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ABSTRACT

The prevalence of color vision deficienceis among youths 12 to 17 years of age in the United States was evaluated during a 1966-1970 survey of 6,768 youths selected as representative of noninstitutionalized adolescents with respect to age, sex, race, geographic region, income, population size of place of residence, and rate of population change in the place of residence from 1950 to 1960. Findings indicated that approximately 4% of adolescents have color vision deficiencies with boys about 12 times more likely to have this defect than girls. No significant differences were found in the prevalence rates for white and Negro boys except in the South. Red-green color vision deficiencies were substantially more prevalent than blue-yellow defects, which were found only in conjunction with the red-green defect. Age was not related to the prevalence of color vision deficiencies. No statistically significant regional differences in the prevalence of red-green deficiencies were found, although a significant racial difference was observed in the South (three times as many white as Negro boys had red-green deficiencies). Differences in the prevalence rates across income levels were negligible. (Approximately half the document consists of detailed tables of the survey's findings.) (Author/DB)

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DATA FROM THE NATIONAL HEALTH SURVEY

Series 11 - Number 134

NATIONAL CENTER FOR HEALTH STATISTICS

NCHS

Color Vision Deficiencies in Youths 12-17 Years of Age United States

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Public Health Service
Health Resources Administration

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Data from the
NATIONAL HEALTH SURVEY

Series 11
Number 134

Color Vision Deficiencies in Youths 12-17 Years of Age United States

Prevalence of color vision deficiencies, as identified on examination with plates from the Ishihara Test and typed with the Hardy-Rand-Rittler Test, among youths 12-17 Years, by age, sex, race, family income, geographic region, and population size of place of residence.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

Health Resources Administration
National Center for Health Statistics
Rockville, Md. January 1974

COOPERATION OF THE BUREAU OF THE CENSUS

In accordance with specifications established by the National Health Survey, the Bureau of the Census, under a contractual agreement, participated in the design and selection of the sample, and carried out the first stage of the field interviewing and certain parts of the statistical processing.

Vital and Health Statistics-Series 11-No. 134

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COLOR VISION DEFICIENCIES IN YOUTHS

David Slaby and Jean Roberts, *Division of Health Examination Statistics*

INTRODUCTION

Presented in this report are data on the prevalence of color vision deficiencies in American youths 12-17 years of age as estimated from the Health Examination Survey of 1966-70. The data are stratified by age, sex, race, geographic region, size of place of residence, and annual family income. Comparisons are also made with the findings from the 1963-65 Health Examination Survey among children 6-11 years of age.

Color vision deficiency, commonly called color blindness, manifests itself in everyday life in the confusion of, or blindness to, one or more primary colors, and its origins may be congenital or acquired.[1,2] Congenital defects occur in two chief forms, total and partial. The former is very rare and is generally associated with nystagmus and a central scotoma. All colors appear as grays of differing brightness. The partial form is the most common type of color vision defect and is primarily an inherited condition transmitted through the mother, who is usually unaffected. It is probably due to the absence of one of the photopigments normally found in the foveal cones.[2] In most cases reds and greens are confused.

Acquired defects of color vision may often develop in the course of ocular, mainly retinal, disease.[1] Red-green defects are frequently characteristic of lesions of the optic nerve and optic pathways, while blue-yellow defects are more likely to result from lesions of the outer layers of the retina.[2]

Source of Data

The Health Examination Survey in which these color vision data were collected is one of the major ongoing programs of the National Center for Health Statistics. Data collection, analysis, and publication of the resulting findings on the health status of the United States population was authorized as a continuing Public Health Service activity in the National Health Survey Act of 1956 by the 84th Congress.

Three different programs are used to carry out the intent of the National Health Survey.[3] The Health Interview Survey focuses primarily on the impact of illness and disability upon the lives and actions of people in various segments of the United States population. It collects health information from samples of people by means of household interviews. The Health Resources Survey program gathers health data as well as health resource and utilization information through surveys of hospitals, nursing homes, other resident institutions, physicians' offices, and other medical facilities and on the entire range of personnel in the health occupations. The Health Examination Survey, on which the data in this report are based, is the only program in the National Center for Health Statistics which collects data by direct physical examinations, tests, and measurements performed on preselected probability samples of the United States population. This approach provides the most efficient and accurate way of obtaining diagnostic data on the prevalence of medically defined illness within the entire population. It is the only program that secures information on unrecognized or undiagnosed conditions as well as physical, physiological, and psychological measurements within the population under study. The survey also collects medical history, demographic, and socioeconomic data from the sample population which are then interrelated with the examination findings.

The Health Examination Survey functions as a series of separate programs referred to as "cycles." Each cycle is limited to some specific segment of the United States population and to specific aspects of the health of that population. During the first cycle conducted in 1960-62, the prevalence of certain chronic diseases and the distribution of various physical and physiological measures were determined among a probability sample representative of the civilian noninstitutional adult population 18-79 years of age, as described previously.[4,5]

The second cycle was a survey among noninstitutionalized children aged 6-11 in 1963-65, the examination concentrating primarily upon health factors related to growth and development.[6]

The third cycle focused upon youth. For this, a probability sample of the noninstitutionalized youths 12-17 years of age in the United States was selected and examined. The examination program for youth was designed to obtain basic measures of growth and development as well as data on other health characteristics for this segment of the American population. The questionnaires and examination content and procedures closely paralleled those used in the survey of children so as to obtain comparable information, using standard measures for the continuum from childhood through adolescence. However, the examination among youth was supplemented and specially adapted, as necessary, to obtain data specifically related to adolescent health. Examinations were conducted by a pediatrician, assisted by a nurse, and by a dentist. Tests were administered by a trained psychologist, and a variety of tests were given and measurements taken by laboratory X-ray technicians. The survey plan, sample design, examination content, and operation of this survey have been described in a previous report.[7]

Field collection operations for the youths' cycle began in March 1966 and were completed in March 1970. In the program, 6,768 youths were examined from the 7,514 youths selected in the sample. This represents a response rate of 90 percent. The national sample is representative and the examined group is closely representative of the 22.7 million noninstitutionalized youths 12-17 years of age in the United States with respect to age, sex, race, geographic region, population size of place of residence, and rate of population change in the place of residence from 1950 to 1960.

In this program, as in the preceding survey of children, examinations were conducted consecutively in 40 different locations throughout the United States. Each youth during his single visit was given a standardized examination by the examining team in the mobile units specially designed for the survey. An exception to the single visit was made for girls whose urine specimen was found positive for bacteriuria. They were brought back for repeat urine tests. Prior to the examination, demographic and socioeconomic data on household members as well as the medical history, behavioral, and related data on the youth to be examined were obtained from his parents. In addition, a Health Habits and History form was completed by the youth before he arrived for the examination and he completed a Health Behavior questionnaire at the examination center. Ancillary data were requested from the school the youth attended. These data included his grade placement, teacher's ratings of his behavior and adjustment, and health problems known to his teacher. A birth certificate was obtained for each youth to verify his age and to provide information related to his condition at birth. Statistical notes on the survey design, reliability of the data, and sampling and measurement error are shown in appendix I. Definitions of the demographic and socioeconomic terms are in appendix II.

THE VISION EXAMINATION

The vision examination for youth was developed under the guidance of ophthalmologists Dr. J. Theodore Schwartz, National Eye Institute, and Dr. Herbert A. Urdweider. It included:

Tests to detect and classify color vision deficiencies.

Determination of the level of central visual acuity (both binocular and monocular) at distance and near.

Determination of the degree of lateral phoria at distance and near.

Determination of the degree and extent of correctability of myopia at distance with the use of simple spherical trial lenses for those scoring less than 20/20 (Snellen).

Measurement with a lensometer of the type and degree of correction in the refractive lenses worn by the examinee.

Color vision tests were performed with the examinee's usual glasses or other refractive lenses. The other vision tests were done without correction, and for those who had their glasses with them, the distance tests were also done with their usual correction.

In addition, each youth was given an eye examination by the survey staff pediatrician. The examination included a careful general inspection for evidence of abnormal conditions of the lids, conjunctivae, sclerae, pupils, and irides; a cover test to detect the presence of any tropia; an inspection of the conjugate gaze; and determination of the focusing or dominant eye. This report is limited to findings on the color vision tests. An earlier report describes results of the visual acuity tests.[8]

The Color Vision Tests

Two of the most reliable and widely used color vision tests commercially available were selected for the survey—The Ishihara Test for Colour-Blindness (1960 edition, 24 plates, seven of which were used) and the American Optical Company's Hardy-Rand-Rittler Pseudoisochromatic Plates (1957 edition, 24 plates). These permitted uniform testing in the time available and were suitable for large-scale administration to youths 12 through 17 years of age. Both tests consist of pseudoisochromatic plates so designed that the color defective individual will see no difference between two or more color samples which appear different to persons with normal color vision.[1,2] These plates contain numerals or symbols represented in dots of various tints set on a neutral background amid dots of the same size but of tints which are most readily confused with those of the numerals or symbols by persons with the principal types of color vision deficiencies. Individuals with color vision deficiencies are unable to see any numbers or patterns on some of the plates; on others they may see a different number or pattern than that seen by persons with normal color vision.

The Ishihara Test

The Ishihara Test for Colour-Blindness was first published in Japan in 1917 and in its various editions has been used extensively in color vision testing. This test has been found to be very effective in differentiating between persons with normal and deficient color vision.[10-15] The 1960 edition, part of which was employed in the Health Examination Survey, consists of 24 plates designed to detect the existence of a color vision deficiency.[9] Seven of the plates found most reliable were used for screening in this survey.[11] These require the ability to correctly identify or indicate the absence of one or two colored numerals.

The Hardy-Rand-Rittler Pseudoisochromatic Plates

The commerical version of the Hardy-Rand-Rittler test (H-R-R) was first produced by the American Optical Company in 1955 and was based on the H-R-R Polychromatic Plates developed earlier.[16] In 1957 a second commercial edition of the H-R-R, which was used in this study, was published. It consisted of four demonstration plates, six screening plates, and 14 diagnostic plates of the pseudoisochromatic type.[17] This H-R-R test is designed to serve three purposes:

A screening test to separate persons with defective color vision from those with normal color vision.

A qualitative diagnostic test to classify type of color defect (whether protan, deutan, tritan, or tetartan).

A quantitative diagnostic test to indicate degree or severity of the defect.

The H-R-R requires only the ability to identify and indicate the position of colored circles, triangles, and crosses. The neutral background pattern of the plates is composed of small, gray circular dots of varying sizes and shades. Set amid the gray dots are dots of similar sizes but of colors which are confused with gray by persons who have any of the principal types of defective color vision. These colored dots are arranged in any quadrant of the plate. A single test plate carries one or two of these symbols. The colored dots, like the background dots, vary in size and shades. In successive plates these symbols are presented in graded steps of chroma.

Two general types of color vision deficiencies are classified by the H-R-R—red-green deficiencies, which comprise most congenital color vision deficiencies, and the much rarer blue-yellow deficiencies. The H-R-R further distinguishes three subtypes of red-green deficiencies, protan, deutan, and "red-green undetermined." The particular errors made on the plates determine the classification.[1,9,14,17] Protan deficiencies are characterized by decreased sensitivity for red and its complementary hue, blue-green. These colors appear as gray or as an indistinct grayish color to the individual with a protan-type deficiency.

Deutan is the term given to the decrease in sensitivity for pure green and its complementary hue, red-purple. These colors are seen as gray or as an indistinct color close to gray by persons with deutan-type deficiencies. Persons whose red-green deficiency could not be classified as protan or deutan are assigned the diagnosis "red-green deficiency undetermined as to type." Blue-yellow deficiencies are classified by the H-R-R as tritan or tetartan or as "blue-yellow deficiency undetermined as to type." Tritan and tetartan deficiencies indicate loss of sensitivity in the blue-yellow perceptual area. To the tritan there is confusion of yellow-green with gray, and for the tetartan blue or yellow is confused with gray.

The H-R-R test is also designed to provide a measure of the degree of deficiency through its graded series of plates in which there is an increasing saturation of the critical hues. Three degrees of severity of defect are recognized in the H-R-R—mild, medium, and strong. The classification is based on the last group of plates in which errors occur. Only a rough quantification of the degree of defect can be made in this manner, and it is recognized that pseudoisochromatic plates do not reliably distinguish among other classifications of color vision deficiency such as "anomalous trichromats" or "dichromats."[14,18,19]

Evaluations of the Hardy-Rand-Rittler test indicate that it is a reliable technique for screening normals and abnormals and for providing qualitative diagnoses of red-green color vision deficiencies.[10,12,16] The test has also been favorably evaluated as a technique for quantitative diagnoses of red-green defects.[13,16] The paucity of individuals with blue-yellow defects has prevented validation of the plates designed to detect the rare tritan and the controversial tetartan form of defective blue-yellow vision.[17]

The first four plates in the H-R-R test are demonstration plates. The next six plates make up the screening series, followed by 14 plates in the diagnostic series. Fourteen of the test plates are concerned with red-green deficiencies, and six are devoted to the detection and the qualitative and quantitative diagnosis of blue-yellow defectives.

Testing Methods

In the survey of youth, color vision testing preceded the other vision tests. The tests were performed binocularly with glasses or other corrective lenses on if the youth normally wore them. Test books were placed on a table under a Macbeth Easel Lamp having an intensity of from 20-28 foot-candles, as measured weekly by light meter at the table level. This is the type of illumination and within the intensity range recommended by the authors of the H-R-R test for valid testing.[17] The Easel Lamp provides sufficient intensity of the desired quality so that a small amount of extraneous light in the room will not appreciably affect the results of the tests. The youth was seated at the testing table so that his eyes were kept about 30 inches from the test book. Each youth was first administered seven plates of the Ishihara test (plates 1, 2, 5, 8, 11, 14, and 16) as a screen to separate youths with normal color vision from those with color vision deficiencies. If the youth had difficulty identifying the numbers on the plates he was asked to trace the figure he saw with a small paint brush. Responses to each plate were entered on a special recording form (appendix III).

Youths who correctly read the Ishihara plates were classified as having normal color vision and testing was terminated. Failure to correctly read any one of the screening plates except plate 1, which was used as a demonstration plate, indicated the possibility of a color vision deficiency, and the youth was then administered the Hardy-Rand-Rittler test to verify his deficiency.

The first four plates of the H-R-R were administered first. These plates are used for demonstration purposes to acquaint the youth with the symbols he will see in the subsequent plates.

Plates 1-6, the screening plates, were then administered. The youth was asked the number of colored symbols he saw, their shape, and their location on the plates. A correct answer to all three parts was required to receive credit toward a rating of normal color vision. Answers were entered on the special recording sheets (appendix III).

If the youth gave the correct response for all six screening plates, he was considered to have normal color vision and no further testing was done. This occasionally occurred after one or more incorrect responses on the Ishihara plates. Youths making one or more errors on the H-R-R screening plates were then given the diagnostic series to determine the specific type of deficiency, i.e., protan, deutan, etc., and severity of the defect, i.e., mild, medium, or strong. All qualitative and quantitative diagnoses in this report are based on H-R-R protocol.

Quality Control

As in the children's cycle, vision tests for youths were administered by the survey staff examining dentist because that member of the survey team had the time available. The effect of this was to have these tests done by a professional person who, once the necessary special training had been given, was adept at administering the tests. Each of the five examining dentists employed during the cycle was given training and practice in vision testing techniques to insure the consistency of the test results. Further practice was obtained during the "dry runs" preceding the start of the regular examinations at each of the 40 locations in which the mobile Health Examination Centers were located. Testing equipment and illumination were checked periodically through the cycle to verify that they were in good working order and both met the required standards.

FINDINGS

Screening Results

An estimated 95.7 percent or 21.7 million youths 12-17 years of age in the noninstitutional population of the United States would have been identified as probably having normal color vision on the basis of screening test results from the findings obtained on the shortened form of the Ishihara test used in the Health Examination Survey of 1966-70. These were youths who were able to correctly identify the characters, or indicate their absence, on each of the six Ishihara plates used in the survey examination (table 1). The remaining 4.3 percent of the youths misread at least one of the six Ishihara screening plates. In addition a small proportion of these youths passed the initial screening section of the Hardy-Rand-Rittler color vision test. The latter test was given all those missing at least one Ishihara plate to determine the extent and severity of their color vision defects. This group of "false positives" on the Ishihara was considered for analytical purposes to also have normal color vision. (This group constituted less than 5 percent of the youths who failed the Ishihara test and so only 0.2 percent of all youths examined.)

The screening findings for youths correspond closely to those obtained for children from the identical color vision test battery used in the Health Examination Survey of 1963-65 (figure 1).[1] In that survey, an estimated 95.2 percent of the noninstitutionalized children aged 6-11 years in the United States were determined to have normal color vision on the basis of the Ishihara screening and an additional 0.2 percent on the basis of the subsequent H-R-R screening.

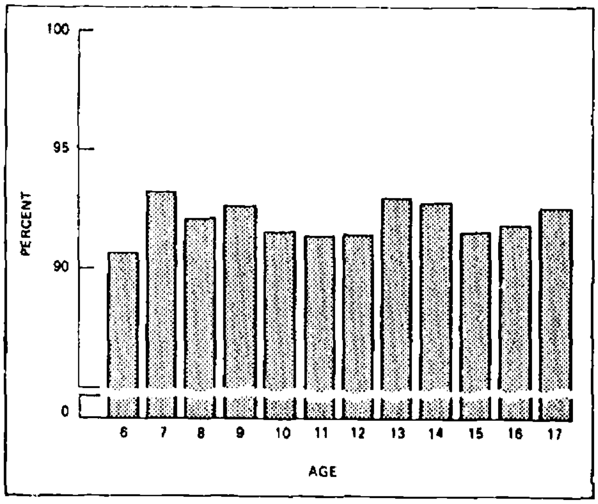

Figure 1. Percent of boys with normal color vision, by age: United States, 1963-70.

Distributions of scores (number of plates read correctly) on the Ishihara plates for youth by age and sex are shown in table 2. No evidence of a pattern between age and performance on the plates is apparent. At all ages boys were much more likely to have misread one Ishihara plate or more than were girls, the difference exceeding the 99 percent confidence limit for these survey findings. Boys who failed the Ishihara screening test were substantially more likely to have missed at least five of the six plates than fewer; while girls with some evidence of color deficiency were about as likely to have missed only one than more than one plate, reflecting the greater severity of the defect among boys.

H-R-R screening score distributions are presented in table 3 for the 4.3 percent of the youth who failed the Ishihara and were administered this test. The number of girls in the group was too small to provide reliable estimates for them by single years of age. The distribution of "false positives" on the Ishihara is indicated in the table by those who read all six H-R-R screening plates correctly.

Prevalence findings of defective color vision in the remainder of this report are based on the H-R-R test protocol. Values for incomplete test results were imputed by the method outlined in appendix I.

Prevalence

The estimated prevelence rate of defective color vision among noninstitutionalized youths 12-17 years of age in the United States based on findings from the Health Examination Survey was 4.1 percent; this delimits a population of approximately 934,000 youths with defective color vision (table A). This percentage is comparable to the 3.8 percent estimated for children with color deficiencies (those 6-11 years of age in 1963-65).

Sharp differences were apparent in the prevalence rates for boys and girls. Boys were more than 12 times as likely to have defective color vision than were girls. More than 7.5 percent of the boys were found to have such a deficiency, but only 0.6 percent of the girls were similarly affected (table 4).

Racial differences in the prevalence of color vision deficiencies were negligible. The prevalence rate was slightly larger among white than Negro boys or boys of other races. However, the differences in the rates were not statistically significant at the 5-percent probability level. The number of youths of other races in the population is too small to provide reliable estimates of the prevalence of this defect for them from the present study. Similarly the prevalence of color deficiency among girls is so low that the estimates for both the Negro and other racial groups are not reliable and are presented only to indicate that the rate among Negro girls is low.

Table A. Prevalence rates for defective color vision among youths 12-17 years, by race and sex: United States, 1966-70

Race and sex	Red-green defects in youth	
	Number in thousands	Percent
Both sexes----	934	4.12
Boys----------	865	7.53
White--------------	767	7.72
Negro--------------	95	6.35
Other races---------	3	5.34
Girls---------	69	0.62
White--------------	67	0.70
Negro--------------	2	0.15
Other races---------	-	-

Type of Deficiency

The most common perceptual color vision deficiency found for both boys and girls was of the red-green type. A small percentage of youths did exhibit a combination of red-green and blue-yellow perceptual defects (less than 1 percent), but none of the surveyed youths failed to correctly identify only the H-R-R blue-yellow screening plates.

Racial differences with respect to the type of color vision defect among boys were not apparent. A slightly larger proportion of white than Negro boys did have a red-green deficiency while slightly more Negro boys had a combination of red-green and blue-yellow perceptual deficiencies, but in neither case were the differences in rates statistically significant.

Boys were substantially more likely than girls to have only a red-green deficiency than a combination of red-green and blue-yellow perceptual defects. The ratio of these defects among boys was nearly 8 (with only red-green) to 1 (with both types) compared with nearly 2 to 1 among girls.

Red-Green Deficiencies

An estimated 7.5 percent of the boys in the United States, ages 12-17, have a red-green color vision deficiency alone or in combination with a blue-yellow defect. A smaller proportion of Negro boys exhibited a red-green deficiency than did white boys, but the percentages were not significantly different (figure 2 and table 5).

The contrast in the proportions of red-green deficiencies between boys and girls is striking. Among white youths, 11 times as many boys were affected as were girls. The difference in the rates for Negro boys and girls for this perceptual deficiency is even greater.

No consistent age-related trend is evident in the proportion of boys with a red-green visual defect across the entire age range from 6-17 years (in the surveys of 1963-70). The prevalence of red-green deficiency was relatively consistent for ages 8 through 17 (figure 3). The only substantial difference occurred between the ages of 7 and 12 years.

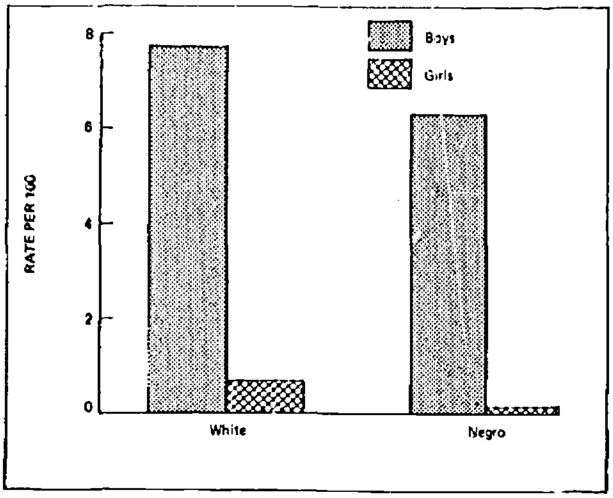

Figure 2. Prevalence of red-green color vision defects among white and Negro boys and girls 12-17 years: United States, 1966-70.

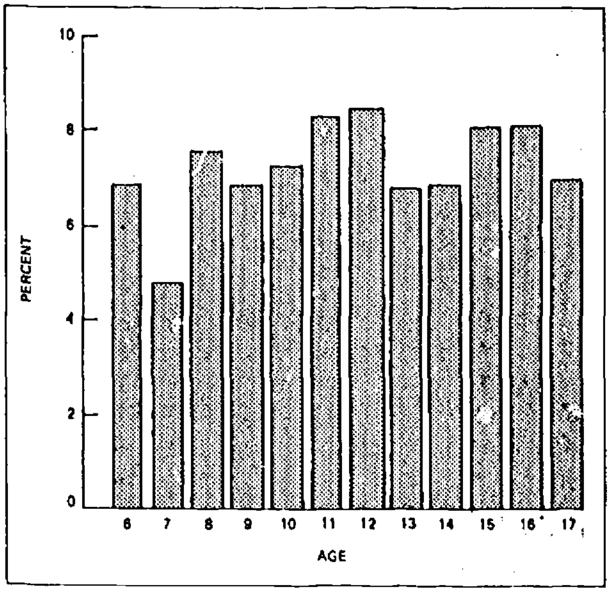

Figure 3. Prevalence of red-green color vision defects among boys, by age: United States, 1963-70.

Severity of Deficiency

The H-R-R protocol provides for grading into three severity categories: mild, medium, and strong. Using this protocol, the proportion of youths with a mild red-green deficiency was slightly greater than for those with a medium defect which in turn slightly exceeded the proportion with a strong defect (table 6). Only the differences in the proportions between the mild and strong groups are large enough to be statistically significant. This pattern was not found among children. For them proportions in the mild and strong severity categories were identical while relatively, slightly fewer were rated as medium (figure 4). Although children and youths exhibited different patterns of red-green severity, the differences between the respective proportions in the severity classes for the two age groups are not statistically significant.

White boys were more likely than Negro boys 12-17 years of age to have a red-green visual defect. Among those with defects of medium or strong severity the differences between white and Negro are negligible. The consistent decrease in

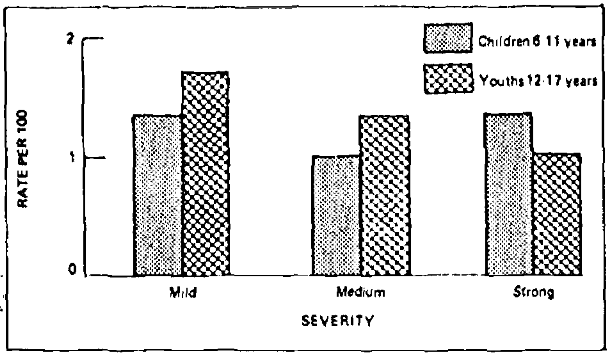

Figure 4. Severity of red-green color vision defects for children and youths 6-17 years: United States, 1963-70.

the prevalence of this red-green visual deficiency with the increase in severity is evident among white boys similar to the pattern for all boys 12-17 years of age. Only the difference in the prevalence rates between the mild and strong defects are statistically significant (figure 5 and table 6). Among Negro boys 12-17 years about the same proportion was found to have a mild or medium defect and somewhat more (but not significantly more) had a strong deficiency.

The prevalence of mild red-green perceptual deficiency among white girls was significantly greater than defects of medium severity, while none were found to have strong deficiency. Only mild red-green deficiencies were found among Negro girls. As previously indicated, the prevalence of color deficiency among girls was too low to provide consistently reliable national estimates for them by race with the size and design of the sample used in this survey.

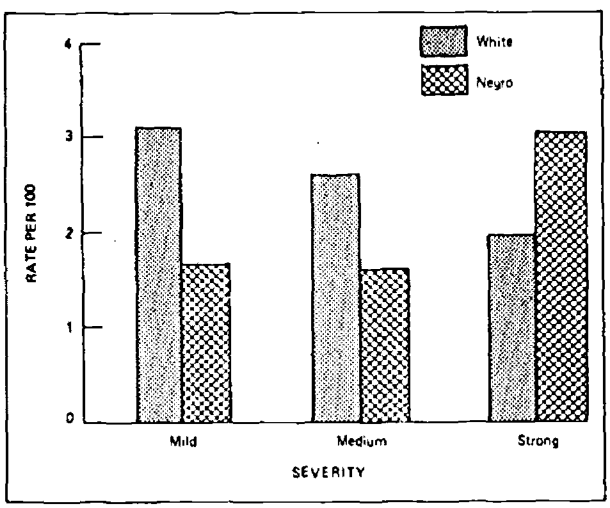

Figure 5. Severity of red-green color vision defects among white and Negro youths 12-17 years, by race: United States, 1966-70.

Subtype of Red-Green Deficiency

The deutan subtype of red-green color vision defect (decreased sensitivity for green) is the most prevalent type of color vision deficiency among boys. It was found among 4.1 percent of those 12-17 years of age in this country. Over half of the boys with defective color vision had this type of problem (table 7). Protan defects (decreased sensitivity for red) were less than half as prevalent among boys as the deutan type (1.7 percent compared with 4.1 percent) and just slightly less frequently found than the undetermined types of red-green deficiency (1.8 percent).

The prevalence rates of protan and deutan deficiencies among boys 12-17 years of age were similar to the corresponding rates among younger boys 6-11 years from the 1963-65 survey (2.2 and 3.8 percent, respectively) (figure 6). However, the proportion of boys with red-green deficiencies of undetermined type were significantly greater among youths than children (1.8 compared with 0.9 percent). This was due to the significantly greater proportion of this type of deficiency found among the older white boys (12-17 years old) than those of 6 to 11 years.

As among the younger girls 6-11 years of age in the 1963-65 survey, more than two-thirds

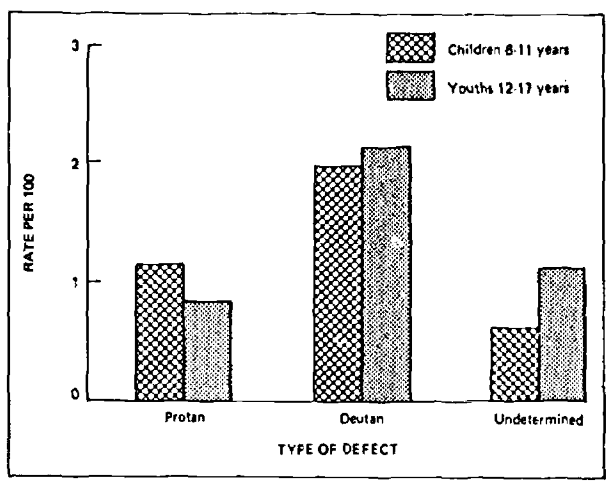

Figure 6. Type of red-green color vision defect among children and youths 6-17 years: United States, 1963-70.

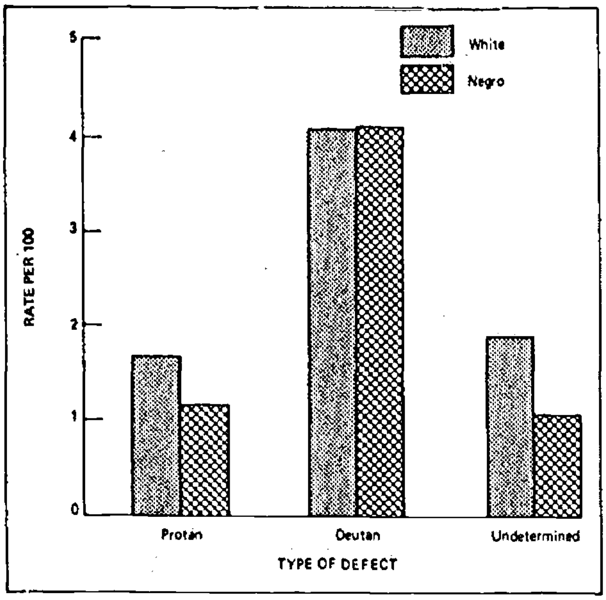

Figure 7. Type of red-green color vision defect among white and Negro youths 12-17 years: United States, 1966-70.

of the girls 12-17 years old with a color vision deficiency had one of undetermined red-green type. Less than 1 percent of either age group had defective color vision of any type.

The prevalence rates of all three types of red-green color deficiency were similar among white and Negro boys aged 12-17 years (figure 7). However, Negro boys of this age were less likely than white boys to have a protan deficiency of medium severity or a mild deutan deficiency but more likely to have a strong deutan deficiency.

Red-Green Deficiencies by Selected Demographic Variables

Only boys were considered in the analysis of red-green deficiencies by demographic variables because of the small number of affected girls. The prevalence estimates for the latter group will, consequently, be less precise but are included in the detailed tables 8-10 with their associated standard errors to convey the overall picture obtained from the national survey of youth.

Region—No significant pattern of regional differences was found in the prevalence of color vision deficiency among boys 12-17 years of age in this country. The prevalence rates of red-green deficiencies among boys ranged from a low of 6.3 percent in the Midwest to a high of 9.1 percent in the West. The difference in these rates is not statistically significant at the 5-percent probability level (table 8). The prevalence of this condition among white and Negro boys was similar in each of the regions except in the South where the rate among white boys is significantly greater (three times as large) as among Negro boys. These regional findings are similar to those among children 6-11 years of age in the 1963-65 survey.

Place of residence—Youths (boys) living in urban communities generally had a higher prevalence rate of red-green perceptual color vision deficiencies than those boys living in rural areas (table 9). This is the reverse of findings among children 6-11 years of age in the 1963-65 survey, but the differences in rates are not significantly different either between surveys or between urban and rural residents in the present study.

The estimated proportions of red-green color deficiencies among boys living in areas of differing population size were found to range from a high of 10.7 percent in cities of 250,000 to 1 million population to a low of 3.0 percent in places with 10,000-24,999 population outside a Census-defined "urbanized area." Even though the difference between these two rates is substantial, care must be taken in concluding that they are in fact different. The coefficient of variation of the smaller estimated proportion is sufficiently large to cast doubt upon its reliability. Hence, caution should be used in concluding that significant differences in the proportions of affected boys exist between cities of differing size. Racial differences in the prevalence of color deficiency were not evident between white and Negro boys from either urban or rural areas.

Family income—The prevalence of red-green deficiencies did not vary consistently with the level of family income. The percentage of boys affected does not differ significantly across all family income levels (table 10). The trend of a slight increase in the prevalence of red-green deficiencies by family income observed among children was absent among youth. There were no significant differences in the prevalence rates across family income levels between youths 12-17 years of age in the present study and children 6-11 years of age in the 1963-65 survey.

Blue-Yellow Deficiencies

All the youths diagnosed as having a blue-yellow deficiency on the Hardy-Rand-Rittler test plates also had an accompanying red-green deficiency, as previously indicated. An estimated 0.6 youths per hundred 12-17 years of age in the United States had this blue-yellow deficiency in the period 1966-70. Almost all of these perceptual color vision defects (97 percent) were diagnosed as the undetermined subtype. The majority were of mild severity (88 percent). Perceptual blue-yellow deficiencies of mild severity also predominated in the survey of children (83 percent) (appendix IV).

Combined Red-Green and Blue-Yellow Deficiencies

A somewhat larger proportion of youths (0.56 percent) were found to have perceptual difficulties in both red-green and blue-yellow areas than were observed in the survey of children (0.32 percent). The difference probably reflects sampling variability and is not statistically significant at the 5-percent level (table 11).

The prevalence rate for white boys with this combination of perceptual color defects was estimated at 0.86 per hundred and was about 0.25 per hundred for white girls. The rates for Negro youths are similar to those found for white youths but are far less reliable. Appendix IV contains further information on the specific combinations of red-green and blue-yellow deficiencies found among the surveyed youths.

Agreement on Reexamination

The Health Examination Survey among youths in 1966-70 utilized the same sampling areas and housing units as the previous Health Examination Survey among children in 1963-65. As a result nearly one-third of the youths in the present study had also been examined in the children's survey. The time lapse between the two examinations ranged from 28 months to 5 years with a median time lapse of about 4 years. Since the color vision tests were identical in both surveys, some longitudinal data on these deficiencies were available for an estimated 7.4 million youths. Comparison of the findings at these two points in time will probably reflect the reliability of the tests used as well as any change in the condition of the children. This subgroup, however, cannot be considered typical of the total group of youths since they will be limited to the group who remained in the same location during that period of time and were willing to be examined again.

The prevalence of red-green color vision deficiencies among youths (both sexes) who had also been examined as children was 3.7 percent. This is slightly (but not significantly) lower than the rate of 4.1 percent for all youths. Among both boys and girls the rate of defective color vision found on reexamination at ages 12-17 years was slightly lower than it had been for them when they were examined as children (6-11 years of age). The rate for the boys in the longitudinal group was 6.9 percent compared with 7.5 percent for all boys aged 12-17 years. Consideration of the comparability of the color vision test results from the two examinations will be limited here to the boys, since the number of girls with such defects is too small to provide reliable estimates for them.

About two-thirds (64 percent) of the boys with red-green color vision deficiencies had been found to have the same type in the earlier survey and there was agreement on both strength and type of defect for 42 percent (table 12). For the remaining 21 percent where there was agreement on the type of defect but the strength of the defect differed, the deficiency was more likely than not to be weaker in the older age group than when they were children (19 percent).

Among the remaining 36 percent whose type of deficiency differed, the shift between childhood and youth was slightly more likely to have been from a definite decreased sensitivity for red or green to an undetermined type (13 percent) than from an undetermined type to a more definite defect (10 percent) or from a predominately decreased sensitivity for red to one for green (10 percent).

COMPARISON WITH OTHER STUDIES

Defective color vision, or color blindness as it is commonly known, has attracted the attention of scientists since its discovery in the

Table B. Selected studies reporting prevalence of red-green color vision deficiencies

Author and year	Reference No.	Population	Male Number	Male Rate per 100	Female Number	Female Rate per 100	Test used
European studies							
Waaler, 1927	23	Norwegian students	9,094	8.01	9,072	0.44	Ishihara and anomaloscope
Von Planta, 1928	24	Swiss students	2,000	7.95	3,000	0.43	Ishihara and anomaloscope
Wieland, 1933	25	Swiss students	1,036	8.2	-	-	Ishihara and anomaloscope
Schmidt, 1936	26	Germany	6,863	7.75	5,604	0.36	One setting of anomaloscope
Vernon and Straker, 1943	27	British males	12,344	7.25	-	-	A-O Pseudoisochromatic Plates
Grieve, 1946	28	British Air Force aircrew candidates	16,180	6.63	-	-	Ishihara
Francois and others, 1957	29	Belgian schoolboys	1,243	[1]8.61	-	-	Ishihara, anomaloscope and Farnsworth Tritan Plate
Mann, 1956	30	Australia	558	7.3	327	0.6	Ishihara
Kherumian and Pickford, 1959	22	France	6,635	8.95	6,990	0.50	Ishihara
Brown, 1951	31	Scottish students	525	7.43	252	0.46	Ishihara
Crone, 1968	32	Netherlands	3,167	7.95	3,359	0.45	Ishihara, H-R-R, and others
U.S. studies							
Haupt, 1922	33	Baltimore, Maryland, school children	448	7.8	487	1.6	Nela Test (colored wool skeins)
Miles, 1929	34	College students	1,286	8.2	436	0.9	Ishihara
Garth, 1933	36	Colorado Whites	795	8.4	232	1.3	Ishihara
		Negroes in Southern United States	538	3.9	496	0.8	
Clements, 1930	35	American Negroes					Ishihara
		Fullblood	205	3.4	-	-	
		Mixed blood	118	4.2	-	-	
Crooks, 1936	37	Negroes, Virginia	2,019	3.9	722	0.1	Ishihara
Sweeney and others, 1964	38	Negro boys in New York City	1,137	6.77	-	-	Screened by H-R-R
				2.99	-	-	Screened by anomaloscope
Thuline, 1964	14	Students in Tacoma, Washington	5,263	6.14	5,078	0.45	Ishihara and H-R-R
Shearron, 1965	39	Students in Tennessee	676	5.67	619	0.32	H-R-R
		White	548	6.83	-	-	
		Negro	128	3.12	-	-	
U.S. Health Examination Survey, 1963-65	40	Representative nationwide sample of children 6-11 years of age in the noninstitutional population of the United States					Ishihara and H-R-R
		White	3,153	7.36	2,947	0.50	
		Negro	464	4.04	523	0.77	
U.S. Health Examination Survey, 1966-70		Representative nationwide sample of children 12-17 years of age in the noninstitutional population of the United States					Ishihara and H-R-R
		White	3,047	7.72	2,688	0.70	
		Negro	479	6.35	520	0.15	

[1] Includes red-green and other defects.

late 18th century.[20] Many surveys of color vision have been conducted, most performed outside the United States and most utilizing testing instruments and procedures somewhat different from those of the Health Examination Survey. Reviews of these studies appear in articles by Post, Kherumian and Pickford, and Kalmus.[20-22] General findings from some of these studies are presented in table B for comparison with national estimates for American youth from the present study. The list of earlier studies in table B is not exhaustive. The studies selected for comparison were primarily based on large-scale testing performed on subgroups of white European or American populations or American Negro populations. Most utilized the Ishihara test or the H-R-R. A few also employed the anomaloscope, a precise instrument for determining defective color vision. In most cases findings are presented only for red-green color vision deficiencies.

Findings from the present survey agree in part with those of other major studies. The prevalence rates for red-green deficiencies among white males in Europe and the United States, reviewed by Post, are near 8 percent.[21] The 7.7 percent prevalence rate found for white American boys 12-17 years of age from the present study approximates this figure. The rate for white girls (0.7 percent) is much higher than that found among 5,078 Tacoma, Washington, schoolgirls.[14] However, it is not significantly larger than the prevalence rate found for white girls in the survey of children conducted by the Health Examination Survey during 1963-65.[40]

The national prevalence rate estimated for Negro boys screened on the H-R-R plates is essentially that found by Sweeney[38] and others among Negro boys in New York City. The rate for American Negro girls in the present study agrees with Crooks' 1936 findings in Virginia.[37] It does not agree with findings among children from the 1963-65 Health Examination Survey. The difference between the two rates found in the surveys of children and youth is most probably due to sampling variability; the coefficient of variation for the prevalence rate of red-green deficiency among Negro girls in the present survey is high and the statistic is unreliable.

The estimated 0.56 percent of the youths in the United States who exhibited evidence of blue-yellow color vision deficiencies is larger than previous estimates by Wright,[43] Thuline,[14] and others.[32,41] It is not significantly larger than the rate estimated for American children by the Health Examination Survey. Most of the cases in the present survey were of the mild blue-yellow undetermined type and all had accompanying red-green defects.

A preponderance of males over females with red-green deficiencies has been observed in most studies of white populations.

The finding from this study of no statistically significant relationship of color vision defects with age among American youths within the age range of the population studied is in accord with earlier studies by Chapanis and Thuline.[14,42]

SUMMARY

National estimates based on Health Examination Survey findings from a probability sample representative of youths 12-17 years of age in the noninstitutional population of the United States show:

1. About 4.1 percent or 934,000 youths were found to have color vision deficiencies. Boys were about 12 times as likely to have this condition as girls. Over 7.5 percent of the boys showed evidence of a color vision deficiency while only 0.6 percent of the girls were similarly affected. There were no significant differences in the prevalence rates for white and Negro boys.

2. Red-green color vision deficiencies were substantially more prevalent than blue-yellow defects. Red-green defects only affected 6.6 percent of boys and 0.4 percent of girls.

3. No significant differences were found between white and Negro boys with respect to the prevalence rates of red-green color deficiencies.

4. Age did not appear to be significantly related to the prevalence of color vision deficiencies.

5. Red-green deficiencies in girls were more frequently of the mild type, while among boys the cases were more evenly distributed by severity.

6. Deutan-type defects (decreased sensitivity to green) occurred with the greatest frequency among boys (4.1 percent of all boys).

7. No statistically significant regional differences in the prevalence of red-green deficiencies were found among boys, although a significant racial difference was observed in the South. Differences in the prevalence rates across income levels were negligible.

8. Blue-yellow deficiencies were found in an estimated 0.6 percent of the youth population and only in conjunction with a red-green defect. This combination of perceptual defects affected about 0.9 percent of the boys and 0.2 percent of the girls. Most blue-yellow defects were of the mild undetermined type.

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LIST OF DETAILED TABLES

Table 1. Number and rate per 100 youths by screening results of color vision test, age, and sex, with standard errors for totals: United States, 1966-70

Sex and age	All youths	Passed Ishihara	Failed Ishihara	
			Failed H-R-R	Passed H-R-R
Both sexes	Number in thousands			
12-17 years	22,692	21,714	934	44
	Percent			
12-17 years	100.0	95.69	4.12	0.19
Boys				
12-17 years	100.0	92.26	7.53	0.21
12 years	100.0	91.44	8.43	0.13
13 years	100.0	93.02	6.78	0.20
14 years	100.0	92.92	6.81	0.27
15 years	100.0	91.63	8.05	0.33
16 years	100.0	91.91	8.09	-
17 years	100.0	92.69	6.97	0.34
Girls				
12-17 years	100.0	99.20	0.62	0.18
12 years	100.0	99.27	0.73	-
13 years	100.0	99.06	0.63	0.31
14 years	100.0	98.97	0.61	0.41
15 years	100.0	99.10	0.90	-
16 years	100.0	99.56	0.28	0.16
17 years	100.0	99.28	0.54	0.18
	Standard error			
Both sexes 12-17 years	...	0.38	0.35	0.07
Boys 12-17 years	...	0.71	0.68	0.07
Girls 12-17 years	...	0.20	0.14	0.10

Table 2. Percent distribution of Ishihara screening scores for youths by age and sex, with standard errors for totals: United States, 1966-70

Sex and age	Total	Number of Ishihara plates read correctly						
		6	5	4	3	2	1	0
		Percent distribution						
Both sexes								
12-17 years	100.0	95.69	0.38	0.41	0.50	0.55	1.84	0.63
Boys								
12-17 years	100.0	92.26	0.42	0.73	0.87	0.96	3.50	1.24
12 years	100.0	91.44	0.70	0.64	1.40	0.72	4.13	0.97
13 years	100.0	93.02	0.36	0.76	0.85	0.99	3.34	0.68
14 years	100.0	92.92	0.24	0.52	1.20	0.71	3.44	0.97
15 years	100.0	91.63	0.26	0.89	0.51	1.47	4.02	1.23
16 years	100.0	91.91	0.19	0.36	0.76	1.31	3.43	2.05
17 years	100.0	92.69	0.77	1.25	0.45	0.61	2.55	1.69
Girls								
12-17 years	100.0	99.20	0.34	0.08	0.12	0.13	0.13	-
12 years	100.0	99.27	0.33	0.10	0.14	0.15	-	-
13 years	100.0	99.06	0.65	0.11	0.17	-	-	-
14 years	100.0	98.97	0.27	0.16	-	0.27	0.34	-
15 years	100.0	99.10	0.15	0.12	-	0.19	0.44	-
16 years	100.0	99.56	0.16	-	0.15	0.13	-	-
17 years	100.0	99.28	0.45	-	0.27	-	-	-
		Standard error						
Both sexes 12-17 years	...	0.38	0.09	0.08	0.10	0.10	0.24	0.11
Boys 12-17 years	...	0.71	0.11	0.15	0.19	0.18	0.47	0.21
Girls	...	0.20	0.12	0.05	0.06	0.07	0.06	-

Table 3. Percent of youths with color vision defects on Ishihara test and percent distribution of their Hardy-Rand-Rittler screening score by age and sex, with standard errors for totals: United States, 1966-70

Sex and age	Percent given H-R-R	Total	Number of H-R-R screening plates read correctly: 6	5	4	3	2	1	0
			Percent distribution						
Both sexes									
12-17 years----------	4.31	100.00	4.51	17.11	13.88	17.37	39.19	5.34	2.61
Boys									
12-17 years----	7.74	100.00	2.71	16.58	13.89	18.05	41.69	5.15	1.92
12 years-------------	8.56	100.00	1.50	25.98	14.84	6.16	47.96	3.57	-
13 years-------------	6.98	100.00	2.89	11.51	19.34	16.55	37.82	9.70	2.19
14 years-------------	7.08	100.00	3.78	7.63	12.95	21.45	46.41	-	7.78
15 years-------------	8.38	100.00	3.90	11.80	12.90	19.50	42.77	9.13	-
16 years-------------	8.09	100.00	-	13.57	13.92	24.75	37.82	7.74	2.19
17 years-------------	7.31	100.00	4.65	28.36	8.92	22.56	35.50	-	-
Girls									
12-17 years----	0.80	100.00	22.40	22.37	13.75	10.57	14.31	7.13	9.47
12 years-------------	0.73	100.00	-	30.92	-	49.28	19.80	-	-
13 years-------------	0.94	100.00	32.92	34.17	-	-	12.21	-	20.70
14 years-------------	1.02	100.00	40.39	15.14	11.79	-	-	32.68	-
15 years-------------	0.90	100.00	-	37.98	31.82	-	30.21	-	-
16 years-------------	0.44	100.00	36.72	-	-	29.72	33.55	-	-
17 years-------------	0.72	100.00	25.46	-	37.27	-	-	-	37.27
			Standard error						
Both sexes 12-17 years---------------	...	...	1.46	2.82	1.93	2.13	3.77	1.38	0.74
Boys 12-17 years-----	...	...	0.86	3.15	1.94	2.17	3.98	1.25	0.79
Girls 12-17 years----	...	...	9.68	7.63	5.71	7.86	6.42	5.78	1.90

Table 4. Prevalence rate per 100 youths 12-17 years showing color vision status from the Hardy-Rand-Rittler test, by race and sex, with standard errors: United States, 1966-70

Race and sex	All youths	Normal color vision	Defective color vision			
			Total	Red-green only	Blue-yellow only	Red-green and blue-yellow
	Percent					
Both sexes						
Total	100.0	95.88	4.12	3.56	-	0.56
Boys						
Total	100.0	92.47	7.53	6.65	-	0.88
White	100.0	92.28	7.72	6.86	-	0.86
Negro	100.0	93.65	6.35	5.33	-	1.02
Other races	100.0	94.66	5.34	5.34	-	-
Girls						
Total	100.0	99.38	0.62	0.39	-	0.23
White	100.0	99.30	0.70	0.45	-	0.25
Negro	100.0	99.85	0.15	-	-	0.15
Other races	100.0	100.00	-	-	-	-
	Standard error					
Both sexes						
Total	...	0.35	0.35	0.29	-	0.13
Boys						
Total	...	0.68	0.68	0.56	-	0.25
White	...	0.65	0.65	0.56	-	0.24
Negro	...	2.58	2.58	1.77	-	0.88
Other races	...	5.50	5.50	5.50	-	-
Girls						
Total	...	0.14	0.14	0.14	-	0.05
White	...	0.17	0.17	0.17	-	0.07
Negro	...	0.13	0.13	-	-	0.13
Other races	...	-	-	-	-	-

Table 5. Prevalence rate per 100 of red-green color vision deficiencies among youths, by race, age, and sex, with standard errors: United States, 1966-70

Sex and age	Total	White	Negro	Other races	Total	White	Negro	Other races
Both sexes	Percent				Standard error			
12-17 years	4.12	4.26	3.22	2.92	0.35	0.34	1.28	3.33
Boys								
12-17 years	7.53	7.72	6.35	5.34	0.68	0.65	2.58	5.50
12 years	8.43	8.93	5.51	-	1.53	1.61	4.25	-
13 years	6.78	7.11	5.03	-	1.11	1.32	1.53	-
14 years	6.81	7.02	5.67	-	1.12	1.13	2.65	-
15 years	8.05	8.44	4.39	26.45	1.51	1.66	2.00	22.53
16 years	8.09	7.79	10.60	-	1.47	1.17	6.94	-
17 years	6.97	6.95	7.47	-	1.29	1.55	4.77	-
Girls								
12-17 years	0.62	0.70	0.15	-	0.14	0.17	0.13	-
12 years	0.73	0.85	-	-	0.35	0.41	-	-
13 years	0.63	0.74	-	-	0.34	0.39	-	-
14 years	0.61	0.71	-	-	0.32	0.38	-	-
15 years	0.90	0.91	0.95	-	0.41	0.46	0.85	-
16 years	0.28	0.33	-	-	0.20	0.23	-	-
17 years	0.54	0.62	-	-	0.53	0.61	-	-

Table 6. Prevalence rate per 100 of color vision defects among youths 12-17 years, by severity of defect, race, and sex, with standard errors: United States, 1966-70

Race and sex	All red-green defects	Severity		
		Mild	Medium	Strong
	Percent			
Both sexes				
Total	4.12	1.71	1.34	1.07
Boys				
Total	7.53	2.91	2.51	2.11
White	7.72	3.11	2.63	1.98
Negro	6.35	1.67	1.62	3.07
Other races	5.34	-	5.34	-
Girls				
Total	0.62	0.49	0.13	-
White	0.70	0.54	0.15	-
Negro	0.15	0.15	-	-
Other races	-	-	-	-
	Standard error			
Both sexes				
Total	0.35	0.19	0.19	0.18
Boys				
Total	0.68	0.34	0.37	0.35
White	0.65	0.39	0.39	0.32
Negro	2.58	0.61	0.90	1.49
Other races	5.50	-	5.50	-
Girls				
Total	0.14	0.15	0.04	-
White	0.17	0.17	0.05	-
Negro	0.13	0.13	-	-
Other races	-	-	-	-

Table 7. Prevalence rate of red-green color vision deficiencies among youths 12-17 years, by type and severity of defect, race, and sex, with standard errors: United States, 1966-70

Race and sex	All red-green defects	Protan				Deutan				Undetermined			
		Total	Mild	Medium	Strong	Total	Mild	Medium	Strong	Total	Mild	Medium	Strong
	Percent												
Both sexes													
Total	4.12	0.84	0.16	0.28	0.40	2.16	0.63	0.88	0.65	1.12	0.93	0.18	0.01
Boys													
Total	7.53	1.66	0.32	0.55	0.79	4.08	1.11	1.68	1.29	1.79	1.48	0.29	0.02
White	7.72	1.70	0.31	0.57	0.82	4.11	1.26	1.73	1.12	1.91	1.55	0.33	0.03
Negro	6.35	1.18	0.41	0.18	0.59	4.10	0.19	1.45	2.46	1.07	1.07	-	-
Other races	5.34	5.34	-	5.34	-	-	-	-	-	-	-	-	-
Girls													
Total	0.62	-	-	-	-	0.18	0.12	0.06	-	0.44	0.36	0.08	-
White	0.70	-	-	-	-	0.22	0.15	0.07	-	0.48	0.39	0.09	-
Negro	0.15	-	-	-	-	-	-	-	-	0.15	0.15	-	-
Other races	-	-	-	-	-	-	-	-	-	-	-	-	-
	Standard error												
Both sexes													
Total	0.35	0.15	0.05	0.07	0.10	0.28	0.11	0.16	0.15	0.12	0.12	0.05	0.01
Boys													
Total	0.68	0.31	0.10	0.14	0.21	0.55	0.20	0.32	0.29	0.21	0.18	0.10	0.03
White	0.65	0.36	0.10	0.16	0.23	0.51	0.23	0.35	0.22	0.24	0.20	0.11	0.03
Negro	2.58	0.51	0.29	0.19	0.35	2.07	0.19	0.74	1.48	0.56	0.56	-	-
Other races	5.50	5.50	-	5.50	-	-	-	-	-	-	-	-	-
Girls													
Total	0.14	-	-	-	-	0.05	0.04	0.04	-	0.14	0.13	0.01	-
White	0.17	-	-	-	-	0.06	0.04	0.05	-	0.15	0.15	0.01	-
Negro	0.13	-	-	-	-	-	-	-	-	0.13	0.13	-	-
Other races	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 8. Prevalence rate per 100 of red-green color vision deficiencies among boys and girls 12-17 years, by race and geographic region, with standard errors: United States, 1966-70

Sex and geographic region	Total	White	Negro	Other races	Total	White	Negro	Other races
Boys	Percent				Standard error			
United States	7.53	7.72	6.35	*	0.68	0.65	2.58	*
Northeast	7.24	7.57	4.78	-	0.81	0.83	3.22	-
Midwest	6.31	6.30	5.48	*	1.77	1.84	2.48	*
South	7.53	9.19	2.93	-	0.87	1.08	0.77	-
West	9.12	8.31	21.10	-	1.96	1.44	10.36	-
Girls								
United States	0.62	0.70	0.15	-	0.14	0.17	0.13	-
Northeast	0.92	1.08	-	-	0.32	0.36	-	-
Midwest	0.39	0.43	-	-	0.31	0.34	-	-
South	1.19	1.52	0.31	-	0.30	0.38	0.28	-
West	0.10	0.11	-	-	0.13	0.14	-	-

Table 9. Prevalence rate per 100 of red-green color vision deficiencies among boys and girls 12-17 years, by race and population size of place of residence, with standard errors: United States, 1966-70

Sex and population size	Total	White	Negro	Other races	Total	White	Negro	Other races
Boys	Percent				Standard error			
Total urban----------	7.54	7.73	6.36	*	0.68	0.65	2.58	*
3,000,000 or more----------	5.98	6.31	5.23	-	0.36	0.58	1.70	-
1,000,000-2,999,999--------	8.52	6.95	18.16	-	3.08	2.31	14.56	-
250,000 to 999,999---------	10.73	11.88	3.66	-	1.47	1.23	5.91	-
Less than 250,000 in an urbanized area---------	8.43	10.54	2.61	-	4.74	5.58	3.20	-
More than 25,000 not in an urbanized area---------	4.52	4.70	-	-	2.32	2.39	-	-
10,000 to 24,999---------	3.01	3.27	-	-	3.54	4.09	-	-
2,500 to 9,999-----------	7.80	8.53	-	-	2.60	2.78	-	-
Rural----------------	7.48	7.57	5.84	*	1.08	1.14	1.68	*
Girls								
Total urban----------	0.62	0.70	0.15	-	0.14	0.17	0.13	-
3,000,000 or more----------	0.58	0.79	-	-	0.37	0.50	-	-
1,000,000-2,999,999--------	0.45	0.51	-	-	0.27	0.31	-	-
250,000 to 999,999---------	0.44	0.32	1.00	-	0.31	0.35	1.27	-
Less than 250,000 in an urbanized area---------	1.32	1.63	-	-	1.18	1.51	-	-
More than 25,000 not in an urbanized area---------	0.53	0.55	-	-	0.54	0.57	-	-
10,000 to 24,999---------	-	-	-	-	-	-	-	-
2,500 to 9,999-----------	-	-	-	-	-	-	-	-
Rural----------------	0.81	0.89	-	-	0.19	0.20	-	-

Table 10. Prevalence rate per 100 of red-green color vision deficiencies among boys and girls 12-17 years, by race and family income, with standard errors: United States, 1966-70

Income and sex	Total	White	Negro	Other races	Total	White	Negro	Other races
Boys	Percent				Standard error			
All incomes	7.53	7.72	6.35	*	0.68	0.65	2.58	*
Less than $3,000	7.57	7.65	7.44	-	1.73	2.04	2.51	-
$3,000-$4,999	5.11	6.14	2.43	-	1.19	1.58	1.32	-
$5,000-$6,999	9.65	8.72	14.48	*	1.82	1.14	11.54	*
$7,000-$9,999	6.39	6.42	6.73	-	1.15	1.06	5.34	-
$10,000-$14,999	9.82	10.06	2.98	-	1.65	1.70	2.86	-
$15,000 or more	7.70	7.90	-	-	1.82	1.88	-	-
Unknown	5.14	5.83	-	-	1.73	1.91	-	-
Girls								
All incomes	0.62	0.70	0.15	-	0.14	0.17	0.13	-
Less than $3,000	0.78	0.95	0.45	-	0.20	0.22	0.40	-
$3,000-$4,999	0.58	0.79	-	-	0.07	0.12	-	-
$5,000-$6,999	0.36	0.42	-	-	0.26	0.30	-	-
$7,000-$9,999	0.91	0.97	-	-	0.42	0.45	-	-
$10,000-$14,999	0.68	0.71	-	-	0.36	0.38	-	-
$15,000 or more	0.27	0.28	-	-	0.26	0.27	-	-
Unknown	0.43	0.51	-	-	0.42	0.52	-	-

Table 11. Prevalence rate per 100 of color vision deficiencies involving both red-green and blue-yellow perception among youths 12-17 years, by race and sex, with standard errors: United States, 1966-70

Sex	Total	White	Negro	Other races
	Percent			
Both sexes	0.56	0.56	0.58	-
Boys	0.88	0.86	1.02	-
Girls	0.23	0.25	0.15	-
	Standard error			
Both sexes	0.13	0.13	0.44	-
Boys	0.25	0.24	0.88	-
Girls	0.05	0.07	0.13	-

Table 12. Percent distribution of type and severity of defective color vision among boys 12-17 years by type and severity of color vision defect for them as boys 6-11 years and population estimates for those with defective color vision both as children and as youths: United States, 1963-70

Type and severity of red-green defect in boys 6-11	All red-green defects	Type and severity of red-green defect in boys 12-17											
		Protan				Deutan				Undetermined			
		Total	Mild	Medium	Strong	Total	Mild	Medium	Strong	Total	Mild	Medium	Strong
	Percent distribution												
All types	100.0	27.7	9.1	9.9	8.7	57.1	19.7	21.8	15.6	15.2	8.2	5.8	1.2
Protan													
Total	35.7	22.4	3.8	9.9	8.7	10.4	5.5	4.9	-	2.9	1.2	1.7	-
Mild	13.0	2.1	2.1	-	-	8.0	5.5	2.5	-	2.9	1.2	1.7	-
Medium	6.2	5.0	1.7	3.3	-	1.2	-	1.2	-	-	-	-	-
Strong	16.5	15.3	-	6.6	8.7	1.2	-	1.2	-	-	-	-	-
Deutan													
Total	52.4	3.3	3.3	-	-	39.1	7.9	16.9	14.2	10.0	4.7	4.1	1.2
Mild	12.1	2.1	2.1	-	-	5.3	5.3	-	-	4.7	4.7	-	-
Medium	19.6	1.2	1.2	-	-	15.5	2.6	10.2	2.7	2.9	-	2.9	-
Strong	20.7	-	-	-	-	18.3	-	6.7	11.5	2.4	-	1.2	1.2
Type undetermined													
Total	11.9	2.0	2.0	-	-	7.6	6.3	-	1.3	2.3	2.3	-	-
Mild	8.3	2.0	2.0	-	-	5.0	5.0	-	-	1.3	1.3	-	-
Medium	3.6	-	-	-	-	2.6	1.3	-	1.3	1.0	1.0	-	-
Strong	-	-	-	-	-	-	-	-	-	-	-	-	-
	Number of boys in the population in thousands												
Total	239	67	22	24	21	135	47	51	37	37	20	14	3

APPENDIX I

STATISTICAL NOTES

The Survey Design

The sample design for the first three programs or Cycles I-III of the Health Examination Survey has been essentially similar in that each has been a multistage, stratified probability sample of clusters of households in land-based segments. The successive elements for this sample design are primary sampling units, census enumeration district, segment (a cluster of households), eligible persons, and finally the sample person.

The 40 sample areas and the segments utilized in the design of Cycle III were the same as those in Cycle II. Previous reports describe in detail the sample design used for Cycle II and in addition discuss the problems and considerations given to other types of sampling frames, cluster versus random sampling, and whether or not to control the selection of siblings.[6,7]

Requirements and limitations placed on the design for Cycle III, similar to those for children in Cycle II, were that:

The target population be defined as the civilian noninstitutional population of the United States, including Alaska and Hawaii, between the ages of 12 and 17 years for Cycle III, with the special exclusion of children residing on reservation lands of the American Indians because of operational problems encountered on these lands in Cycle I.

The time period of data collection be limited to about 3 years for each cycle and the length of the individual examination within the specially constructed mobile examination center be between 2 and 3 hours.

Ancillary data be collected on specially designed household, medical history, and school questionnaires and from birth certificate copies.

Examination objectives be related primarily to factors of physical and intellectual growth and development.

The sample be sufficiently large to yield reliable findings within broad geographic regions and population density groups as well as age, sex, and limited socioeconomic groups for the total sample.

The sample was drawn jointly with the Bureau of the Census starting with the 1960 decennial census list of addresses and the nearly 1,900 primary sampling units (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, each stratum having an average size of about 4.5 million persons, in such a manner as to maximize 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 were then, within each region, cross-classified by four population density classes and classes of rate of population change from 1950 to 1960. Using a modified Goodman-Kish controlled-selection technique, one PSU was drawn from each of the 40 strata.

Further stages of sampling within PSU's required first the selection of census enumeration districts (ED's). The 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 were selected by systematic sampling, each ED having a probability of selection proportional to the population of children 5-9 years at the time of the 1960 census date. A further random selection by size of segments (smaller clusters of housing units) within each ED was then made.

Because of the 3-year time interval between Cycle II and Cycle III, the Cycle III frame had to be supplemented for new construction and to compensate for segments where housing was partially or totally demolished to make room for highway construction or urban redevelopment.

Advanced planning for the examinations at the various locations or stands provided for about 17 days of examinations which limited the number of examinees per location to approximately 200. When the number of eligible youths in the sample drawn for a particular location exceeded this number, subsampling was done by deleting from the master list of eligible youths (ordered by segment, household order within segment, and age within household) every *nth* name on the list starting with the *yth* name, *y* being a number between *1* and *n* selected randomly and *n* being the extent of oversampling in the original draw.

In Cycle III, as in Cycle II, twins who were deleted in the sample selection, were also scheduled for examination, time permitting, as were youths deleted from the Cycle III sample who had been examined in Cycle II. The sample was selected in Cycle III, as it had been for the children in Cycle II, so as to contain the correct proportion of youths from families having only one eligible youth, two eligible youths, and so on to be representative of the total target population. However, since households were one of the elements in the sample frame, the number of related youths in the resultant sample is greater than would come from a design which sampled youths 12-17 years without regard to household. The resultant estimated mean measurements or rates should be unbiased but their sampling variability will be somewhat greater than those from more costly, time-consuming systematic sample design in which every *kth* youth would be selected.

The total probability sample for Cycle III included 7,514 youths representative of the approximately 22.7 million noninstitutionalized United States youths of 12-17 years. The sample contained youths from 25 different States and approximately 1,000 in each single year of age.

The response rate in Cycle III was 90 percent, 6,768 youths being examined out of the total sample. These examinees were closely representative of those in the samples as well as the population from which the samples were drawn with respect to age, sex, race, region, population density, and population growth in area of residence. Hence it appears unlikely that nonresponse could bias the findings appreciably.

Measures used to control the quality of the data from these Surveys have been cited previously;[7] those additional measures specifically related to the particular examinations, tests, or measurements are outlined in the analytic reports describing and presenting the respective initial findings. As indicated, each of the seven dentists employed during the youth cycle was given training and practice in vision testing techniques throughout his employment to insure the consistency of test results. As may be seen in table I, the proportion of youths per thousand found to have red-green color vision deficiencies showed essentially no differences that might be attributable to the examiners when age and sex differences among the examinees at the various locations were removed.

Reliability

While measurement processes in the Surveys were carefully standardized and closely controlled, the correspondence between the real world and Survey results cannot be expected to be exact. Survey data are imperfect for three major reasons: (1) results are sub-

Table I. Examiner variability for red-green deficiencies among youths: Health Examination Survey, 1966-70

Rate and sex	Total	Examiner 1	2	3	4	5	6	7
		Number of examined youths						
All youths	6,768	1	38	476	1,817	1,856	1,446	1,134
Both sexes		Rate per 1,000 with a red-green deficiency						
Actual	...	-	*	27.3	41.3	38.3	51.2	39.7
Expected	...	-	*	27.0	41.4	38.3	51.4	39.5
Boys								
Actual	...	-	*	47.1	73.4	71.0	89.3	65.1
Expected	...	-	*	45.9	73.6	71.1	88.8	65.6
Girls								
Actual	...	-	*	4.5	6.8	3.3	11.3	7.9
Expected	...	-	*	3.8	6.7	3.2	11.8	7.6

ject to sampling error, (2) the actual conduct of a survey never agrees perfectly with the design, and (3) the measurement processes themselves are inexact even though standardized and controlled.

The first report on Cycle III [7] describes in detail the faithfulness with which the sampling design was carried out.

Data recorded for each sample youth are inflated in the estimation process to characterize the larger universe of which the sample youth is representative. The weights used in this inflation process are a product of the reciprocal of the probability of selecting the youth, an adjustment for nonresponse cases, and a poststratified ratio adjustment which increases precision by bringing survey results into closer alignment with known United States population figures by color and sex within single years of age 12 through 17 for the youth's survey.

In the third cycle of the Health Examination Survey (as for the children in Cycle II) the samples were the result of three principal stages of selection--the single PSU from each stratum, the 20 segments from each sample PSU, and the sample youth from the eligible persons. The probability of selecting an individual youth is the product of the probability of selection at each stage.

Since the strata are 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 is essentially self-weighting with respect to the target population; that is, each youth 12 through 17 years of age had about the same probability of being drawn into the respective samples.

The adjustment upward for nonresponse is 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 youths not examined in that sample PSU.

The poststratified ratio adjustment used in the third cycle achieved most of the gains in precision which would have been attained if the sample had been drawn from a population stratified by age, color, and sex and makes the final sample estimates of population agree exactly with independent controls prepared by the Bureau of the Census for the United States noninstitutional population as of March 9, 1968 (approximate midsurvey point for Cycle III), by color and sex for each single year of age 12-17. The weights of every responding sample youth in each of the 24 age, color, and sex classes are adjusted upward or downward so that the weighted total within the class equals the independent population control for each survey.

Sample frequencies and estimated United States population frequencies as of the approximate midsurvey point are shown by age, sex, and race in table II. In addition to youths not examined at all, there were

Table II. Sample of examinees and estimated U.S. population frequency distribution of youths in the noninstitutional population of the United States, by race, age, and sex: Health Examination Survey, 1966-70

Age and sex	Total	White	Negro	Other races	Total	White	Negro	Other races
	Number of examinees				Population in thousands			
Both sexes								
12-17 years	6,768	5,735	999	34	22,692	19,552	3,024	116
Boys								
12-17 years	3,545	3,047	479	19	11,489	9,929	1,496	64
12 years	643	540	101	2	2,032	1,747	280	5
13 years	626	542	80	4	2,006	1,729	262	15
14 years	618	527	88	3	1,951	1,686	256	9
15 years	613	525	84	4	1,900	1,646	241	13
16 years	556	496	57	3	1,836	1,594	231	11
17 years	489	417	69	3	1,764	1,528	225	11
Girls								
12-17 years	3,223	2,688	520	15	11,203	9,623	1,527	53
12 years	547	455	88	4	1,970	1,685	272	14
13 years	582	490	91	1	1,946	1,667	275	4
14 years	586	484	101	1	1,901	1,633	266	2
15 years	503	425	73	5	1,851	1,594	235	21
16 years	536	441	93	2	1,789	1,542	243	5
17 years	469	393	74	2	1,746	1,502	237	7

Table III. Extent of missing data for examinees on the color vision plates: Health Examination Survey, 1966-70

Test item	Both sexes	Boys	Girls
	Number of examinees		
Total number of parts of color vision test missing----------	74	42	32
Ishihara plate			
2--------------------	1	0	1
4--------------------	0	0	0
8--------------------	1	0	1
10--------------------	1	1	0
14--------------------	5	4	1
17--------------------	1	0	1
H-R-R screening plate			
1--------------------	3	2	1
2--------------------	1	0	1
3--------------------	1	0	1
4--------------------	1	0	1
5--------------------	2	0	2
6--------------------	2	0	2
H-R-R diagnostic plate			
7--------------------	2	1	1
8--------------------	12	10	2
9--------------------	13	12	1
10--------------------	1	0	1
11--------------------	1	0	1
12--------------------	1	0	1
13--------------------	1	0	1
14--------------------	3	2	1
15--------------------	2	0	2
16--------------------	4	3	1
17--------------------	3	1	2
18--------------------	4	2	2
19--------------------	4	2	2
20--------------------	4	2	2

some whose examination was incomplete in one procedure or another. The extent of missing data for the color vision plates relevant to this report is shown in table III.

Sampling and Measurement Error

In the present report, reference has been made to efforts to minimize bias and variability of measurement techniques.

The probability design of the Survey makes possible the calculation of sampling errors. The sampling error is used here to determine how imprecise the survey test results may be because they come from a sample rather than from the measurements of all elements in the universe.

The estimation of sampling errors for a study of the type of the Health Examination Survey is difficult for at least three reasons: (1) measurement error and "pure" sampling error are confounded in the data--it is not easy to find a procedure which will either completely include both or treat one or the other separately, (2) the survey design and estimation procedure are complex and accordingly require computationally involved techniques for the calculation of variances, and (3) from the survey are coming thousands of statistics, many for subclasses of the population for which there are a small number of cases. Estimates of sampling error are obtained from the sample data and are themselves subject to sampling error which may be large when the number of cases in a cell is small or even occasionally when the number of cases is substantial.

Estimates of approximate sampling variability for selected statistics used in this report are included in the detailed tables. These estimates have been prepared by a replication technique which yields overall variability through observation of variability among random subsamples of the total sample. The method reflects both "pure" sampling variance and a part of the measurement variance.

In accordance with usual practice, the interval estimate for any statistic may be considered the range within one standard error of the tabulated statistic, with 68-percent confidence, or the range within two standard errors of the tabulated statistic, with 95-percent confidence. The latter is used as the level of significance in this report.

An approximation of the standard error of a difference $d = x - y$ of two statistics x and y is given by the formula $S_d = (S_x^2 + S_y^2)^{1/2}$ where S_x and S_y are the sampling errors, respectively, of and y. Of course, where the two groups or measures are positively or negatively correlated, this will give an overestimate or underestimate, respectively, of the actual standard error.

Small Numbers

In some tables magnitudes are shown for cells for which the sample size is so small that the sampling error may be several times as great as the statistic itself. Obviously in such instances the statistic has no meaning in itself except to indicate that the true quantity is small. Such numbers, if shown, have been included in the belief that they may help to convey an impression of the overall story of the table.

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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 in terms of age at time of interview. Since the examination usually took place 2 to 4 weeks after the interview, some of those who were 17 years old at the time of interview became 18 years old by the time of examination. There were 23 such cases. In the adjustment and weighting procedures used to produce national estimates, these 23 were included in the 17-year group.

Race.—Race was recorded as "white," "Negro," or "other races." "Other races" included American Indians, Chinese, Japanese, and all races other than white or Negro. Mexican persons were included with "white" unless definitely known to be American Indian or of another race. Negroes and persons of mixed Negro and other parentage were recorded as "Negro."

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

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

Urban-rural.—The definition of urban-rural areas was the same as that used in the 1960 census. According to this definition, the urban population comprised all persons living in (1) places of 2,500 inhabitants or more incorporated as cities, boroughs, villages, and towns (except towns in New England, New York, and Wisconsin); (2) the densely settled urban fringe, whether incorporated or unincorporated, of urbanized areas; (3) towns in New England and townships in New Jersey and Pennsylvania which contained no incorporated municipalities as subdivisions and had either 2,500 inhabitants or more, or a population of 2,500 to 25,000 and a density of 1,500 persons or more per square mile; (4) counties in States other than the New England States, New Jersey, and Pennsylvania that had no incorporated municipalities within their boundaries and had a density of 1,500 persons or more per square mile; and (5) unincorporated places of 2,500 inhabitants or more not included in any urban fringe. The remaining population was classified as rural.

Urban areas are further classified by population size for places within urbanized areas and other urban places outside urbanized areas.

Family Income.—The income recorded was the total income of the past 12 months received by the head of the household and all other household members related to the head by blood, marriage, or adoption. This income was the gross cash income (excluding pay in kind) except in the case of a family with their own farm or business, in which case no income was recorded.

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APPENDIX III

RECORDING SHEET USED FOR COLOR VISION TESTING

HEALTH EXAMINATION SURVEY—III

COLOR VISION

EXAMINER

NO REPORT

Wears glasses for test: 1 ☐

Wears contact lenses for test: 2 ☐

Wears neither for test: 3 ☐

COLOR VISION TEST NO. 1—Ishihara binocular test

PLATE	READ AS	
1	☐ 12	☐ Other
2	☐ 8	☐ 3 ☐ Other
4	☐ 5	☐ 2 ☐ Other
8	☐ 6	☐ Other
10	☐ 5	☐ Other
14	☐ Other	☐ 5
17	☐ 42	☐ 2 ☐ 42
		☐ 4 ☐ 42
		☐ Other

SCORE: (If total score for plates 2-17 is 6 skip to page 2 of Vision Form)

COLOR VISION TEST NUMBER 2—H-R-R

	PLATE	I	II
B-Y	1	O X	☐ Other
B-Y	2	O ▽	☐ Other
R-G	3	X ▽	☐ Other
R-G	4	O ▽	☐ Other
R-G	5	O	☐ Other
R-G	6	X	☐ Other

SCORE (1-6): ____________

COLOR VISION TEST NO. 2—H-R-R (Continued)

	PLATE	I	II	III	IV
Mi. R-G	7	▽ O	O	▽	☐ Other
Mi. R-G	8		☐ None	X	
Mi. R-G	9		▽	☐ None	
Mi. R-G	10	X O	O	X	☐ Other
Mi. R-G	11	O X	X	O	☐ Other
Mod. R-G	12	▽ O	▽	O	☐ Other
Mod. R-G	13	O ▽	O	▽	☐ Other
Mod. R-G	14	▽ X	▽	X	☐ Other
Sev. R-G	15	X O	X	O	☐ Other
Sev. R-G	16	O ▽	O	▽	☐ Other

SCORE: (7 through 16) ______ ______

High = ☐ Protan ☐ Deutan

	PLATE	I	II	III	IV
Mod. B-Y	17	X ▽	▽	X	☐ Other
Mod. B-Y	18	O X	X	O	☐ Other
Sev. B-Y	19	O ▽	O	▽	☐ Other
Sev. B-Y	20	X ▽	▽	X	☐ Other

SCORE: (17 through 20) ______ ______

High = ☐ Tritan ☐ Tetartan

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REV 11-66

SAMPLE NO (1-5)

APPENDIX IV

YOUTHS WITH BOTH RED-GREEN AND BLUE-YELLOW COLOR VISION DEFICIENCIES

A frequency distribution of youths found to have specific combinations of both red-green and blue-yellow color vision deficiencies is shown by sex in table IV.

Most of the 28 boys affected had a mild blue-yellow undetermined deficiency in combination with red-green defects. The largest frequency of occurrence was in combination with a strong red-green deutan deficiency.

Only eight girls were diagnosed as color deficient in both the red-green and blue-yellow perceptual areas. Five showed mild blue-yellow undetermined deficiencies while two were found in the strong undetermined category. One girl exhibited a mild tetartan defect associated with a mild red-green undetermined deficiency.

The most frequent combination of deficiencies encountered among both sexes was a strong red-green deutan deficiency associated with a mild blue-yellow undetermined color vision defect.

Table IV. Frequency distribution of youths 12-17 years, with both red-green and blue-yellow deficiencies, by diagnosis and sex: Health Examination Survey, 1966-70

Blue-yellow deficiency and sex	Total	Red-green deficiency								
		Protan			Deutan			Undetermined		
		Mild	Medium	Strong	Mild	Medium	Strong	Mild	Medium	Strong
Both sexes	36	1	3	5	1	4	11	7	4	-
Type undetermined:										
Mild	31	1	3	5	1	4	11	4	2	-
Medium	2	-	-	-	-	-	-	-	2	-
Strong	2	-	-	-	-	-	-	2	-	-
Tetartan:										
Medium	1	-	-	-	-	-	-	1	-	-
Strong	-	-	-	-	-	-	-	-	-	-
Boys	28	1	3	5	-	2	11	4	2	-
Type undetermined:										
Mild	26	1	3	5	-	2	11	3	1	-
Medium	-	-	-	-	-	-	-	-	-	-
Strong	2	-	-	-	-	-	-	1	1	-
Tetartan:										
Medium	-	-	-	-	-	-	-	-	-	-
Strong	-	-	-	-	-	-	-	-	-	-
Girls	8	-	-	-	1	2	-	3	2	-
Type undetermined:										
Mild	5	-	-	-	1	2	-	1	1	-
Medium	-	-	-	-	-	-	-	-	-	-
Strong	2	-	-	-	-	-	-	1	1	-
Tetartan:										
Medium	1	-	-	-	-	-	-	1	-	-
Strong	-	-	-	-	-	-	-	-	-	-

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