	18.9	2.4	-	0.5	2.3
13-15 years	79.2	15.7	-	-	-	5.1
16 years	74.2	25.8	-	-	-	-
17 years or more	53.1	46.9	-	-	-	-
Unknown	59.2	34.0	6.7	-	-	-

Table 19. Number of youths 12-17 years old, by race, sex, and age: United States, 1966-70

Age	White[1]			Black[1]		
	Both sexes	Male	Female	Both sexes	Male	Female
	Number in thousands					
12-17 years	19,552	9,929	9,623	3,024	1,496	1,527
12 years	3,432	1,747	1,685	552	280	272
13 years	3,396	1,729	1,667	538	262	275
14 years	3,318	1,686	1,633	522	256	266
15 years	3,241	1,646	1,594	476	241	235
16 years	3,136	1,594	1,542	474	231	243
17 years	3,030	1,528	1,502	462	225	237

[1]Data for youths of "other" races are not included in this table.

Table 20. Number of youths 12-17 years old, by race, geographic region, income, and education: United States, 1966-70

Region, income, and education	White[1]	Black[1]
	Number in thousands	
Region		
Northeast	4,375	648
Midwest	5,929	524
South	3,909	1,446
West	5,338	407
Income		
Less than $1,000	205	241
$1,000-$2,999	1,495	742
$3,000-$4,999	2,224	803
$5,000-$6,999	3,000	503
$7,000-$9,999	4,815	328
$10,000-$14,999	4,187	163
$15,000 or more	2,351	42
Unknown	1,275	202
Education		
Less than 5 years	513	234
5-7 years	1,090	390
8 years	1,410	227
9-11 years	3,164	1,124
12 years	7,513	698
13-15 years	2,416	166
16 years	1,825	55
17 years or more	1,333	39
Unknown	289	90

[1]Data for youths of "other" races are not included in this table.

Table 21. Number of examined youths 12-17 years old, by race, sex, and age: United States, 1966-70

Age	White[1]			Black[1]		
	Both sexes	Male	Female	Both sexes	Male	Female
12-17 years	5,735	3,047	2,688	999	479	520
12 years	995	540	455	189	101	88
13 years	1,032	542	490	171	80	91
14 years	1,011	527	484	189	88	101
15 years	950	525	425	157	84	73
16 years	937	496	441	150	57	93
17 years	810	417	393	143	69	74

[1]Data for youths of "other" races, of whom 34 were examined, are not included in this table.

Table 22. Number of examined youths 12-17 years old, by race, geographic region, income, and education: United States, 1966-70

Region, income, and education	White[1]	Black[1]
Region		
Northeast	1,428	210
Midwest	1,582	166
South	1,206	498
West	1,519	125
Income		
Less than $1,000	64	79
$1,000-$2,999	427	247
$3,000-$4,999	665	275
$5,000-$6,999	922	158
$7,000-$9,999	1,440	105
$10,000-$14,999	1,221	51
$15,000 or more	629	15
Unknown	367	69
Education		
Less than 5 years	148	79
5-7 years	316	129
8 years	412	80
9-11 years	981	365
12 years	2,252	233
13-15 years	679	54
16 years	496	17
17 years or more	366	11
Unknown	85	31

[1]Data for youths of "other" races, of whom 34 were examined, were not included in this table.

APPENDIXES

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APPENDIX I

STATISTICAL NOTES

The Survey Design

The sampling plan of the third cycle of the Health Examination Survey followed a multistage, stratified probability sample of clusters of households in land-based segments in which a sample of the U.S. population (including Alaska and Hawaii) aged 12 through 17 years was selected. Excluded were those youths confined to institutions or residing upon any of the reservation lands set aside for use by American Indians.

The sample design of Cycle III is similar to that of Cycle II in that it uses the same 40 sample areas and the same segments. The decision to incorporate this feature into Cycle III was not made prior to the selection of the second cycle sample, although it is consistent with the early concept of a single program for 6-17-year-olds. The final decision to use this identical sampling frame was made during the operation of the second cycle program.

The successive elements for this sample design are the primary sampling unit (PSU); census enumeration district (ED); segment (a cluster of households); household; all eligible youths; and finally, the sample youth. Every eligible youth within the defined population had a known and approximately equal chance for selection into the sample.

The steps of drawing the sample were carried out jointly with the U.S. Bureau of the Census; the starting points were the 1960 decennial census lists of addresses and the nearly 1,900 PSU's into which the entire United States was divided. Each PSU is a standard metropolitan statistical area (SMSA), a county, or a group of two or three contiguous counties. These PSU's were grouped into 40 strata so that each stratum had an average size of about 4.5 million persons. This grouping maximized the degree of homogeneity within strata with regard to the population size of the PSU's, degree of urbanization, geographic proximity, and degree of industrialization. The 40 strata were then classified into four broad geographic regions of 10 strata each and then, within each region, cross-classified by four population density classes and by the rates of population change from 1950 to 1960. By using a modified Goodman-Kish controlled-selection technique, one PSU was drawn from each of the 40 strata.

The sampling within PSU's was carried out in several steps. First, census ED's were selected. These ED's are small well-defined areas of about 250 housing units into which the entire Nation was divided for the 1960 population census. Each ED was assigned a "measure of size" equal to the rounded whole number resulting from a "division by nine" of the number of children aged 5-9 in the ED at the time of the 1960 census. A sample of 20 ED's in the sample PSU was selected according to a systematic sampling technique with each ED having a probability of selection proportional to the population of children aged 5-9 at the time of the 1960 census. From each ED a random selection of one measure of size (segment) was taken.

Minor changes required in the Cycle III design were that it be supplemented for new construction to a greater extent than had been necessary in Cycle II and that reserve segments be added. Although it was the plan for Cycle III to use the Cycle II segments, it was recognized that within several PSU's additional reserve segments would be needed to avoid the risk of having an insufficient number of examinees. This additional reserve was prompted by the fact

that four of the PSU's in Cycle II had yields of less than 165 eligible children and several others were marginal in their yields. In addition, there was a 3-year interval between Cycles II and III, so that it was quite possible for some segments to have been completely demolished to make room for highway construction or urban redevelopment.

The time available for examinations at a particular stand, as they have been designated, was necessarily set far in advance of any preliminary field work at the stand. Therefore, the number of examinations that could be performed at a particular location depended on the number of examining days available. At most locations, the number of days available, excluding Saturdays, was 17. At the rate of 12 examinations each day, 204 examination slots were possible. Examinations were conducted on Saturdays if it became necessary. Because of rescheduling for cancellations or "no-shows," the maximum number of youths considered for inclusion in the sample is 200. When the number of eligible youths exceeded this number, subsampling was performed to reduce the number to manageable limits. This reduction was accomplished through the use of a master list, which is a listing of all eligible youths in order by segment, serial number (household order within segment), and column number (order in the household by age). After the subsampling rate had been determined, every nth name on the list was deleted, starting with the yth name, y being a randomly selected number between 1 and n. Youths who were deleted from the Cycle III sample but who were examined in Cycle II as well as any twin who may have been deleted were, if time permitted, scheduled for an examination for inclusion only in the longitudinal study portion of the survey. Their data were not included in the report as part of the regular sample.

Because the strata were roughly equal in population size and a nearly equal number of sample youths were examined in each of the sample PSU's, the sample design was essentially self-weighting with respect to the target population; that is, each youth aged 12 through 17 had about the same probability of being drawn into the sample.

The adjustment upward for nonresponse was intended to minimize the impact of nonresponse on final estimates by imputing to nonrespondents the characteristics of "similar" respondents. Here "similar" respondents were judged to be examined youths in a sample PSU having the same age (in years) and sex as those not examined in that sample PSU.

The poststratified ratio adjustment used in Cycle III achieved most of the gains in precision that would have been attained if the sample had been drawn from a population stratified by age, color, and sex; and it made the final sample estimates of population (tables 19 and 20) agree exactly with independent controls prepared by the Bureau of the Census for the noninstitutional population of the United States as of March 9, 1968 (approximate midsurvey point), by color and sex for each single year of age 12 through 17. The weight of every responding sample child in each of the 24 age, race, and sex classes is adjusted upward or downward so that the weighted total within the class equals the independent population control.

A more detailed description of the sampling plan and estimation procedures is included in *Vital and Health Statistics*, Series 2, Number 43,[49] and in Series 1, Numbers 1,[50] 5,[3] and 8,[4] which describe the plan and operation of the first three cycles of the Health Examination Survey (HES).

Response Rates

As mentioned previously, the sample designs of the second and third cycles of the HES were similar. Differences did occur, however, in response rates of various subgroups of these samples and these differences deserve consideration.

Most importantly, the number of youths selected for examination increased from 7,417 in Cycle II to 7,514 in Cycle III. The response rate, that is, the number of youths selected who were actually examined, decreased from 96 percent in Cycle II to 90 percent in Cycle III (tables 21 and 22). Of the examined youths of Cycle II, 13.86 percent were black compared with 14.76 percent of those examined in Cycle III. This difference does not reflect a difference in the percent of black youths selected for examination, but instead, a smaller decrease in response rate

NOTE: A list of references follows the text.

for black youths between the two cycles than was the case for the white youths. In Cycle III, 13.8 percent of the sample selected for examination was black, corresponding to 13.5 percent for Cycle II. The response rate for white youths dropped from 95.6 percent in Cycle II to 89.1 percent in Cycle III, but the response rate for black youths dropped a far lesser degree, from 98.4 to 96.6 percent. Thus better relative response from the black portion of the sample yielded a greater percent of these youths actually examined during Cycle III than during the previous sample.

At every age group, fewer females actually were examined than males. This situation again is not attributed to differences in numbers of youths selected in the sampling design, but rather to differential response rates between males and females shown in table I. At each age group the response rate for males exceeded that for females.

A similar analysis of response rates can be done by sex, race, and age as shown in table II.

Table II clearly indicates that for all ages under consideration in Cycle III of the HES, the response rate for black youths exceeded that for white youths of the same sex and age.

Table I. HES III response rates by sex and age

Age	Male	Female
12-17 years	91.4	88.7
12 years	93.5	91.3
13 years	93.2	91.9
14 years	91.7	90.7
15 years	91.6	87.9
16 years	89.8	87.7
17 years	87.6	81.8

Table II. HES III response rates by sex, race, and age

Age	Male		Female	
	White	Black	White	Black
12-17 years	90.5	97.6	87.4	95.8
12 years	92.6	99.0	90.1	98.9
13 years	92.5	98.8	91.1	96.8
14 years	91.0	97.8	89.6	96.2
15 years	90.7	97.7	86.4	98.6
16 years	89.2	95.0	86.6	93.0
17 years	86.5	95.8	80.2	91.4

Reasons for differences in response rates are many, and may range from the incentive to miss a day of school, to fear of the examination itself, to inhibitions with respect to being examined. The very worst response rates among both white and black youths were recorded for the oldest females, that is, 17-year-old females.

Parameter and Variance Estimation

Because each of the 6,768 sample children has an assigned statistical weight, all estimates of population parameters presented in HES publications are computed taking this weight into consideration. Thus the estimate of a population mean μ is computed as follows: $\overline{X} = \Sigma W_i X_i / \Sigma W_i$; where X_i is the observation or measurement on the ith person and W_i is the weight assigned to that person.

The Health Examination Survey has an extremely complex sampling plan, and obviously the estimation procedure is, by the very nature of the sample, complex as well. A method is required for estimating the reliability of findings that "reflects both losses from clustering sample cases at two stages and the gains from stratification, ratio estimation, and poststratification."[51]

The method of estimating variances in HES is the half-sample replication technique. The method was developed at the Bureau of the Census prior to 1957 and has at times been given limited use in the estimation of the reliability of results from the Current Population Survey. The half-sample replication technique is particularly well suited to HES because the sample, although complex in design, is relatively small (6,768 cases) and is based on only 40 strata. This feature permitted the development of a variance estimation computer program that produces tables containing desired estimates of aggregates, means, and distributions, together with a table identical in format but with the estimated variances instead of the estimated statistics. The computations required by the method are simple, and the internal storage requirements are well within the limitation of the IBM 370-158 computer system used at the National Center for Health Statistics.

NOTE: A list of references follows the text.

Variance estimates computed for this report were based on 20 balanced half-sample replications. A half-sample was formed by choosing 1 sample PSU from each of 20 pairs of sample PSU's. To compute the variance of any statistic, this statistic is computed for each of the 20 half-samples. Then, the weighted mean of the entire, undivided sample is computed. The variance of the mean is the mean square deviation of each of the 20 half-sample means about the overall mean. The standard error of the mean is simply the square root of this variance of the mean. In a similar manner, the standard error of any statistic may be computed.

However, to eliminate the great mass of tables required to present variance estimates for all of the statistics in this report, a "variance smoothing" approach has been used for the presentation of estimated variances.

By using this approach, variance estimators are produced in two steps. First, the simple random sample (SRS) estimate of variance is calculated with the usual formula,

$$\hat{\text{Var}}(\hat{p}_{ij}) = \hat{p}_{ij}(1 - \hat{p}_{ij})/n_i$$

where p is the estimated proportion and n_i is the unweighted number of cases in the row of the table containing the estimated proportion. Second, the SRS estimate of variance is multiplied by a design effect (defined as the effect on variances consequent to using a complex sampling design rather than a simple random sampling design) specific to the independent variable of interest (e.g., sex X age, region, income, or education) to produce the variance estimate for p_{ij}.

The design effects were estimated by the method of least squares. The replicated half-sample variance estimates for a subset of the variables presented in this paper were used as the dependent variables and the corresponding SRS variance estimates were used as the independent variables in the model

$$\hat{\text{Var}}(\hat{p}_{ij}) = (\text{design effect}) \times \hat{p}_{ij}(1 - \hat{p}_{ij})/n_i + \epsilon$$

to produce the estimates of the design effects.

The estimated design effects and the correlations between the half-sample variance estimates and the "smoothed" or predicted variance estimates (giving a measure of the strength of the relationship between the two, that is, the effectiveness of the fitting process) are given in table III.

The following example may be illustrative. The variances for the proportions of type B blood for white and black youths in the Midwest were estimated through the following calculations:

$$\hat{V}(\hat{p}_w) = 0.115 \times 0.885/1582 = 0.0000643$$

$$\hat{V}(\hat{p}_b) = 0.221 \times 0.779/166 = 0.0010371$$

With design effects from Table III,

$$\hat{V}(\hat{p}_w) = 1.43 \times 0.0000643 = 0.0000919$$

$$\hat{V}(\hat{p}_b) = 1.43 \times 0.0010371 = 0.0014831$$

The variances used in all significance tests presented in the main text employed this technique.

The usual test for the difference between proportions is used to determine significance:

$$z = (\hat{p}_1 - \hat{p}_2)/\sqrt{\hat{V}(\hat{p}_1) + \hat{V}(\hat{p}_2)}$$

For the example described in the paragraph above,

$$z = (0.115 - 0.221)/\sqrt{0.0000919 + 0.0014831}$$
$$= -2.671 \ (p < 0.01).$$

Table III. Estimated design effects by demographic classification

Independent variable	Design effect	Correlation
Sex X age	1.08	0.89
Region	1.43	0.93
Income	1.60	0.77
Education	1.66	0.77

APPENDIX II

DEMOGRAPHIC AND SOCIOECONOMIC TERMS

Age.—The age recorded for each youth was the age at last birthday on the date of examination. The age criterion for inclusion in the sample used in this survey was defined as age at time of interview. Because the examination usually took place 2-4 weeks after the interview, 23 youths who were 17 years old at the time of the interview became 18 years old by the time of the examination. In the adjustment and weighting procedures used to produce national estimates, these 23 were included in the 17-year-old group.

Race.—Race was recorded as "white," "black," and "other races."[g] In Cycle III, the white youths constituted 84.74 percent of the total; the black youths, 14.76 percent; and youths of other races, 0.50 percent. In Cycle II white youths constituted 85.69 percent of the examined subjects and black youths, 13.86 percent. As in Cycle II, because so few youths of "other races" were part of the sample, data from them have not been analyzed as a separate category.

Geographic region.—For purposes of stratification the United States was divided into four broad geographic regions of approximately equal population. These regions, which correspond closely to those used by the U.S. Bureau of the Census, are as follows:

Region	*States included*
Northeast	Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, and Pennsylvania
South	Delaware, Maryland, District of Columbia, West Virginia, Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Arkansas
Midwest	Ohio, Illinois, Indiana, Michigan, Wisconsin, Minnesota, Iowa, and Missouri
West	Washington, Oregon, California, Nevada, New Mexico, Arizona, Texas, Oklahoma, Kansas, Nebraska, North Dakota, South Dakota, Idaho, Utah, Colorado, Montana, Wyoming, Alaska, and Hawaii

Family income.—The income recorded was the total income during the past 12 months received by the head of the household and all other household members related to the head by

[g]The same classification scheme as used in the 1960 census was employed here. As described in the previously mentioned report on the operation of HES Cycle III,[4] this information was obtained at the initial household interview by the U.S. Bureau of the Census field worker. Its accuracy was checked at the subsequent home visit by the highly experienced representative from HES and again at the examination in the trailer. A final record check by birth certificate turned up only seven inconsistencies, and these were mostly pertaining to the category "other races." Hence, the possible extent of misclassification of the variable race as described, is so minimal that it could have no effect on the data analyzed in this report. However, when comparing the present HES findings to those of other variously defined racial groupings in the world, the problems of ascertainment caused by various degrees of genetic admixture, as first discussed by Herskowitz[52] in 1928 and later by Glass and Li,[53] Roberts,[54,55] and Reed,[45] should be taken into consideration.

blood, marriage, or adoption. This income was the gross cash income (excluding pay in kind, e.g., meals, living quarters, or supplies provided in place of cash wages) except in the case of a family with its own farm or business, in which case net income was recorded. Also included in the family income figure were allotments and other money received by the family from a member of the Armed Forces whether that member was living at home or not.

Education of parent or guardian.—This item was recorded as the highest grade that had been completed in school. The only grades counted were those that had been completed in a regular school where persons were given formal education in graded or private schools, either day or night schools, with either full-time or part-time attendance. A "regular" school is one that advances a person toward an elementary or high school diploma, or a college, university, or professional school degree. Education in vocational, trade, or business schools outside the regular school system was not counted in determining the highest grade of school completed.

APPENDIX III

Rh GENOTYPE COMBINATIONS CLASSIFICATION

Table IV. Rh genotype combinations classification codes

Code	Genotype	Symbol	Code	Genotype	Symbol
1	cde/cde	rr	10	Cde/cdE	R'R''
				CdE/cde	R_yr
2	CDe/cde	R_1r			
	CDe/cDe	R_1R_0	11	Cde/Cde	R'R'
	cDe/Cde	R_0R'			
			12	Cde/cde	R'r
3	CDe/CDe	R_1R_1			
	CDe/Cde	R_1R'	13	cdE/cde	R''r
4[1]	CDe/cDE	R_1R_2	14	cdE/cdE	R''R''
	CDE/cde	R_zr			
	CDE/cDe	R_zR_0	15	Cde/CdE	$R'R_y$
	CDe/cdE	R_1R''			
	CDE/Cde	R_2R'	16	cdE/CdE	$R''R_y$
	CdE/cDe	R_2R_0			
			17	CDE/CDE	R_zR_z
5[2]	cDe/cDe	R_0R_0		CDE/CdE	R_zR_y
	cDe/cde	R_0r			
			18	CdE/CdE	R_yR_y
6[3]	cDe/cde	R_2r			
	cDE/cDe	r_2R_0	32	CD^ue/cde	
	cDe/cdE	R_0R''			
			33	CD^ue/Cde	
7	cDE/cDE	R_2R_2			
	cDE/cdE	R_2R''	34	CD^uE/cde	
8	CDe/CDE	R_1R_z	35[2]	cD^ue/cde	
	Cde/CDE	$R'R_z$			
	CDe/Cde	R_1R_y	36[3]	cD^uE/cde	
9[1]	cDE/CDE	R_2R_z			
	cdE/CDE	$R''R_z$			
	cDE/CdE	R_2R_y			

[1]Codes 4 and 9 are combined in one classification.
[2]Codes 5 and 35 are combined in one classification.
[3]Codes 6 and 36 are combined in one classification.

Table V. Numerical distribution of sample by Rh genotype combinations classification

Code	White	Black
Total	5,735	999
Not done	103	24
1	803	43
2	1,997	226
3	1,010	17
4	780	19
5	121	497
6	666	138
7	170	13
8	14	-
9	1	-
12	29	11
13	24	3
32	7	-
35	2	3
36	4	-
Unsatisfactory	4	5

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