NATIONAL CENTER For HEALTH STATISTICS | Series 2 Number 1

VITAL and HEALTH STATISTICS

DATA EVALUATION AND METHODS RESEARCH

Comparison of Two Vision-Testing Devices

A study to compare visual acuity as measured by the Sight-Screener and the Sloan Letter Chart.

Washington, D.C. June 1963

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
Anthony J. Celebrezze
Secretary

Public Health Service
Luther L. Terry
Surgeon General

Public Health Service Publication No. 1000-Series 2-No. 1

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C., 20402 - Price 40 cents

NATIONAL CENTER FOR HEALTH STATISTICS

Forrest E. Linder, Ph.D., Director
Theodore D. Woolsey, Assistant Director
O. K. Sagen, Ph.D., Assistant Director

U. S. NATIONAL HEALTH SURVEY

Theodore D. Woolsey, Chief
Alice M. Waterhouse, M.D., Medical Advisor
James E. Kelly, D.D.S., Dental Advisor
Walt R. Simmons, Statistical Advisor
Arthur J. McDowell, Chief, Health Examination Survey
Philip S. Lawrence, Sc.D., Chief, Health Interview Survey
Robert T. Little, Chief, Computer Applications

Public Health Service Publication No. 1000-Series 2-No. 1

PREFACE

This is one of the special methodological studies carried out during the first cycle of the Health Examination Survey program of the U.S. National Health Survey to calibrate certain of the tests and measurements used in the standardized special health examination of the Survey.

Adequate data were not available on the reliability of some of the tests used or on the comparability of test results with those obtained by other frequently used methods which were not practical for this Survey. Such information was needed to evaluate examination findings—to determine the actual extent of variation existing within the population tested apart from the variation due to the measurement devices used.

The measurement of visual acuity was one of the areas in which such a calibration study was needed. Since the examinations had to be conducted uniformly by a number of different examiners in a limited amount of time and in a space too small for testing with the usual wall charts, it was necessary to use a portable measuring device. The instrument selected was the Sight-Screener. However, the vision test in the Survey was intended to provide a measurement of sight across the entire scale of visual acuity, rather than just a visual screening. Information was lacking or inadequate on the comparability of measurements obtainable from the different Sight-Screener instruments used and on the comparability of the Sight-Screener test results with those obtained from a standard wall chart.

For these reasons, the U.S. National Health Survey contracted with the Pennsylvania State College of Optometry to conduct a calibration study on the Sight-Screener instruments. Dr. Vernon I. Ryan, Assistant Professor of Optometry, directed the project which was carried out in the Eye Clinics of the College and provided consultation in the preparation of this report. Arrangements were made with the Wilmer Ophthalmological Institute of the Johns Hopkins University for the use of an improved Snellen-type chart developed by Dr. Louise L. Sloan at the Institute.

The design used in the study was developed by Donald Loveland, who was assigned to act as liaison between the Pennsylvania State College of Optometry and the Health Examination Survey Branch during the data collection phases of the study.

CONTENTS

SYMBOLS

Data not available	---
Category not applicable	...
Quantity zero	-
Quantity more than 0 but less than 0.05	0.0
Figure does not meet standards of reliability or precision	*

COMPARISON OF TWO VISION-TESTING DEVICES

INTRODUCTION

This report presents the findings from a research study of visual acuity testing conducted by the Pennsylvania State College of Optometry under contract with the U.S. National Health Survey.

The purpose of the study was:

1. to determine the comparability between the test results that might be expected from the two American Optical Company Sight-Screener instruments used in the first cycle of the Health Examination Survey, and
2. to obtain information on the comparability of results from the Sight-Screener instruments and an improved Snellen-type test on a population whose visual acuity was no better than that which might be expected in the general adult population reached through the first cycle of the Health Examination Survey.

Relevant Research Findings

Sulzman, Cook, and Bartlett[1] investigated the reliability of visual acuity measures obtained from several screening devices, using as subjects 128 naval personnel and others from the New London Submarine Base whose visual acuity tended to be normal or near normal. In their study, the test-retest reliability of the Sight-Screener was found to be slightly greater than that for commercial Snellen-type charts but slightly less than that for an improved Snellen-type chart developed at the Base. The reliability of measures of acuity for distance vision exceeded those for near vision.

The relationship between results from the Sight-Screener and from clinical tests was assessed by Fonda, Green, and Heagan[2] among 41 aviation medical examiner students from Randolph Field. In their study, the determinations of visual acuity using the Sight-Screener did not vary more from the determinations utilizing clinical tests than the clinical tests varied among themselves.

The comparability of visual acuity test results is dependent upon many factors. The effect of illumination of the test target on visual acuity has been demonstrated in investigations of Lythgoe,[3] Hecht,[4] and many others. These studies show that, within a middle range of luminances, visual acuity is directly proportional to the logarithm of the luminance when the contrast between test object and background remains constant. Low luminance exaggerates the effect on acuity of uncorrected errors of refraction. High luminance minimizes the effect of errors of refraction. Cobb and Moss[5] and Ludvigh[6] showed that acuity increases with increasing contrast

---

This report was prepared by Jean Roberts of the U.S. National Health Survey staff.

between target and background. In her review of the research done with measurements of visual acuity, Sloan [7] concluded that, on the basis of available research, the best test situation exists if the contrast is at least 84 percent and when the background brightness is maintained constant within the limits of about 12 to 18 millilamberts (11 to 17 foot-candles).

The selection of the "end-point" or criterion for scoring the tests will also affect the measurements of visual acuity. A number of studies, including that of Lythgoe [3] and others, demonstrate that a more accurate measure of visual acuity is obtained at the normal illumination level if the standard of at least 7 out of 10 correct answers is adopted as the criterion of being able to see (read) the test object.

STUDY DESIGN

Visual acuity for near and distance vision was determined by the Sight-Screener and by Sloan Charts (improved Snellen-type charts developed at the Wilmer Institute) for each person in the study group during the 3-month period from June 19 to September 18, 1961. The tests were administered without glasses, and then the appropriate parts were repeated if the examinee wore glasses and had them with him.

The order of administration of the tests was randomized so that it would be possible to assess the effect that eye fatigue and other factors might have had on the two visual acuity test series. The Sight-Screener was used first on even-numbered days and the Sloan test first on odd-numbered days. Numbers were assigned examinees in the order in which they were admitted to the project. The distance tests were administered first for those with even numbers, the near tests first for those with odd numbers. For any particular subject, the near-far order was the same for both Sight-Screener and Sloan testing. Right eye, left eye, and binocular acuity were always measured in that order. Subjects wearing glasses were tested first without glasses and then with the glasses.

Two Sight-Screener instruments from the National Health Survey were used in the study. Instrument "A" was used at the start and through the first complete week of the project. Instrument "B" was used during the second and third weeks, and the instruments alternated biweekly thereafter. Because of the large number of volunteers available in the early stages of the project, three-fourths of the group were tested on Instrument A and one-fourth on Instrument B.

Different examiners administered the Sight-Screener and the Sloan tests for a given subject. In all, 21 examiners were used during the study. With the exception of the project director, who also did some of the testing, none were assigned for more than a 2-week period. In this way, it was possible to minimize measurement variance attributable to any one examiner.

Preprinted record cards, containing the test letters at each acuity level for the Sight-Screener and Sloan tests, were used for recording the test results (see Appendix I). These contained separate sections for near and distance vision as well as for tests with and without glasses.

A maximum of 24 tests would have been given a subject who wore glasses for near and distance vision.

DESCRIPTION OF TESTS AND CONTROLS

Sight-Screener

This instrument uses the stereoscopic principle to achieve the optical equivalent for distance in testing visual acuity. Near vision is tested without the interposition of lenses.

Monocular visual acuity is measured under conditions of binocular seeing. Both eyes view the illuminated slide with vectographic lettering but only the eye that is being tested can see the letters. This is achieved by means of polarized light and polarizing screens near the lenses of the eyepiece. In addition, monocular acuity is tested in such a way that the subject is unaware of which eye is being checked. With the suppression test (see the last line of figure 1) it is possible to determine before starting the acuity testing whether the vision is substantially poorer in one eye than the other. Use of the monocular occluder over the better eye for such persons prevents any possibility of overrating the acuity in the poorer eye in these cases. However, occluders were not used in this study so that it would be possible to obtain information on the

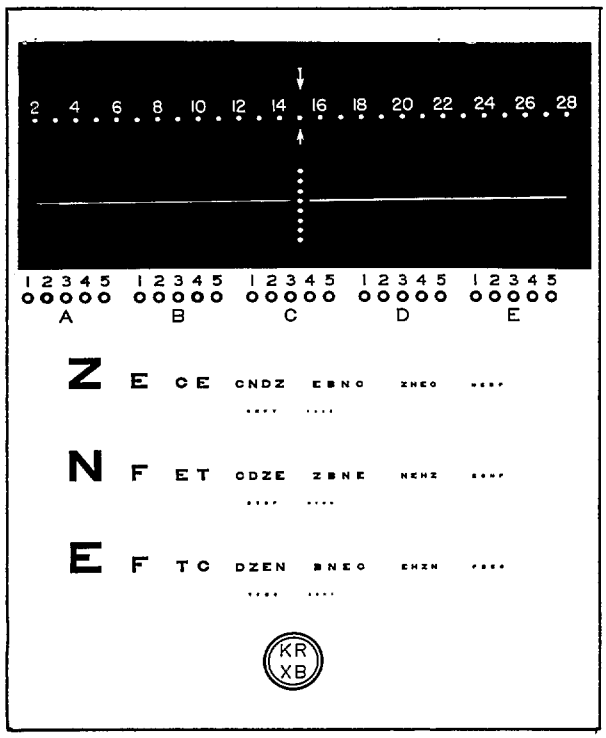

Figure 1. Sight-Screener target.

circumstances under which this overrating may be expected.

Identical targets are employed for the optical equivalent of distance and for near vision; but the lines for testing the right eye, left eye, and binocular vision differ (see the top three lines in figure 1).

With the tests of near acuity, the target is 14 inches from the eye and about 20 degrees below the primary position. The far target is at the optical equivalent of 20 feet simulated by means of lenses. The headrest and mechanical positioning of the eyepiece make it possible to maintain the target distances consistently.

Since the Sight-Screener is essentially a screening instrument, it does not provide for the measurement of visual acuity at as many levels as are usually represented on a good wall chart or near-test card. The acuity scale is coarse for the poorer levels, ranging from 20/200 down to 20/50, since there are only four steps and few letters; but it has five steps within the range for better acuities from 20/50 to 20/10 (see Appendix I). Only one letter is provided for testing at the 20/200 and 20/100 levels, two letters at 20/70 and four letters at each of the other levels. The design of the letters follows the Snellen principle, without the serifs—the height or width of the letter being five times the width of the lines in the letter.

To "pass" or be able to read a particular level no errors are allowed in groups with one or two letters and only one error is permitted in groups of four letters. The visual acuity level reached corresponds to that for the group of letters farthest to the right which the examinee is able to read with no more than the allowable number of errors.

Sloan Charts

The improved Snellen-type near and distance charts used in this study were those developed by Sloan[8] at the Wilmer Ophthalmological Institute of Johns Hopkins University.

The charts utilize 10 capital letters—Z N H R V K D C O S—designed in accordance with the Snellen principle, except that serifs are omitted. Experimental evidence indicates that these letters are about as nearly equal in legibility as can be obtained when simple capital letters are used. Moreover, the average difficulty offered by these letters has been shown to be equal to the difficulty in visual resolution offered by Landolt rings having breaks at horizontal and vertical locations. Hence, these letters meet the recommendations made by the Committee of Optics and Visual Physiology of the American Medical Association in 1916[9] and again in 1930.[10] Six of the 10 letters are the same as those on the Sight-Screener targets, while 4 differ.

Specifications for the size of letters on the Sloan Charts, as well as the Sight-Screener targets, are shown in Appendix I. On the Sloan distance charts there are 13 gradations in letter size for the range from 20/13 to 20/200 (fig. 2).

The Sloan near chart provides for measurement at 14 levels from 16/12.8 to 16/256 (corresponding to a range of 20/16 to 20/320 in the notation for distance testing).

To "pass" or be considered able to read at a particular level no more than 3 errors were allowed if the line contained 9 or 10 letters and no more than 2 errors if there were 5, 6, or 8 letters. For lines with 1, 2, or 4 letters, the same criterion was used for scoring as in the

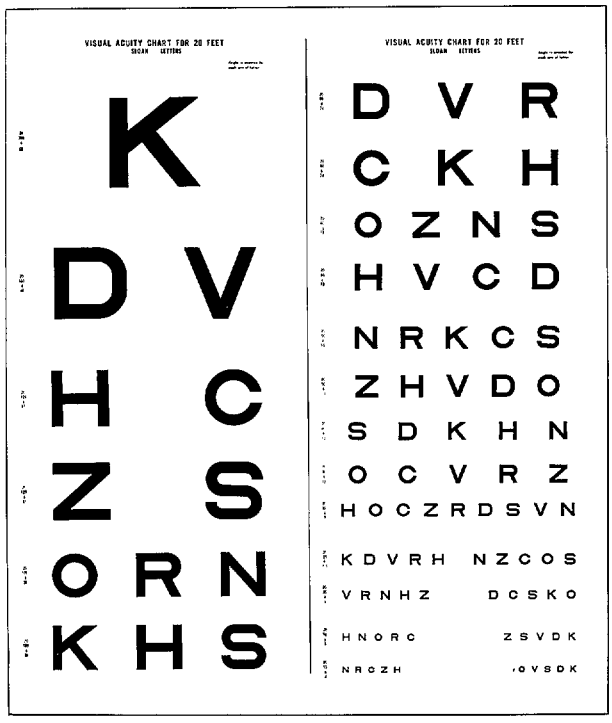

Figure 2. Sloan distance chart.

Sight-Screener tests. The visual acuity level reached corresponds with the line farthest from the top of the chart which the examinee is able to read with no more than the allowable number of errors.

Target illumination was maintained within a range of 12 to 18 foot-candles on both near and distance charts throughout the study.

The far target was at a distance of 20 feet, that for near vision at 16 inches. While the near target distance for the Sloan test differed from that in the Sight-Screener, appropriately scaled near targets were used for each so that the test results would be comparable. The device which supported the near Sloan target at the standard distance contained a chin rest and occluders which could be moved so as to cover the eye not being tested (fig. 3). The metal backing on which the near target rested was curved so that the entire card would be roughly 16 inches from the eye in normal position.

With these charts, the same target was used for testing the right eye, left eye, and binocular vision. Targets for near and distance vision differ.

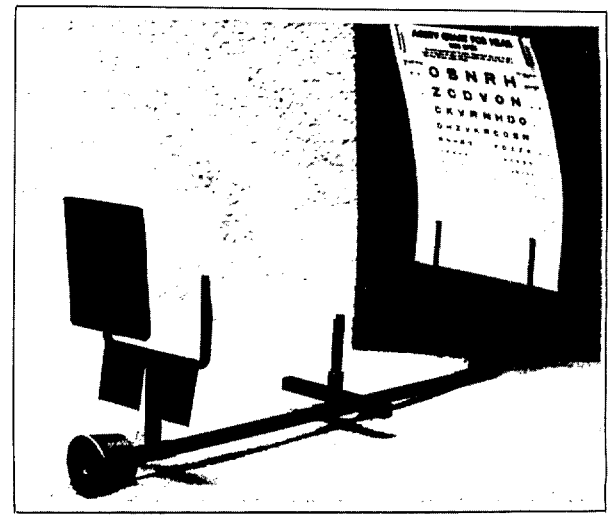

Figure 3. Sloan near target mounted.

THE STUDY GROUP

The study group consisted of 502 English-speaking, literate adult volunteers ranging in age from 17 through 79 years with a wide range of visual acuity. They were selected from the patients of the Eye Clinics at the Pennsylvania State College of Optometry, friends and relatives accompanying the patients, and the staff of the Eye Clinics, during the 3-month period from July 19 to September 18, 1961. Clinic patients were given the test batteries in the study before undergoing their regular examinations in the clinic. Only those persons who had no obvious handicap, such as an inconveniencing infirmity, lack of intelligence, or language barrier, were admitted to the study. The presence of an ocular pathology without discomfort did not bar acceptance.

While no attempt was made to select a random sample of the adult population under 80 years, the group did include a substantial number of persons throughout the entire age span and over the range of visual acuity of concern in the first cycle of the Health Examination Survey. The age-sex composition of the group is shown in table A.

Sixty percent were of the white race (table 1). Proportions of men and women aged 45-64 years and of nonwhite women aged 25-44 years were slightly larger than might have been expected.

Table A. Number of persons and percent distribution of study group, by age and sex

Age	Total	Male	Female
All ages	502	238	264
	Percent distribution		
Total	100.0	47.5	52.5
17-24 years	11.0	6.8	4.2
25-44 years	34.9	13.4	21.5
45-64 years	41.3	20.9	20.4
65-79 years	12.8	6.4	6.4

Fifty-six percent of the group (282 persons) were tested with and without glasses. Nearly three-fourths of these persons (205) needed a correction made in their lenses. The remaining 220 persons were tested without glasses only. Roughly one-third of these persons were in need of glasses for either near or distance vision or both.

Among persons under 45 years of age, 60 percent were found to have uncorrected binocular distance visual acuity of 20/20 or better on both tests, the proportion dropping to less than 10 percent for those 65 years of age and older (see table B and tables 2-5).

FINDINGS

Comparison is made here between test results from the two Sight-Screener instruments for groups of subjects tested under identical conditions and between Sight-Screener and Sloan scores for the same individuals on comparable tests.

For making these comparisons, visual acuity was expressed in terms of the size of the visual angle in minutes subtended by the optotypes—the width of the lines in the smallest letters read correctly in accordance with the study criterion. Averages were then converted to decimal or to

Table B. Proportion of the study group with normal binocular vision without glasses, by age

Acuity test	17-24 years	25-44 years	45-64 years	65-79 years
Sight-Screener	Proportion with 20/20 vision or better			
Distance	60	65	37	2
Near	72	49	1	2
Sloan				
Distance	62	64	37	9
Near	69	58	3	2

Snellen notation in the text tables presented here. The decimal values shown are the reciprocals of the visual angle measurements. The more commonly used Snellen fractions give in the numerator the distance of the test target from the examinee. The denominator is the distance at which the particular line (or block of letters) should be read correctly by a person with normal vision. Scores of 2.0, 1.0, and 0.5 minutes (visual angle size), for example, would be equivalent to scores of 0.5, 1.0, and 2.0, respectively, in decimal notation and to 20/40, 20/20, and 20/10, respectively, in Snellen notation.

Persons whose visual acuity was less than 20/200 on a particular Sloan or Sight-Screener test of near vision were excluded from both comparable test parts, since this was the lower limit measurable with the Sight-Screener targets.

Instrument Differences

Determination of the reliability of the Sight-Screener instruments, as measured by the comparability of scores attained on two of the instruments used in the Health Examination Survey, was one major concern of this study.

As indicated in the Study Design, three-fourths of the group were tested with Instrument A and one-fourth with Instrument B. Each of these was further subdivided into four groups according to which tests were given first—the near or far and the Sight-Screener or Sloan. (See tables 10-13.)

Fatigue does not appear to have affected the test results appreciably for those tested on either instrument. In general, scores attained on the Sight-Screener were no better when that battery was given first than when it followed the Sloan series. Similarly, subjects did no better on the first near or far test than on the second comparable test regardless of whether the near or far battery was given first.

An indication of the comparability of scores attained on the two instruments is shown in table C and figure 4. Visual acuity scores for persons tested on Instrument A did not differ significantly from scores attained by those tested with Instrument B on any of the 12 tests—monocular (right and left eye) and binocular, near and distance vision with or without glasses. The differences between average scores shown here is no greater than would be expected through chance alone in samples of this size. It may be seen in figure 4 that the distribution of scores obtained on the two instruments is similar.

Sight-Screener and Sloan Test Differences

The second major purpose of this study was to obtain information on the comparability between Sight-Screener and Sloan test results for a population whose visual acuity was no better on the average than that which might be expected in the general adult population to be reached through the first cycle of the Health Examination Survey.

To do this it is necessary to take into account the fact that measurements of visual acuity are affected by a number of external factors not all of which are directly related to the comparability of the Sloan and Sight-Screener tests. Recall of identical lines on the test target, the effect of practice, fatigue resulting from taking two tests in sequence without rest, and differences in the test targets are some of those which need to be considered.

Recall and practice.—As mentioned previously, the near and far targets for the Sight-Screener are identical, although the lines for testing the right eye, left eye, and binocular vision differ.

If recall of the target letters substantially affected measurements on these instruments, acuity scores would be better on distance tests for those given the near tests first and on the near tests for those given the distance ones first, provided this occurred in the absence of similar results on the Sloan. This assumes that the subject recognizes the letters he was able to recall from the first test more quickly the second time he sees them and, hence, would have time to resolve letters further along on the target within the normal test time limits. Comparison is made here only on tests given without glasses since these were the series given first in each battery.

Average scores for the subgroups in the study, as shown in table D, indicate the possibility of recall or some other factor affecting results on the near tests given without glasses—for both monocular and binocular vision. The near uncorrected acuity on the Sight-Screener, but not on the Sloan tests, is significantly better on the

Table C. Average scores on Sight-Screener and Sloan Tests for groups in which Sight-Screener Instruments A and B were used[1]

Test[2]	Sight-Screener A Group		Sight-Screener B Group	
	Sight-Screener	Sloan	Sight-Screener	Sloan
WITHOUT GLASSES				
Distance vision				
Monocular	.38	.43	.44	.42
Binocular	.46	.52	.53	.54
Near vision				
Monocular	.27	.32	.25	.28
Binocular	.33	.35	.27	.29
WITH GLASSES				
Distance vision				
Monocular	.67	.66	.73	.78
Binocular	.81	.85	.89	.99
Near vision				
Monocular	.60	.58	.61	.59
Binocular	.72	.70	.65	.65

[1]Scores given in decimal notation.

[2]Monocular tests are those in which the right eye and the left eye were examined separately. The results were combined for this and subsequent tables unless otherwise indicated.

average for those given the far tests first than it is for those given the near tests first. While a similar pattern may be seen with the Sloan scores, the differences are not statistically significant.

Average uncorrected distance acuity scores when the near tests are given first do not differ from those when the far tests are given first any more than would be expected through chance alone. Consequently, the Sight-Screener tests do not show any consistent evidence that recall has affected the results here.

The possibility of recall also exists on the Sloan tests, since the lines for the right eye, left eye, and binocular vision are identical. If learning the target letters substantially affected the scores, there would be a consistent increase from the right eye to the left eye to the binocular scores on the Sloan tests in the absence of a similar pattern or to a greater extent than on the Sight-Screener scores for the same persons.

Table E shows a systematic improvement in average scores on the successive types of test. However, the differences between the corresponding Sight-Screener and Sloan scores are insignificant; hence, recall does not appear to have appreciably affected the Sloan test results. Instead, the pattern here may indicate an improved score resulting from practice in both tests.

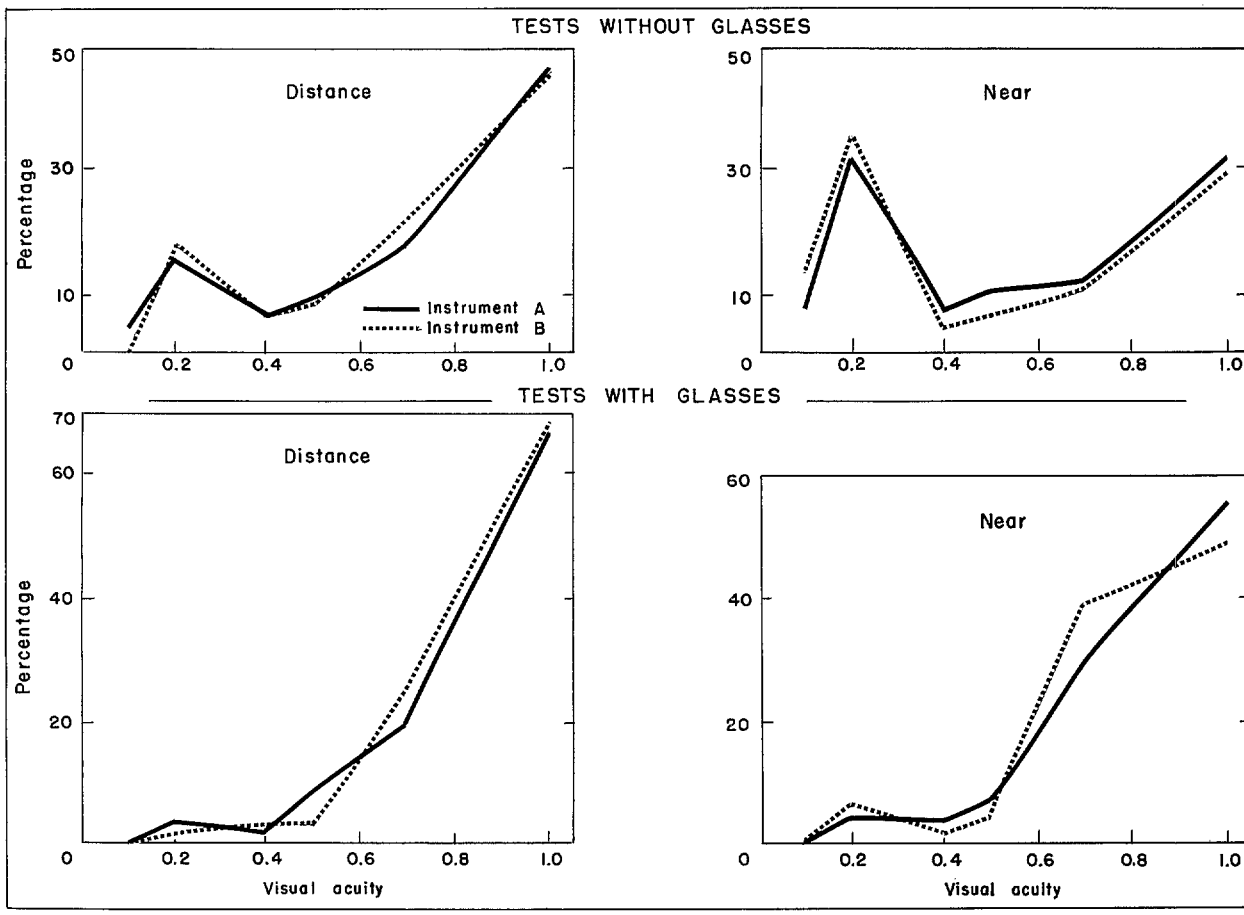

Figure 4. Percentage distribution of binocular visual acuity, in decimal notation, on Sight-Screener Instruments A and B.

Fatigue.—The administration in sequence of two complete visual acuity tests to the same person without rest might be expected to produce fatigue, although available experimental evidence would indicate that the series used in this study are probably not of sufficient length to do so. If this factor did in fact affect the scores, the study group could be expected to perform better on the test battery given first.

Average scores for distance monocular vision, uncorrected, on the Sloan tests exceeded those on the Sight-Screener regardless of which battery was given first (table F). On the binocular distance tests without glasses, the group given the Sight-Screener test first did better on the Sloan. Only on the distance binocular tests with glasses did the group given the Sloan tests first do better on their first than on their second comparable test.

Half of each of these two groups—those given the Sloan first and those given the Sight-Screener first—started with the near tests and half with the far tests. In the foregoing comparison, the effect of fatigue may have been masked when those starting with the near tests were combined with those who started with the distance tests.

If these persons are now separated and comparison made between Sight-Screener and Sloan scores for the appropriate subgroups, the subjects tended to do no better, if as well, in the tests which they took first than they did on the comparable tests parts administered later (table G). Even scores on the binocular distance tests with glasses do not differ more than would be expected through chance alone in samples of this size.

Table D. Average scores attained on Sight-Screener and Sloan Tests for those given near tests and those given far tests first[1]

Test	Average score on			
	Sight-Screener		Sloan	
	Near first	Far first	Near first	Far first
WITHOUT GLASSES				
Distance vision				
Monocular	.39	.40	.43	.42
Binocular	.49	.47	.54	.51
Near vision				
Monocular	.25	.29	.29	.30
Binocular	.28	.35	.31	.35
WITH GLASSES				
Distance vision				
Monocular	.72	.65	.74	.64
Binocular	.86	.81	.98	.79
Near vision				
Monocular	.57	.62	.55	.61
Binocular	.70	.69	.71	.66

[1]Scores given in decimal notation.

Consequently, fatigue does not appear to have affected the test results substantially. These findings are consistent with those of Rabideau[11] who found that fatigue did not affect test results in series of tests consisting of eight different targets each presented 20 times in succession without rest.

Test target differences.—The effective illumination and target-background contrast were within generally acceptable limits for both tests. However, two essential differences do exist between the targets which may account for the slightly better scores on the Sloan than on the Sight-Screener. At each level, the Sloan charts provide more letters for practice—10 letters each for more than half of the levels as compared with a maximum of 4 letters for the Sight-Screener. Also the Sloan letters are more nearly comparable in difficulty than are those on the Sight-Screener targets.

Test comparison.—Assuming that the Sight-Screener and the Sloan tests are measuring the same aspects of visual acuity in a similar manner, scores attained on the two tests by the same individual should differ only by chance, other factors being equal.

It has been shown that for persons in this study, recall of the test target letters and fatigue have not affected test results appreciably. Yet, scores attained on the Sloan battery tended to be slightly better than those on the Sight-Screener.

Table E. Average scores attained on Sight-Screener and Sloan Tests for the right eye, left eye, and binocular vision[1]

Test	Average score without glasses		Average score with glasses	
	Distance tests	Near tests	Distance tests	Near tests
Sight-Screener				
Right eye	.39	.26	.64	.55
Left eye	.40	.27	.73	.63
Binocular	.48	.31	.83	.70
Sloan				
Right eye	.40	.28	.66	.56
Left eye	.44	.30	.73	.60
Binocular	.53	.33	.88	.68

[1]Scores given in decimal notation.

Table F. Average scores on Sight-Screener and Sloan tests for those given Sight-Screener or Sloan first[1]

Test	Sight-Screener tests first—average scores		Sloan tests first—average scores	
	Sight-Screener	Sloan	Sight-Screener	Sloan
WITHOUT GLASSES				
Distance vision				
Monocular	.38	.42	.41	.44
Binocular	.47	.53	.49	.53
Near vision				
Monocular	.27	.30	.26	.29
Binocular	.31	.34	.32	.33
WITH GLASSES				
Distance vision				
Monocular	.67	.68	.70	.71
Binocular	.83	.84	.83	.93
Near vision				
Monocular	.59	.60	.59	.56
Binocular	.72	.73	.68	.64

[1]Scores given in decimal notation.

Table G. Average scores on Sight-Screener and Sloan tests for selected groups, according to which tests were given first[1]

Test	Average scores with			
	Distance and Sight-Screener tests first		Distance and Sloan tests first	
	Sight-Screener	Sloan	Sight-Screener	Sloan
DISTANCE VISION				
Without glasses				
Monocular	.38	.41	.42	.43
Binocular	.44	.50	.51	.52
With glasses				
Monocular	.63	.62	.67	.68
Binocular	.84	.77	.77	.87
	Near and Sight-Screener tests first		Near and Sloan tests first	
NEAR VISION				
Without glasses				
Monocular	.24	.29	.33	.37
Binocular	.29	.33	.28	.30
With glasses				
Monocular	.54	.56	.60	.54
Binocular	.68	.73	.73	.69

[1]Scores given in decimal notation.

Only on uncorrected distance tests of monocular and binocular vision, however, were the mean differences statistically significant (table H). As may be seen in figure 5 and tables 6-9, the distribution of scores on Sight-Screener tests is similar to that for the corresponding Sloan tests.

A test of the comparability of the entire distribution on each Sloan test with its counterpart on the Sight-Screener series required combining the scores on each into six groups—20/20 or better, 20/30, 20/40, 20/50, 20/100, and 20/200. The percentage of examinees reaching the various levels for binocular vision are shown in figure 5. Only for uncorrected monocular distance and binocular near vision do the distributions differ more than would have been expected through chance alone. The former comparison gives a chi-square value of 20 which is significant at the 1 percent level; while the near binocular test shows greater dissimilarity between

Table H. Visual acuity from Sight-Screener and Sloan Tests with and without glasses[1]

Test	Sight-Screener average score	Sloan average score	Correlation (Sight-Screener with Sloan)
WITHOUT GLASSES			
Distance vision			
Monocular	.40	.42	+0.80
Binocular	.48	.53	+0.82
Near			
Monocular	.27	.29	+0.82
Binocular	.31	.33	+0.83
WITH GLASSES			
Distance vision			
Monocular	.68	.69	+0.75
Binocular	.83	.88	+0.70
Near			
Monocular	.59	.58	+0.67
Binocular	.70	.68	+0.71

[1]Scores given in decimal notation.

scores with a chi-square value of 25. It is to be expected that this coarser grouping will tend to mask some differences between tests that might be observable if acuity were measurable at as many and the same levels on the Sight-Screener.

A high degree of association was found between Sight-Screener and Sloan scores in this study, better on tests without than with glasses. This is true despite the differences noted between the test targets and the wide range of visual acuities among the study group. As indicated in table H the correlation between scores for uncorrected visual acuity ranged from +0.80 for distance monocular tests to +0.83 for binocular near tests. The extent of agreement between test scores for one group on near binocular vision without glasses (the 323 persons tested on Sight-Screener A) is shown in figure 6. Scores on the tests with glasses were not as highly correlated, presumably because of the substantial number of these persons in need of refractive changes in their lenses.

The lack of agreement between scores on tests without glasses was primarily of two types. On the one hand, there were those persons whose acuity for one eye was substantially better than for the other. These persons tended to rate better on Sight-Screener tests for the eye with the poorer acuity than they did on the Sloan test. Since occluders were not used for Sight-Screener tests, the eye not under test often could see a faint ghost image of the target in use and hence read further than the eye under test would normally have been able to read.

The second type of problem was evident for other examinees both on monocular and binocular

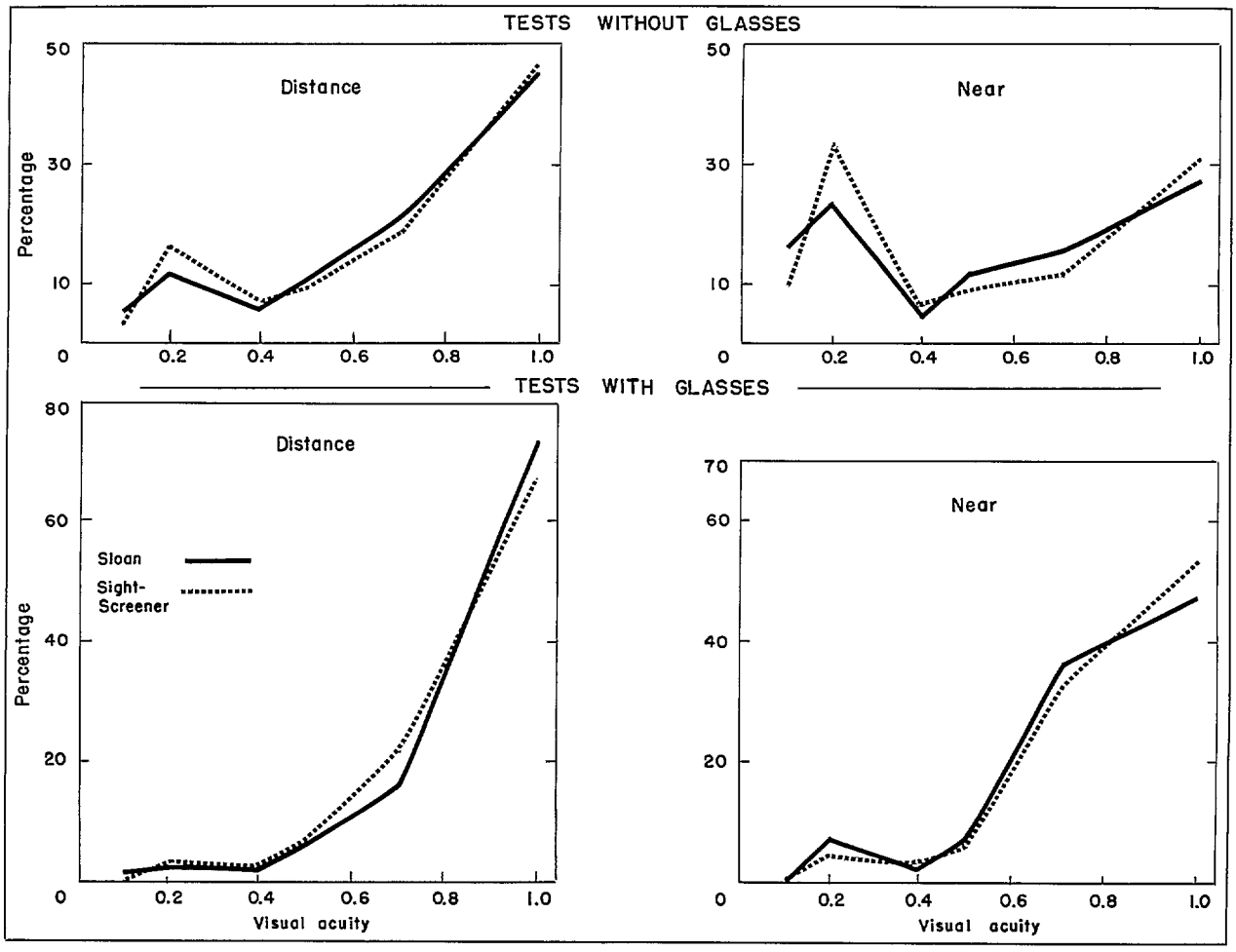

Figure 5. Percentage distribution of binocular visual acuity, in decimal notation, on Sight-Screener and Sloan tests

tests—the examinee who tested as high as 20/100 level on the Sloan test but was unable to read any of the Sight-Screener target. For these persons, it may be that other visual problems such as astigmatism make it more difficult for them to read the vectographic lettering in the Sight-Screener, with the limited number of chances allowed at each level, than it is to read the Sloan charts.

Despite those cases in which scores on the two tests differed by two or more acuity levels a correlation of +0.82 was found on binocular distance tests without glasses and +0.83 for binocular near test (uncorrected), as indicated previously. Comparison of these results for uncorrected binocular acuity with the test-retest reliabilities found by Sulzman et al.,[1] showed a slightly lower degree of association for distance tests in this study but a higher correlation than for the near tests on both the Sight-Screener and the New London (an improved Snellen-type) tests, as indicated below:

Tests binocular, uncorrected		Test-retest reliability (Sulzman et al.)
New London:	Far	+0.88
	Near	+0.75
Snellen:	Far	+0.80
Sight-Screener	Far	+0.84
	Near	+0.77

If the test conditions in the New London study were comparable to those in the present investi-

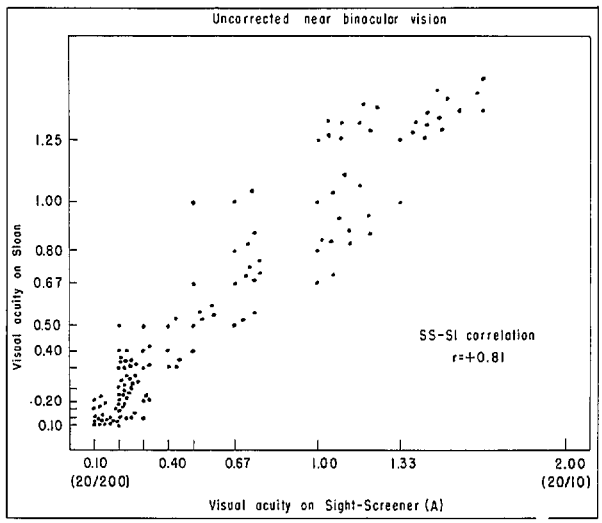

Figure 6. Scatter diagram of visual acuity on Sight-Screener (A) and Sloan tests.

gation, one might conclude that the scores on the Sight-Screener compare as well with the Sloan as they do with repeated tests on the Sight-Screener or the standard Snellen Charts. This was true in spite of the fact that the New London group had visual acuities substantially better than those in the present study—roughly 20/20 as compared with 20/40 on the average in distance tests.

A further comparison of Sight-Screener and Sloan test results over the entire range of vision from 20/15 to 20/200 is shown in table J for one of the groups in this study. Here it was assumed that persons reaching a particular level or threshold of visual acuity in fact have acuities spaced over the interval between that level and the next higher measurable level, and that the distribution of Sight-Screener scores will be similar to that for the Sloan within the interval. On this basis it was possible to estimate roughly the number and proportion of persons expected to have reached the intermediate thresholds which are not measurable on the particular test. It may be seen that, as with the grouped scores, the differences between the estimated distributions are negligible. Hence, if the above assumptions are valid, the scores obtained on the Sight-Screener in this study were, in general, comparable to those obtained on the Sloan tests throughout the entire range of vision from 20/15 to 20/200.

SUMMARY AND CONCLUSIONS

Comparison was made of visual acuity as determined by the Sight-Screener instruments and by Sloan charts (an improved Snellen-type) for a group of 502 English-speaking, literate men and women, aged 17 through 79 years, with visual acuity correctable to 20/200 or better.

Testing was done without glasses for the entire group and then the appropriate parts were repeated if the examinee wore glasses and had them with him.

The two Sight-Screener instruments in the study were those used in the first cycle of the Health Examination Survey. Part of the study group was tested on one instrument, the remainder on the other. Results obtained on the two instruments were compared.

Comparison was also made of results obtained on Sight-Screener and Sloan tests for the same persons and at the various measurable acuity levels. The effect on these test scores of recall or practice, fatigue, and target differences were considered.

Visual acuity scores attained by the study group show:

1. There was no difference in scores on the two Sight-Screener instruments that could indicate essential differences between the two devices. In all 12 tests, the distribution of scores is similar and mean differences are no greater than would be expected through chance alone.

2. Neither fatigue nor recall of target letters appear to have affected scores on either test battery.

3. Target differences do appear to have affected test scores to some extent. Scores on the Sloan tended to be slightly better in general than those on the Sight-Screener. However, only on uncorrected monocular and binocular distance tests did the average scores differ more than would be expected through chance.

4. Scores at the various measurable levels on the two tests appear to be essentially comparable if it is assumed that persons reaching a particular acuity level in fact have acuities distributed over the next higher interval in accordance with the distribution of Sloan scores within that interval. It is then possible to estimate roughly the proportion that could be expected to

Table J. Actual and estimated distributions of visual acuity scores for uncorrected binocular distance vision

Visual acuity (Snellen notation)	Actual distribution of scores		Estimated distribution of scores	
	Sight-Screener	Sloan	Sight-Screener	Sloan
Total number of persons-----	465	465	465	465
	Percent distribution			
Total-----------------------	100.0	100.0	100.0	100.0
20/10-----------------------	1.5	...	---	---
20/13-----------------------	...	17.4	15.9	17.4
20/15-----------------------	17.6	...	3.2	3.9
20/16-----------------------	...	11.8	9.0	7.9
20/20-----------------------	26.5	15.5	17.5	15.5
20/25-----------------------	...	13.1	11.7	13.1
20/30-----------------------	18.5	7.7	6.8	7.7
20/40-----------------------	8.8	10.8	8.8	10.8
20/50-----------------------	6.2	5.4	6.2	5.4
20/60-----------------------	...	3.9	2.9	3.9
20/70-----------------------	4.7	...	1.8	2.4
20/80-----------------------	...	4.9	5.4	2.5
20/100----------------------	12.3	3.2	6.9	3.2
20/125----------------------	...	2.4	1.5	2.4
20/160----------------------	...	2.2	1.4	2.2
20/200----------------------	3.9	1.7	1.0	1.7

reach intermediate levels. (It is not possible, however, to predict from this an intermediate score that a particular individual could be expected to reach.)

5. A correlation of +0.80 or better between Sight-Screener and Sloan scores was obtained on each of the tests given without glasses. This is as high or nearly as high as the test-retest reliability found for the Sight-Screener and for the standard Snellen charts in the New London Submarine Base study.

REFERENCES

[1]J. H. Sulzman, E. B. Cook, and N. C. Bartlett, "Visual Acuity Measurements With Three Commercial Screening Devices," Progress Report No. 2 on Bureau of Medicine and Surgery Research Project No. X-493, February 7, 1946, as revised by E. B. Cook. Medical Research Department, U.S. Naval Submarine Base, New London, Conn., April 22, 1948.

[2]G. E. Fonda, E. L. Green, and F. V. Heagan, Jr., "Comparison of Results of Sight-Screener and Clinical Tests," Project No. 480, Report No. 1. 27th AAF Base Unit, AAF School of Aviation Medicine, Randolph Field, Texas, September 4, 1946.

[3]R. J. Lythgoe, "The Measurement of Visual Acuity," Medical Research Council, Special Report Series No. 173. London, His Majesty's Stationery Office, 1932.

[4]S. Hecht, "Relationship Between Visual Acuity and Illumination," *Journal of Physiology,* 11:25, January 1928.

[5]P. W. Cobb and F. K. Moss, "Relation Between Extent and Contrast in Liminal Stimulus for Vision," *Journal of Experimental Psychology,* 10:350, August 1927.

[6]E. Ludvigh, "Effect of Reduced Contrast on Visual Acuity as Measured With Snellen Test Letters," *Archives of Ophthalmology,* 25:469, March 1941.

[7]L. L. Sloan, "Measurement of Visual Acuity," *Archives of Ophthalmology,* 45:704-725, June 1951.

[8]L. L. Sloan, "New Test Charts for the Measurement of Visual Acuity at Far and Near Distances," *American Journal of Ophthalmology,* 48(6): 807-813, December 1959.

[9]E. Jackson, M. M. Black, A. E. Ewing, W. B. Lancaster, and R. Fagin, "Committee of Standardizing Test Cards for Visual Acuity," *Transactions of the Section of Ophthalmology of the American Medical Association,* 1916, pp. 383-388.

[10]E. Jackson, et al., "Report of American Committee on Optics and Visual Physiology: Report on Tests and Records of Visual Acuity," *Transactions of the Section of Ophthalmology of the American Medical Association,* 1930, pp. 358-363.

[11]G. F. Rabideau, "Differences in Visual Acuity Measurement Obtained With Different Types of Targets," *Psychological Monographs* 69(10), No. 395, 1955.

DETAILED TABLES

STUDY POPULATION CHARACTERISTICS

VISUAL ACUITY BY AGE

COMPARISON OF TEST RESULTS

Table 1. Percent distribution of selected characteristics of study group—race and source of referral, by age

Characteristic	All ages	17-24 years	25-44 years	45-64 years	65-79 years
Number	502	55	175	208	64
Percent	100.0	11.0	34.9	41.3	12.8
	Percent distribution				
Race					
White	59.6	7.0	18.4	25.8	8.4
Nonwhite	40.4	4.0	16.5	15.5	4.4
Source					
Clinic patient	26.1	1.6	5.8	14.5	4.2
Friend or relative	66.5	7.6	26.5	24.4	8.0
Other	7.4	1.8	2.6	2.4	0.6

Table 2. Sight-Screener Tests without glasses showing visual acuity, by age

Test and acuity[1]	All ages	17-24 years	25-44 years	45-64 years	65-79 years
DISTANCE VISION					
Monocular					
Total	918	91	334	382	111
20/20 or better-(1.0+)	286	45	152	83	6
20/30-(0.7)	234	18	89	107	20
20/40-(0.5)	83	10	22	41	10
20/50-(0.4)	67	4	19	29	15
20/100-(0.2)	169	10	36	86	37
20/200-(0.1)	79	4	16	36	23
Binocular					
Total	469	47	168	196	58
20/20 or better-(1.0+)	214	29	107	73	5
20/30-(0.7)	88	8	26	39	15
20/40-(0.5)	42	2	14	24	2
20/50-(0.4)	29	-	4	17	8
20/100-(0.2)	78	6	15	34	23
20/200-(0.1)	18	2	2	9	5
NEAR VISION					
Monocular					
Total	861	94	335	342	90
14/14 or better-(1.0+)	192	52	133	4	3
14/21-(0.7)	131	18	90	20	3
14/28-(0.5)	60	5	29	24	2
14/35-(0.4)	56	6	16	24	10
14/70-(0.2)	246	5	46	157	38
14/140-(0.1)	176	8	21	113	34
Binocular					
Total	457	48	170	187	52
14/14 or better-(1.0+)	137	33	98	5	1
14/21-(0.7)	50	5	27	14	4
14/28-(0.5)	40	3	13	21	3
14/35-(0.4)	28	1	6	15	6
14/70-(0.2)	150	4	18	103	25
14/140-(0.1)	52	2	8	29	13

[1]Visual acuity in Snellen notation with decimal equivalent shown in parentheses.

Table 3. Sight-Screener Tests without glasses according to percent distribution of visual acuity, by age

Test and acuity[1]	All ages	17-24 years	25-44 years	45-64 years	65-79 years
	Percent distribution				
DISTANCE VISION					
Monocular					
Total	100.0	100.0	100.0	100.0	100.0
20/20 or better	31.2	49.5	45.5	21.7	5.4
20/30	25.5	19.8	26.6	28.0	18.0
20/40	9.0	11.0	6.6	10.7	9.0
20/50	7.3	4.4	5.7	7.6	13.5
20/100	18.4	11.0	10.8	22.5	33.3
20/200	8.6	4.4	4.8	9.4	20.7
Binocular					
Total	100.0	100.0	100.0	100.0	100.0
20/20 or better	45.6	61.7	63.7	37.2	8.6
20/30	18.8	17.0	15.5	19.9	25.9
20/40	9.0	4.3	8.3	12.2	3.4
20/50	6.2	-	2.4	8.7	13.8
20/100	16.6	12.8	8.9	17.3	39.7
20/200	3.8	4.3	1.2	4.6	8.6
NEAR VISION					
Monocular					
Total	100.0	100.0	100.0	100.0	100.0
14/14 or better	22.3	55.3	39.7	1.2	3.3
14/21	15.2	19.1	26.9	5.8	3.3
14/28	7.0	5.3	8.7	7.0	2.2
14/35	6.5	6.4	4.8	7.0	11.1
14/70	28.6	5.3	13.7	45.9	42.2
14/140	20.4	8.5	6.3	33.0	37.8
Binocular					
Total	100.0	100.0	100.0	100.0	100.0
14/14 or better	30.0	68.7	57.6	2.7	1.9
14/21	10.9	10.4	15.9	7.5	7.7
14/28	8.8	6.2	7.6	11.2	5.8
14/35	6.1	2.1	3.5	8.0	11.5
14/70	32.8	8.3	10.6	55.1	48.1
14/140	11.4	4.2	4.7	15.5	25.0

[1]Visual acuity in Snellen notation.

Table 4. Sloan Tests without glasses showing visual acuity, by age

Test and acuity[1]	All ages	17-24 years	25-44 years	45-64 years	65-79 years
DISTANCE VISION					
Monocular					
Total	911	86	331	381	113
20/20 or better	310	49	165	87	9
20/30	184	12	56	104	12
20/40	86	6	22	47	11
20/50	91	7	27	38	19
20/100	138	7	37	62	32
20/200	102	5	24	43	30
Binocular					
Total	464	45	168	194	57
20/20 or better	208	27	109	71	1
20/30	97	8	18	53	18
20/40	50	5	14	21	10
20/50	25	-	8	10	7
20/100	55	4	12	24	15
20/200	29	1	7	15	6
NEAR VISION					
Monocular					
Total	839	90	331	331	87
16/16 or better	169	52	114	1	2
16/24	138	15	97	26	-
16/32	80	9	38	28	5
16/40	44	2	14	22	6
16/80	223	5	46	133	39
16/160	185	7	22	121	35
Binocular					
Total	452	46	170	180	56
16/16 or better	119	33	83	2	1
16/24	73	5	43	25	-
16/32	52	3	14	27	8
16/40	21	1	8	11	1
16/80	104	2	11	66	25
16/160	83	2	11	49	21

[1]Visual acuity in Snellen notation.

Table 5. Sloan Tests without glasses according to percent distribution of visual acuity, by age

Test and acuity[1]	All ages	17-24 years	25-44 years	45-64 years	65-79 years
	Percent distribution				
DISTANCE VISION					
Monocular					
Total	100.0	100.0	100.0	100.0	100.0
20/20 or better	34.0	57.0	49.8	22.8	8.0
20/30	20.2	14.0	16.9	27.3	10.6
20/40	9.4	7.0	6.6	12.3	9.7
20/50	10.0	8.1	8.2	10.0	16.8
20/100	15.1	8.1	11.2	16.3	28.3
20/200	11.2	5.8	7.3	11.3	26.5
Binocular					
Total	100.0	100.0	100.0	100.0	100.0
20/20 or better	44.8	60.0	64.9	36.6	1.8
20/30	20.9	17.8	10.7	27.3	31.6
20/40	10.8	11.1	8.3	10.8	17.5
20/50	5.4	-	4.8	5.2	12.3
20/100	11.9	8.9	7.1	12.4	26.3
20/200	6.2	2.2	4.2	7.7	10.5
NEAR VISION					
Monocular					
Total	100.0	100.0	100.0	100.0	100.0
16/16 or better	20.1	57.8	34.4	0.3	2.3
16/24	16.4	16.7	29.3	7.9	0.0
16/32	9.5	10.0	11.5	8.5	5.7
16/40	5.2	2.2	4.2	6.6	6.9
16/80	26.6	5.6	13.9	40.2	44.8
16/160	22.1	7.8	6.6	36.6	40.2
Binocular					
Total	100.0	100.0	100.0	100.0	100.0
16/16 or better	26.3	71.7	48.8	1.1	1.8
16/24	16.2	10.9	25.3	13.9	0.0
16/32	11.5	6.5	8.2	15.0	14.3
16/40	4.6	2.2	4.7	6.1	1.8
16/80	23.0	4.3	6.5	36.7	44.6
16/160	18.4	4.3	6.5	27.2	37.5

[1]Visual acuity in Snellen notation.

Table 6. Visual acuity thresholds attained on Sight-Screener and Sloan Tests for distance vision without glasses

Test part and threshold[1]	Sloan Test	Sight-Screener Tests		
		Total	Instrument A	Instrument B
Monocular tests				
Total number tested	892	892	642	250
	Percent distribution			
Total	100.0	100.0	100.0	100.0
20/20 or better (1.0+)	34.8	32.1	31.2	34.4
20/30 (0.7)	20.6	26.2	26.5	25.6
20/40 (0.5)	9.6	9.3	9.5	8.8
20/50 (0.4)	10.2	7.4	7.3	7.6
20/100 (0.2)	15.0	18.5	17.8	20.4
20/200 (0.1)	9.8	6.5	7.8	3.2
Binocular tests				
Total number tested	460	460	332	128
	Percent distribution			
Total	100.0	100.0	100.0	100.0
20/20 or better (1.0+)	45.2	46.6	46.7	46.1
20/30 (0.7)	21.1	18.9	17.8	21.9
20/40 (0.5)	10.9	9.1	9.6	7.8
20/50 (0.4)	5.4	6.3	6.3	6.3
20/100 (0.2)	11.7	16.1	15.4	18.0
20/200 (0.1)	5.7	3.0	4.2	-

[1]Visual acuity score in Snellen notation with decimal equivalent shown in parentheses.

Table 7. Visual acuity thresholds attained on Sight-Screener and Sloan Tests for near vision without glasses

Test part and threshold[1]	Sloan Test	Sight-Screener Tests		
		Total	Instrument A	Instrument B
Monocular tests				
Total number tested	811	811	581	230
	Percent distribution			
Total	100.0	100.0	100.0	100.0
1.0 or better	20.8	23.7	23.8	23.5
0.7	17.0	16.2	15.7	17.4
0.5	9.9	7.4	8.4	4.8
0.4	5.4	6.8	7.2	5.7
0.2	27.2	29.4	28.9	30.9
0.1	19.7	16.5	16.0	17.8
Binocular tests				
Total number tested	442	442	313	129
	Percent distribution			
Total	100.0	100.0	100.0	100.0
1.0 or better	26.9	31.0	31.6	29.5
0.7	16.5	11.3	11.5	10.9
0.5	11.8	9.0	10.2	6.2
0.4	4.8	6.3	7.0	4.7
0.2	23.3	33.1	31.9	35.7
0.1	16.7	9.3	7.7	13.2

[1]Visual acuity score shown just in the decimal equivalent of the Snellen fraction since the Snellen ratios differ for the two test series.

Table 8. Visual acuity thresholds attained on Sight-Screener and Sloan Tests for distance vision with glasses

Test part and threshold[1]	Sloan Test	Sight-Screener Tests		
		Total	Instrument A	Instrument B
Monocular tests				
Total number tested	485	485	342	143
	Percent distribution			
Total	100.0	100.0	100.0	100.0
20/20 or better	56.7	51.6	50.3	54.5
20/30	24.7	29.3	28.1	32.2
20/40	8.0	8.2	9.1	6.3
20/50	4.3	4.7	5.3	3.5
20/100	3.7	5.6	6.7	2.8
20/200	2.5	0.6	0.6	0.7
Binocular tests				
Total number tested	245	245	173	72
	Percent distribution			
Total	100.0	100.0	100.0	100.0
20/20 or better	73.5	67.0	66.5	68.1
20/30	15.9	21.2	19.7	25.0
20/40	5.7	6.5	8.1	2.8
20/50	1.6	2.0	1.7	2.8
20/100	2.0	3.3	4.0	1.4
20/200	1.2	-	-	-

[1]Visual acuity score in Snellen notation.

Table 9. Visual acuity thresholds attained on Sight-Screener and Sloan Tests for near vision with glasses

Test part and threshold[1]	Sloan Test	Sight-Screener Tests		
		Total	Instrument A	Instrument B
Monocular tests				
Total number tested	535	535	382	153
	Percent distribution			
Total	100.0	100.0	100.0	100.0
1.0 or better	32.5	37.5	37.7	36.6
0.7	37.8	36.4	35.6	38.6
0.5	12.5	10.8	10.7	11.1
0.4	5.8	7.3	7.9	5.9
0.2	9.3	7.1	7.1	7.2
0.1	2.1	0.9	1.0	0.7
Binocular tests				
Total number tested	272	272	195	77
	Percent distribution			
Total	100.0	100.0	100.0	100.0
1.0 or better	47.1	53.6	55.4	49.4
0.7	36.4	32.4	29.7	39.0
0.5	7.0	5.9	6.7	3.9
0.4	1.8	2.9	3.6	1.3
0.2	7.4	4.8	4.1	6.5
0.1	0.4	0.4	0.5	-

[1]Visual acuity score shown just in the decimal equivalent of the Snellen fraction since the Snellen ratios differ for the two test series.

Table 10. Distance visual acuity without glasses—mean, standard deviation, and correlation of Sight-Screener and Sloan scores for the eight study subgroups[1]

Test and subgroup	Number tested in subgroup	Sight-Screener		Sloan		Correlation
		Mean	Standard deviation	Mean	Standard deviation	
Monocular vision						
Far 1st, SS 1st, SS-Inst. A-----	170	2.56	2.438	2.28	2.129	+0.87
Far 1st, SS 1st, SS-Inst. B-----	57	2.95	2.218	2.88	2.227	0.79
Near 1st, SS 1st, SS-Inst. A----	179	2.79	2.829	2.47	2.334	0.84
Near 1st, SS 1st, SS-Inst. B----	53	1.93	1.555	2.07	2.151	0.74
Far 1st, S1 1st, SS-Inst. A-----	145	2.47	2.170	2.32	2.320	0.77
Far 1st, S1 1st, SS-Inst. B-----	69	2.21	2.047	2.30	2.116	0.80
Near 1st, S1 1st, SS-Inst. A----	148	2.65	2.565	2.26	2.161	0.80
Near 1st, S1 1st, SS-Inst. B----	71	2.11	1.646	2.28	2.114	0.79
Binocular vision						
Far 1st, SS 1st, SS-Inst. A-----	87	2.23	2.197	2.00	2.062	0.89
Far 1st, SS 1st, SS-Inst. B-----	28	2.35	1.687	1.91	1.327	0.87
Near 1st, SS 1st, SS-Inst. A----	91	2.05	2.092	1.85	2.315	0.70
Near 1st, SS 1st, SS-Inst. B----	27	1.76	1.275	1.67	1.950	0.57
Far 1st, S1 1st, SS-Inst. A-----	76	2.03	1.860	1.86	1.447	0.77
Far 1st, S1 1st, SS-Inst. B-----	37	1.85	1.390	2.09	2.255	0.64
Near 1st, S1 1st, SS-Inst. A----	78	2.33	2.262	1.96	1.810	0.85
Near 1st, S1 1st, SS-Inst. B----	36	1.61	1.085	1.66	1.325	0.73

[1]Scores given in minutes of visual angle subtended by target optotypes. The mean score of 2.56 minutes would be equivalent to 20/51.2 in the Snellen notation or 0.39 in the decimal notation. SS—Sight-Screener; Sl—Sloan.

Table 11. Near visual acuity without glasses—mean, standard deviation, and correlation of Sight-Screener and Sloan scores for the eight study subgroups[1]

Test and subgroup	Number tested in subgroup	Sight-Screener		Sloan		Correlation
		Mean	Standard deviation	Mean	Standard deviation	
Monocular vision						
Far 1st, SS 1st, SS-Inst. A-----	166	3.48	3.070	3.57	3.348	+0.88
Far 1st, SS 1st, SS-Inst. B-----	56	4.13	3.602	4.51	3.921	0.82
Near 1st, SS 1st, SS-Inst. A----	162	4.27	3.409	3.78	3.234	0.82
Near 1st, SS 1st, SS-Inst. B----	51	4.55	3.591	4.00	3.413	0.77
Far 1st, S1 1st, SS-Inst. A-----	145	3.94	3.240	3.84	3.264	0.81
Far 1st, S1 1st, SS-Inst. B-----	72	4.21	4.205	4.37	3.762	0.84
Near 1st, S1 1st, SS-Inst. A----	137	4.24	3.447	4.01	3.400	0.75
Near 1st, S1 1st, SS-Inst. B----	70	4.52	3.580	4.38	3.685	0.79
Binocular vision						
Far 1st, SS 1st, SS-Inst. A-----	85	3.06	2.812	3.17	3.152	0.79
Far 1st, SS 1st, SS-Inst. B-----	29	3.67	3.087	3.63	3.210	0.89
Near 1st, SS 1st, SS-Inst. A----	86	3.30	2.532	2.84	2.160	0.81
Near 1st, SS 1st, SS-Inst. B----	28	4.23	3.275	4.07	3.767	0.66
Far 1st, S1 1st, SS-Inst. A-----	77	2.74	2.217	3.21	3.232	0.69
Far 1st, S1 1st, SS-Inst. B-----	36	3.15	2.327	3.07	2.592	0.78
Near 1st, S1 1st, SS-Inst. A----	75	3.70	3.245	3.55	3.267	0.81
Near 1st, S1 1st, SS-Inst. B----	38	3.94	3.325	3.83	3.160	0.89

[1]Scores given in minutes of visual angle subtended by target optotypes. The mean Sight-Screener score of 3.48 minutes would be equivalent to 14/48.7 in the Snellen notation or 0.29 in the decimal notation. The mean Sloan score of 3.57 minutes would be equivalent to 16/57.1 in the Snellen notation or 0.28 in the decimal notation.

Table 12. Distance visual acuity with glasses—mean, standard deviation, and correlation of Sight-Screener and Sloan scores for the eight study subgroups[1]

Test and subgroup	Number tested in subgroup	Sight-Screener		Sloan		Correlation
		Mean	Standard deviation	Mean	Standard deviation	
Monocular vision						
Far 1st, SS 1st, SS-Inst. A-----	77	1.64	1.393	1.72	2.086	+0.72
Far 1st, SS 1st, SS-Inst. B-----	37	1.51	1.361	1.46	1.525	0.89
Near 1st, SS 1st, SS-Inst. A----	100	1.47	0.872	1.39	1.244	0.67
Near 1st, SS 1st, SS-Inst. B----	26	1.12	0.343	1.09	0.355	0.55
Far 1st, S1 1st, SS-Inst. A-----	67	1.51	0.809	1.56	1.286	0.78
Far 1st, S1 1st, SS-Inst. B-----	41	1.49	0.879	1.35	0.683	0.73
Near 1st, S1 1st, SS-Inst. A----	98	1.44	1.087	1.45	1.398	0.90
Near 1st, S1 1st, SS-Inst. B----	39	1.26	0.408	1.18	0.495	0.62
Binocular vision						
Far 1st, SS 1st, SS-Inst. A-----	40	1.23	0.652	1.52	1.982	0.54
Far 1st, SS 1st, SS-Inst. B-----	18	1.08	0.517	1.05	0.775	0.80
Near 1st, SS 1st, SS-Inst. A----	50	1.28	0.765	1.07	0.665	0.80
Near 1st, SS 1st, SS-Inst. B----	13	0.98	0.262	0.92	0.210	0.74
Far 1st, S1 1st, SS-Inst. A-----	34	1.31	0.805	1.16	0.585	0.83
Far 1st, S1 1st, SS-Inst. B-----	21	1.28	0.702	1.13	0.512	0.70
Near 1st, S1 1st, SS-Inst. A----	49	1.13	0.460	1.06	0.567	0.70
Near 1st, S1 1st, SS-Inst. B----	20	1.10	0.317	0.90	0.217	0.42

[1]Scores in minutes of visual angle subtended by target optotypes.

Table 13. Near visual acuity with glasses—mean, standard deviation, and correlation of Sight-Screener and Sloan scores for the eight study subgroups[1]

Test and subgroup	Number tested in subgroup	Sight-Screener		Sloan		Correlation
		Mean	Standard deviation	Mean	Standard deviation	
Monocular vision						
Far 1st, SS 1st, SS-Inst. A-----	88	1.52	0.798	1.61	1.207	+0.54
Far 1st, SS 1st, SS-Inst. B-----	37	1.51	0.868	1.47	0.808	0.87
Near 1st, SS 1st, SS-Inst. A----	110	1.91	1.455	1.82	1.479	0.77
Near 1st, SS 1st, SS-Inst. B----	28	1.66	0.848	1.60	1.041	0.42
Far 1st, Sl 1st, SS-Inst. A-----	83	1.69	1.230	1.69	1.056	0.58
Far 1st, Sl 1st, SS-Inst. B-----	43	1.74	1.454	1.81	1.225	0.60
Near 1st, Sl 1st, SS-Inst. A----	102	1.70	1.135	1.86	1.501	0.69
Near 1st, Sl 1st, SS-Inst. B----	45	1.60	1.107	1.79	1.110	0.87
Binocular vision						
Far 1st, SS 1st, SS-Inst. A-----	46	1.30	0.557	1.41	0.887	0.70
Far 1st, SS 1st, SS-Inst. B-----	18	1.36	0.675	1.24	0.762	0.81
Near 1st, SS 1st, SS-Inst. A----	55	1.54	1.045	1.37	0.800	0.68
Near 1st, SS 1st, SS-Inst. B----	14	1.22	0.302	1.36	0.872	0.54
Far 1st, Sl 1st, SS-Inst. A-----	43	1.41	0.927	1.49	1.410	0.72
Far 1st, Sl 1st, SS-Inst. B-----	23	1.89	2.022	2.03	2.560	0.95
Near 1st, Sl 1st, SS-Inst. A----	51	1.33	1.300	1.45	0.970	0.58
Near 1st, Sl 1st, SS-Inst. B----	23	1.49	0.935	1.43	0.742	0.87

[1]Scores in minutes of visual angle subtended by target optotypes.

APPENDIX I

TARGET-SPECIFICATIONS AND RECORD FORMS

Specifications for the sizes of optotypes (width of the lines in the letters) and the number of letters of each size on the Sloan and the Sight-Screener targets used in the study are shown in Appendix I.

The Sloan charts contain optotypes ranging in size from 10.00 to 0.65 minutes for distance and from 16.00 to 0.80 minutes for near vision. These form a series in which the steps are approximately equal on a logarithmic scale with a gradation of 0.1 log unit. This means that the size of the letters of each successive line is approximately 26 percent larger than that of the following line. Slight deviations from an exact geometric progression are used to maintain relatively simple numbers for specifications in visual angle and Snellen notation.

Sight-Screener targets contain optotypes ranging from 10.00 to 0.50 minutes for both near and distance vision.

The first column in table I gives the visual angles in minutes subtended by the width of the lines in the letters of both distance and near test targets.

The second column gives the decimal equivalent of the Snellen notation for letters in the targets of both tests.

PHS-3787 6-61 — SIGHT-SCREENER CALIBRATION STUDY — Sight-Screener data

Examinee number_____ Instrument_____

WITHOUT GLASSES — RED series (even)

9 200	8 100	7 70	6 50	5 40	4 30	3 20	2 15	1 10
R (2) E	F	T C	D Z E N	B N E C	E H Z N	F Z E C	T F E O	Z N H T
L (3) N	F	E T	C D Z E	Z B N E	N E H Z	E C N F	E T O F	N T Z H
B (4) Z	E	C E	C N D Z	E B N C	Z H E C	N E D F	O E F T	T H N Z

BLACK series (odd)

R (2) E	F	T C	D Z E N	B N E C	E H Z N	F Z E C	T F E O	Z N H T
L (3) N	F	E T	C D Z E	Z B N E	N E H Z	E C N F	E T O F	N T Z H
B (4) Z	E	C E	C N D Z	E B N C	Z H E C	N E D F	O E F T	T H N Z

Tested by_____

Figure 1. Record card for Sight-Screener scoring.

The next four columns give the Snellen notation for the letters used for distance and for near vision on the Sight-Screener and on the Sloan tests.

The number of letters at each level on the targets is shown in the last three columns of the table.

Figures 1 and 2 contain samples of the record cards used for recording the test findings in the study. Two record cards per subject were used for the Sight-Screener tests—one for those without and one for those with glasses. Four cards per subject were used for the Sloan tests—one each for distance vision, uncorrected; near vision, uncorrected; distance vision, corrected; and near vision, corrected. As the test was administered, the examiner drew an oblique line through the letters that were misnamed. If a line (a block of letters on the Sight-Screener target) could not be attempted, he drew a horizontal line in the record card through the letters at that and any subsequent levels. Explanation of the scoring is contained in the section on "Description of Tests and Controls."

PHS-3785 6/61 — SIGHT-SCREENER CALIBRATION STUDY. Sloan data. Exam No._____ WITH/WITHOUT GLASSES

FAR (even) (R) (13) K (12) D V (11) H C Z S (10) O R N K H S (9) D V R C K H
(8) O Z N S H V C D (7) N R K C S Z H V D O (6) C D K H N O C V R Z
(5) H O C Z R D S V N (4) K D V R H N Z C O S (3) V R N H Z D C S K O
(2) H N O R C Z S V D K (1) N R C Z H O V S D K

(L) (13) K (12) D V (11) H C Z S (10) O R N K H S (9) D V R C K H
(8) O Z N S H V C D (7) N R K C S Z H V D O (6) S D K H N O C V R Z
(5) H O C Z R D S V N (4) K D V R H N Z C O S (3) V R N H Z D C S K O
(2) H N O R C Z S V D K (1) N R C Z H O V S D K

(R) (13) K (12) D V (11) H C Z S (10) O R N K H S (9) D V R C K H
(8) O Z N S H V C D (7) N R K C S Z H V D O (6) S D K H N O C V R Z
(5) H O C Z R D S V N (4) K D V R H N Z C O S (3) V R N H Z D C S K O
(2) H N O R C Z S V D K (1) N R C Z H O V S D K

_____/200 Tested by_____

Figure 2. Record card for scoring on Sloan distance test.

Table I. Specification of the sizes of letters and number of letters, Sight-Screener and Sloan Targets for testing distance and near vision[1]

Visual angle in minutes subtended at standard test distance (20 ft., 14 in., 16 in.)[2]	Decimal equivalent of Snellen ratio (Reciprocal of visual angle)	Snellen ratios for letter sizes used				Number of letters at each level		
		Distance charts		Near charts			Sloan	
		Sight-Screener (20 ft.)	Sloan (20 ft.)	Sight-Screener (14 in.)	Sloan (16 in.)	Sight-Screener distance and near	Distance	Near
16.00	.0625	...	...	...	16/256	...	...	5
12.50	.0800	...	...	...	16/200	...	...	6
10.00	.1000	20/200	20/200	14/140	16/160	1	1	8
8.00	.1250	...	20/160	...	16/128	...	2	10
6.25	.1600	...	20/125	...	16/100	...	4	10
5.00	.2000	20/100	20/100	14/70	16/80	1	6	10
4.00	.2500	...	20/80	...	16/64	...	6	10
3.50	.2857	20/70	...	14/49	...	2	...	...
3.00	.3333	...	20/60	...	16/48	...	8	10
2.50	.4000	20/50	20/50	14/35	16/40	4	10	10
2.00	.5000	20/40	20/40	14/28	16/32	4	10	10
1.50	.6667	20/30	20/30	14/21	16/24	4	9	10
1.25	.8000	...	20/25	...	16/20	...	10	10
1.00	1.0000	20/20	20/20	14/14	16/16	4	10	10
.80	1.2500	...	20/16	...	16/12.8	...	10	10
.75	1.3333	20/15	...	14/10.5	...	4	...	...
.65	1.5385	...	20/13	...	...	...	10	...
.50	2.0000	20/10	...	14/7	...	4	...	...

[1]Adapted from L. L. Sloan, "New Test Charts for the Measurement of Visual Acuity and Far and Near Distances," American Journal of Ophthalmology 48(6): 809, December, 1959.

[2]This is the size of the visual angle of resolution in minutes of arc subtended by the width of the lines in the test letters used at each threshold level.

APPENDIX II

SOME TECHNICAL NOTES

In this study visual acuity was measured at arbitrarily selected points, determined by the size of the letters in the targets, along the continuum of possible letter sizes from 0.50 to 16.00 minutes of visual angle which the component lines of those letters would subtend when viewed from the standard distance by the normal eye. The points or levels at which measurements were taken differed for the two tests at all but six points, as indicated in Appendix I.

It was assumed in the analysis of the study data that persons reaching a particular acuity level actually had acuities uniformly distributed over the interval between that level and the next higher level (the level with the next smaller size letters) measurable on the particular test. All analysis was done in terms of minutes of visual angle. Findings in the text tables have been converted into the reciprocal of the visual angle size (of the letters), called the "decimal" notation, or into the Snellen notation, since the latter two notations are so frequently used to express visual acuity. The Snellen fraction contains in the numerator the standard distance between the subject and the test target and in the denominator the distance at which the smallest letters discriminated (read) by the subject would be read by the "normal" eye. The decimal notation is the decimal equivalent of the Snellen fraction.

In testing the significance of the difference between mean scores in the Sight-Screener or the Sloan tests for different groups of examinees, the determination has been one of whether the two samples of examinees may be regarded as independent samples drawn from the same normal population, i.e., testing the hypothesis that the true difference between the mean scores is zero. If the above hypothesis is true, the variable

$$u = \sqrt{\frac{n_1 n_2 (n_1 + n_2 - 2)}{n_1 + n_2}} \cdot \frac{\bar{x} - \bar{y}}{\sqrt{(n_1 - 1) s_x^2 + (n_2 - 1) s_y^2}}$$

has the t-distribution with $n_1 + n_2 - 2$ degrees of freedom. Here the mean and variance of the first sample of size n_1 are denoted by

$$\bar{x} = \frac{1}{n_1} \sum_1^{n_1} x_i \quad \text{and} \quad s_x^2 = \frac{1}{n_1 - 1} \sum_1^{n_1} (x_i - \bar{x})^2$$

while $\bar{y}$ and s_y^2 are the corresponding characteristics of the second sample of size n_2.

When assessing the significance of the mean difference between scores on the Sight-Screener and Sloan tests for the same group of persons, account has been taken of the correlation between scores on the two tests, since these are in fact two highly correlated measures of the same characteristic for each person. In this case, the variable

$$u = (\bar{x} - \bar{y}) \Big/ \sqrt{\frac{s_x^2 + s_y^2 - 2 r_{xy} s_x s_y}{n}}$$

has the t-distribution with n-1 degrees of freedom.

In testing the hypothesis that two samples—the Sloan or the Sight-Screener scores for two different groups of examinees, or the Sloan and Sight-Screener scores for the same persons—are independent samples drawn from the same population, with respect to the visual acuity characteristic, the χ^2-test of homogeneity was used. Here the hypothesis being tested is that in the two independent samples being compared there are r constants $p_1, \ldots, p_r$ (for the r acuity levels) with $\sum p_i = 1$ such that the probability of a result belonging to the i^{th} acuity level is equal to p_i in both samples. In this case

$$\chi^2 = n_1 n_2 \sum_i \frac{1}{x_i + y_i} \left(\frac{x_i}{n_1} - \frac{y_i}{n_2} \right)^2$$

$$= \frac{(n_1 + n_2)^2}{n_1 n_2} \left(\sum_i \frac{x_i^2}{x_i + y_i} - \frac{n_1^2}{n_1 + n_2} \right)$$

with r-1 degrees of freedom. Here x_i and y_i are the number of persons in the two series reaching the i^{th} acuity level.

The 5-percent level was used for determining significance for all statistical tests unless otherwise indicated in the text.

☆ U. S. GOVERNMENT PRINTING OFFICE : 1963 O - 688263

OUTLINE OF REPORT SERIES FOR VITAL AND HEALTH STATISTICS

Public Health Service Publication No. 1000

SERIES 1-4. GENERAL SERIES. Program descriptions, methodological research, and analytical studies of vital and health statistics. Earlier reports of this kind have appeared in "Vital Statistics–Special Reports" and in "Health Statistics from the National Health Survey," Series A and D, PHS Publication No. 584.

Series 1: Programs and collection procedures.– Reports which describe the general programs of the National Center for Health Statistics and its offices and divisions, data collection methods used, definitions, and other material necessary for understanding of the technical characteristics of published data.

Series 2: Data evaluation and methods research.–Studies of new statistical methodology including: experimental tests of new survey methods, studies of vital statistics collection methods, new analytical techniques, objective evaluations of reliability of collected data, contributions to statistical theory.

Series 3: Analytical Studies.–This series comprises reports presenting analytical or interpretive studies based on vital and health statistics.

Series 4: Documents and committee reports.– Final reports of major committees concerned with vital and health statistics and documents such as recommended model vital registration laws and revised birth and death certificates.

SERIES 10-12. DATA FROM THE NATIONAL HEALTH SURVEY

Earlier reports of the kind appearing in Series 10 have been issued as "Health Statistics from the National Health Survey," Series B and C, PHS Publication No. 584.

Series 10: Statistics on illness, accidental injuries, disability, use of hospital, medical, dental, and other services, and other health-related topics, based on data collected in the continuing National Health Interview Survey.

Series 11: Data from the Health Examination Survey based on the direct examination, testing, and measurement of national samples of the population of the United States, including the medically defined prevalence of specific diseases, and distributions of the population with respect to various physical and physiological measurements.

Series 12: Data from the Health Records Survey relating to the health characteristics of persons in institutions, and on hospital, medical nursing, and personal care received, based on national samples of establishments providing these services and samples of the residents of patients, or of records of the establishments.

SERIES 20-23. DATA FROM THE NATIONAL VITAL STATISTICS SYSTEM

Earlier reports of this kind have been issued in "Vital Statistics–Special Reports."

Series 20: Various reports on mortality, tabulations by cause of death, age, etc., time series of rates, data for geographic areas, States, cities, etc.–other than as included in annual or monthly reports.

Series 21: Data on natality such as birth by age of mother, birth order, geographic areas, States, cities, time series of rates, etc.–compilations of data not included in the regular annual volumes or monthly reports.

Series 22: Data on marriage and divorce by various demographic factors, geographic areas, etc.–other than that included in annual or monthly reports.

Series 23: Data from the program of sample surveys related to vital records. The subjects being covered in these surveys are varied including topics such as mortality by socioeconomic classes, hospitalization in the last year of life, X-ray exposure during pregnancy, etc.

Catalog Card

U.S. National Center for Health Statistics

Comparison of two vision-testing devices. A study to compare visual acuity as measured by the Sight-Screener and the Sloan Letter Chart. Washington, U.S. Dept. of Health, Education, and Welfare. Public Health Service, 1963.

33 p. diagrs. tables 27 cm. (*Its* Vital and Health Statistics, Series 2, no. 1)

U.S. Public Health Service. Publication no. 1,000, Series 2, no. 1

1. Vision-Testing. 2. Eye-Examination. I. Title. II. Title: A study to compare visual acuity as measured by the Sight-Screener and the Sloan Letter Chart. (Series)

Cataloged by Department of Health, Education, and Welfare Library.

PUBLIC HEALTH SERVICE PUBLICATION NO. 1000 - SERIES 2 - NO. 1