POPULATION TRENDS AND PROBLEMS OF PUBLIC HEALTH

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THE scope and emphasis of a public health program are necessarily influenced by the changing characteristics of the population it serves. The rate of population growth affects long-range planning of community health and medical facilities. Alterations in age composition, internal migration of racial or industrial groups, changes in population density and urban-rural movement require current adaptation of the health program to solve the new problems thus created. Among the various characteristics of recent population trends, aging of the population is one of the most fundamental in its bearing on national health. The social and economic effects of an aging population have long been recognized. Dr. Louis I. Dublin appraised the problem of old age in some detail in 1926, when the provision of economic security for the aged was the dominant theme of contemporary discussion.[2] The passage of the Social Security Act in 1935 represented the fruits of the efforts of this early period.

Adjustment of national policy with respect to the health problems associated with aging of the population has been slower in development. Under the terms of the Social Security Act, a limited expansion of activities designed to promote the health of older adults—control of cancer and pneumonia, and industrial hygiene services—has been made possible in the cooperating States. How-

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The authors make grateful acknowledgment of the contribution of Bernard D. Karpinos, Assistant Statistician, United States Public Health Service, represented in the population forecasts utilized in this paper.

[2] Dublin, Louis I.: Chapter VII. The Problem of Old Age, an address presented at the 17th annual New York City Conference of Charities and Corrections, May 13, 1926. Published in HEALTH AND WEALTH: A SURVEY OF THE ECONOMICS OF WORLD HEALTH. New York, Harper & Brothers, 1928.

ever, the Act makes no provision for the solution of such fundamental problems as invalidity insurance and medical care of the aged. During the past five years, the health aspects of old age have received increasing attention in the discussions of public health administrators. It therefore seems appropriate to resurvey this general problem, and to consider, in particular, the nature of future trends in mortality, morbidity, and the receipt of medical care which may be expected solely as a result of changing age structure of the population.

The Effect on the Death Rate

The effect of a declining proportion of children and an increasing proportion of "elders" on the future trend of the death rate may be readily predicated from the characteristics of age variation in mortality, which are generally familiar. The period of infancy is characterized by a large proportion of fatally terminating illnesses. Following the high mortality of the first year, the death rate declines rapidly in the succeeding years of early childhood, and the rate among children 5 to 14 years of age is lower than in any period of life. The age curve of mortality remains at a relatively low level in youth and the young adult ages. During the period of middle age, a marked upward trend in the death rate becomes apparent, and the increase thereafter is progressive. The sharp downward trend in the death rate following infancy, and the rapid rise which occurs during middle and old age are the most pronounced characteristics of age variation in mortality. The mortality rate in infancy and early childhood has shown a marked reduction in the present century, while the rate at the advanced ages has remained practically unchanged. Thus, the death rate at the older ages has shown an increasing relative excess over the rate in the early years of life. Furthermore, aging of the population has increased the number of older persons exposed to the chance of death. Deaths of persons 45 years of age and over constituted over two-thirds of all deaths in

this country in 1935; in the Registration States of 1900, the proportion was approximately two-fifths.

It thus results that the diseases which at present are the leading causes of death in the population of all ages are largely those characteristic of middle and old age. Diseases of the heart, cerebral hemorrhage, nephritis, cancer, and diabetes accounted for 65 per cent of the deaths among persons 45 years of age and over, and for 44 per cent of the total deaths among persons of all ages occurring in the period 1934-1936. Thompson and Whelpton estimate that by 1980, the number of persons in middle and old age (45 years and over) would be 120 per cent larger than in 1930 (and children under 5 years 13 per cent fewer), assuming no increase of the population through immigration, a moderate decline in the birth rate, and a gain of approximately eight years in the expectation of life at birth.[3] It is apparent that aging of this magnitude would have a marked tendency to increase the death rate from diseases characteristic of middle and old age, and, in consequence, the crude death rate from all causes. Population analysts (Thompson and Whelp-

Table 1. Distribution of population and deaths by age in the United States, 1900 and 1935.[1]

Age in Years	Population		Deaths	
	1900[2]	1935	1900[2]	1935
	Per Cent			
ALL AGES	100.0	100.0	100.0	100.0
Under 15	29.5	27.3	34.6	13.9
Under 5	10.4	8.1	30.3	11.3
5-14	19.1	19.3	4.3	2.6
15-24	18.6	18.3	6.4	4.5
25-44	31.1	29.8	16.5	13.9
45-64	15.7	18.7	18.2	27.6
65 and Over	5.1	5.9	24.3	40.1

[1] Population, United States Registration States of 1900, from Mortality Rates, 1910-1920, Bureau of the Census, 1923, p. 654, and for the United States in 1935, from Special Release of the Bureau of the Census, Feb. 18, 1937. The number of children under 5 years of age in 1935 have been increased to allow for underenumeration, as estimated by Whelpton in National Resources Committee, POPULATION STATISTICS, 1. NATIONAL DATA, Washington, D. C., October 1937. Deaths, 1900, from Special Reports, Bureau of the Census, Mortality, 1900-1904, and for 1935, from *ibid.*, Mortality Statistics, 1935.

[2] Population and deaths in the United States Registration States of 1900 (Connecticut, District of Columbia, Maryland, Maine, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Rhode Island, and Vermont).

[3] Thompson, Warren S. and Whelpton, P. K.: report included in THE PROBLEMS OF A CHANGING POPULATION. Washington, D.C., National Resources Committee, 1938.

ton,[4] Dublin and Lotka[5]) have estimated the amount of increase which may be expected in the crude death rate as a result of aging, on the basis of varying assumptions concerning the future trend in fertility and the amount of decline in age specific mortality rates for all causes of death.

A precise estimate of the effect of aging of the population *per se* on future death rates from specific causes would involve a similar prediction of the future trend of age specific mortality rates from the diseases under consideration, and the application of these hypothetical rates to an estimated population in which survivals were determined by these rates. An undertaking of this nature was not practicable in connection with the preparation of the present report. However, the effect of changing age structure on the death rate from specific diseases may be broadly indicated by assuming that their age specific mortality rates undergo no future decline. A population has been constructed for the United States on the basis of such an assumption in regard to mortality (i.e., a continuation of age specific mortality rates as of 1929-1931) and a moderate decline in fertility.[6] In 1980, children under 15 years of age would represent 21.2 per cent of this total estimated population, compared with 29.4 per cent in 1930; and children of these ages would number in 1980, 30.3 million, compared with 36.1 million in 1930. Persons 65 years of age and over would form 11.1 per cent of this estimated population in 1980, and number 15.9 million, compared with 5.4 per cent, and 6.6 million, in 1930.

[4] Thompson, Warren S. and Whelpton, P. K.: POPULATION TRENDS IN THE UNITED STATES. New York and London, McGraw-Hill Book Company, Inc., 1933.

[5] Dublin, Louis I. and Lotka, Alfred J.: LENGTH OF LIFE. New York, The Ronald Press Company, 1936.

[6] The population was constructed by Karpinos according to the following method:

The population of the United States enumerated in the Census of 1930, distributed by five-year age groups according to sex and race, was taken as a base. "Other colored" persons, exclusive of Negroes, were included in the white population. Persons of unknown age were distributed proportionally in each sex-race group. The number of children under 5 years of age was corrected for under-enumeration on the basis of an estimate by Thompson and Whelpton, included in Table 1 of

(Continued on page 363)

The results of the application of the age specific mortality rates for selected causes of death as of 1934-1936 to this estimated population in future years are shown in Figure 1. The age specific death rates used in these computations are not included in this report, since the basic data are readily available in the publications of the Bureau of the Census.[7]

The dotted line in the chart indicates the percentage change in the estimated population between 1935 and decennial periods beginning in 1940. The percentage change in the number of deaths from all causes, and from each selected cause of death estimated on the basis of the respective crude death rates would be equivalent to that of the total population. Thus, taking into account only the increase in the total population, the number of deaths from each

POPULATION STATISTICS. 1. NATIONAL DATA. National Resources Committee, Washington, D.C. 1937.

For the white population, an average net reproduction rate of .980 for the period 1931-1935 was reported in *Population Index,* April, 1939, 5, No. 2, based on data supplied by the Statistical Bureau of the Metropolitan Life Insurance Company. From this rate taken as a base, a gradual decline in fertility was assumed in succeeding years, reaching a net reproduction rate of .870 in 1980. The assumed rate of decline in fertility corresponds closely with the "medium" fertility assumption for the white population made by Thompson and Whelpton, as stated in POPULATION STATISTICS. 1. NATIONAL DATA, referred to in the first paragraph above. For the Negro population, it was assumed that a net reproduction rate of 1.00 would prevail without change in the period 1930-1980. On the basis of these assumptions, the number of births in the total population would decline 12.4 per cent between 1935 and 1980.

Survivals based on the life tables for the United States, exclusive of Texas and South Dakota, 1929-1931, prepared by the Metropolitan Life Insurance Company, were used in the construction of the population, the life tables for Continental United States prepared by the Bureau of the Census having been published subsequent to the period when the basic computations for these population estimates were made.

The age distribution of this estimated total population in 1980 would be as follows:

Age in Years	*Number (in Thousands)*	*Per Cent*	*Age in Years*	*Number (in Thousands)*	*Per Cent*
Total	142,898	100.0	25-34	21,004	14.7
Under 5	10,034	7.0	35-44	19,940	14.0
5- 9	10,103	7.1	45-54	18,254	12.8
10-14	10,202	7.1	55-64	16,769	11.7
15-19	10,288	7.2	65 and		
20-24	10,377	7.3	Over	15,927	11.1

[7] The annual reports on mortality statistics published by the United States Bureau of the Census (years 1934-1936) were used as the source of the data on deaths. An unpublished estimate of the population of the United States in 1935 by Bernard D. Karpinos was used in the computation of the death rates.

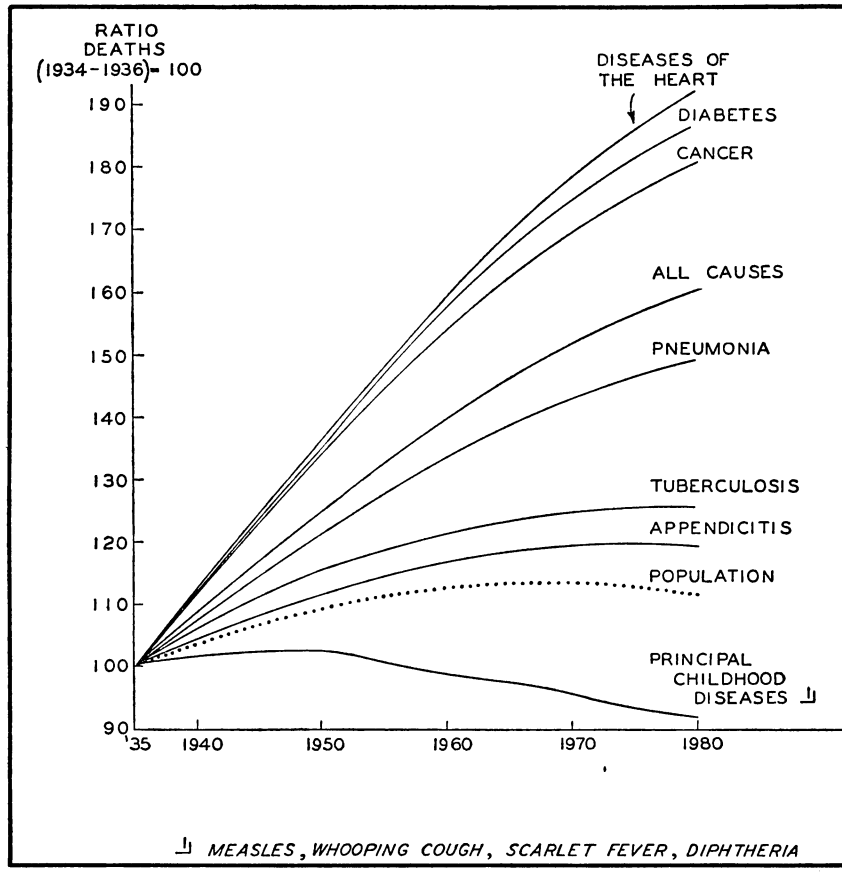


Fig. 1. Ratios of deaths from selected causes in the United States, 1940-1980, estimated on the basis of age-adjusted mortality rates, to deaths in 1934-1936. Diseases of the coronary arteries and angina pectoris are included with diseases of the heart. Cancer includes other malignant tumors. The designations pneumonia and tuberculosis relate to all forms of these diseases.

of the selected causes would increase 12 per cent between 1935 and 1980. However, if the age specific mortality rates for these causes of death were applied to the population constituted with respect to age as estimated for 1980, the increase would amount to 92 per cent in deaths from diseases of the heart, 80 per cent in cancer deaths, and 87 per cent in deaths from diabetes. The age variation in mortality from these diseases is similar, the death rates being relatively low prior to middle age and rising sharply thereafter.

The tendency of deaths from these causes to increase as the population ages is therefore marked, and of approximately the same order.

Future population changes among children, and, in particular, among children under 5 years of age, are reflected in the trend of deaths from the principal communicable diseases of childhood between 1935 and succeeding periods, estimated on the basis of age specific death rates. In the population as estimated, the number of children under 5 years of age would increase between 1935 and 1950 (the effect of a declining birth rate being offset by a continued increase in the number of women at the principal childbearing ages to the period 1945-1955) and deaths from the common communicable diseases of childhood would show a corresponding rise. A decline in the number of deaths from this group of diseases would accompany the numerical decline in children of these ages after 1950. Aging of the population would result in a relatively small increase in deaths from tuberculosis. The death rate from this disease reaches a high level at the early adult ages, and remains high in subsequent age periods. Thus, the decrease in tuberculosis deaths accruing from young adults, who would decline somewhat in the population of the future, would provide a counter-tendency toward the increase in deaths associated with the increment of older persons.

If the mortality rates of the life tables of 1929-1931[e] are applied to the population of the United States in 1935 and 1980 distributed by age in accordance with the assumptions adopted, it is found that aging of the population in this period would result in a 61 per cent increase in deaths from all causes. In terms of the crude death rate, this change would represent an increase from a rate of the order of 11 per 1,000 in 1935 to an estimated rate of 17 per 1,000 in 1980. It is not probable, of course, that so marked an increase in the crude death rate will actually occur, since it seems reasonable to expect some reduction of the age specific mortality rates now prevailing.

The Effect on Frequency and Disability Rates of Illness

Aging of the population may be expected to result in a relatively lower rate of increase of illnesses than of deaths. After the first year of life, the chance of death is relatively small until the periods of middle and old age are attained. While the incidence of illness shows a similar upward trend at the advanced ages, age variation in the incidence of illness and death presents striking differences prior to this period. In childhood, the mortality rate is high only in the first year, but high frequency rates of illness are observed through the first ten years of life. The incidence of illness falls sharply in late childhood and youth, yet the level of the frequency rate of illness in comparison with the death rate at these ages is relatively high. A further striking difference between the incidence of illness and death is seen in the young adult period, in which the age curve of illness shows a secondary peak, while the death rate, still at a relatively low level, is undergoing a slow increase from the minimal rate observed at ages 10 to 14 years.[8, 9, 10] Thus, changes in the structure of the future population prior to the period of middle and old age will have a significant effect on the future incidence of illness.

However, the aging factor should result in a material increase in the days of disability accruing from illness, since the average duration of illness increases progressively with age in a manner resembling the age incidence of death. The diseases which account for the high frequency of illness in childhood and the young adult period are typically short in duration. Thus, the disability rate is

[8] Falk, I. S.; Klem, Margaret C.; and Sinai, Nathan: The Incidence of Illness and the Receipt and Costs of Medical Care Among Representative Families. Chicago, Illinois, The University of Chicago Press, 1933.

[9] Collins, Selwyn D.: A General View of the Causes of Illness and Death at Specific Ages. U. S. Government Printing Office, Washington, *Public Health Reports,* February 22, 1935, 50, No. 8.

[10] Holland, Dorothy F.: Disabling Diseases of Childhood. *American Journal of Diseases of Children,* December, 1939, Vol. 58.

relatively low prior to middle and old age, when a rise occurs which is associated with the increasing incidence of chronic disease.[10, 11]

The records of disabling illness obtained in the National Health Survey, a house-to-house canvass conducted by the United States Public Health Service in 1935-1936, provide a basis for estimating the effect of changing age composition of the population on the future incidence of illness and the volume of disability. The experience of 1,581,577 white persons in thirty-one cities of 100,000 population and over canvassed in this survey has been selected for this purpose.

The illnesses recorded had caused a minimum of seven consecutive days of disability, i.e., time lost from school, gainful or other work, or other usual activities, in the twelve months preceding the date of the canvass. The method and scope of the survey, and its broad results have been reported in earlier publications.[10, 12, 13] In the interpretation of subsequent estimates based on data of the National Health Survey, it should be noted that the survey records relating to tuberculosis, mental disease and defect, cancer and syphilis are incomplete because of certain limitations inherent in the house-to-house method of enumerating illness. The informant may fail to include on the family roster persons confined in tuberculosis sanatoria, or in institutions for the mentally diseased or defective; or, because of long confinement (as of the mentally diseased or defective), such persons may have no family status. Inadequate or incorrect information concerning the diagnosis of cases of cancer and syphilis, or unwillingness to report such cases to the enumerator, probably accounts for the incompleteness of records of these diseases obtained from laymen. Under-enumeration of illness due to certain of

[11] Collins, Selwyn D.: Cases and Days of Illness Among Males and Females with Special Reference to Confinement to Bed. U. S. Government Printing Office, Washington, *Public Health Reports,* January 12, 1940, 55, No. 2.

[12] Perrott, George St.J.; Tibbitts, Clark; and Britten, Rollo H.: The National Health Survey: Scope and Method of the Nation-wide Family Canvass of Sickness in Relation to its Social and Economic Setting, U. S. Government Printing Office, Washington, *Public Health Reports,* September 15, 1939, 54, No. 37.

[13] Britten, Rollo H.; Collins, Selwyn D.; and Fitzgerald, James S.: Some General Findings as to Disease, Accidents, and Impairments in Urban Areas. U. S. Government Printing Office, Washington, *Public Health Reports,* March 15, 1940, 55, No. 11.

these causes has been observed also in the results of the representative family survey made by the Committee on the Costs of Medical Care.[14]

The nature of age variation in the frequency and disability rates of illness classified by cause observed in this population is shown in Appendix Table 1. The age specific rates shown here, except those relating to confinements terminating in live births, have been applied to the estimated population of the United States in 1935, and to the 1980 population estimated by the method outlined previously. The number of confinements terminating in live births has been estimated for 1935 on the basis of the live births actually registered in the United States in that year (increased to allow for underregistration), the resultant days of disability being estimated from the average duration as observed in the large cities canvassed in the National Health Survey. For 1980, the number of disabilities associated with confinement, and the days of disability associated therewith were reduced in accordance with the decline in the birth rate assumed in the construction of the 1980 population. The age specific frequency and disability rates of illness due to all causes except confinement cases were assumed to prevail at the same rate in 1980 as in 1935.

The results of these estimates of the future incidence of disabling illness and the resulting days of disability for illness of specific causes are shown graphically in Figure 2. If the number of disabling illnesses due to these specific causes increased at the rate of growth of the total population, a 12 per cent increase would represent the change between 1935 and 1980. However, the total increase in this period would amount to 56 per cent in cancer cases, 51 per cent in illnesses due to the degenerative diseases, and 41 per cent in illnesses

[14] The incomplete enumeration of institutional cases in the survey of the Committee on the Costs of Medical Care is indicated by the fact that the number of hospital days per capita recorded for patients in tuberculosis and mental hospitals in 1928-31 was .19. (*See* footnote 8.) On the basis of data in The Census of Hospitals of the American Medical Association relating to the year 1930, hospital days for patients in these institutions in the country as a whole amounted to 1.40 per capita.

due to rheumatism, on the basis of estimates which take into account the age specific frequency rates of illness due to these causes. In nervous and mental disease, the total increase would amount to 23 per cent. The effect of aging on the incidence of the group of nervous and mental diseases would be increased by a more complete representation of cases of insanity, but it is estimated that only 9 per cent of the illnesses included in the broad group of nervous and mental diseases as used here were due to this cause.[15] Underenumeration of the insane, usually residents of institutions, is a defect of the technic of the family survey.

On the other hand, the changed age structure of the population would result in no material increase in illnesses due to diseases of the respiratory system (exclusive of pneumonia, tonsillitis, and respiratory tuberculosis). Illnesses due to the communicable diseases (in the classification used here, largely those of childhood), tonsillitis, and disabilities associated with the puerperal state, would be fewer in number in 1980 than in 1935, due to the decrease in births and in the child population. Thus, several of the most frequent causes of illness would not be affected by the factor of aging *per se*. Furthermore, the large proportionate increase of illness due to the characteristic chronic diseases of middle and old age associated with aging of the population represents an actual increase of small magnitude in certain chronic diseases of low incidence.

The average age specific frequency rates of illness of all causes take these various factors into account. When these rates are applied to the estimated population in 1980, it is found that the total number of disabling illnesses would show no excess above the number expected on the basis of population growth. However, the total days of disability accruing from illnesses of this category would increase 31 per cent as a result of changing age composition, compared with a 12 per cent increase in the total population. The

[15] Based on the experience of 280,073 white persons in eight large cities canvassed in the National Health Survey. Comparable data for all cities of 100,000 population and over canvassed in this survey are not available.

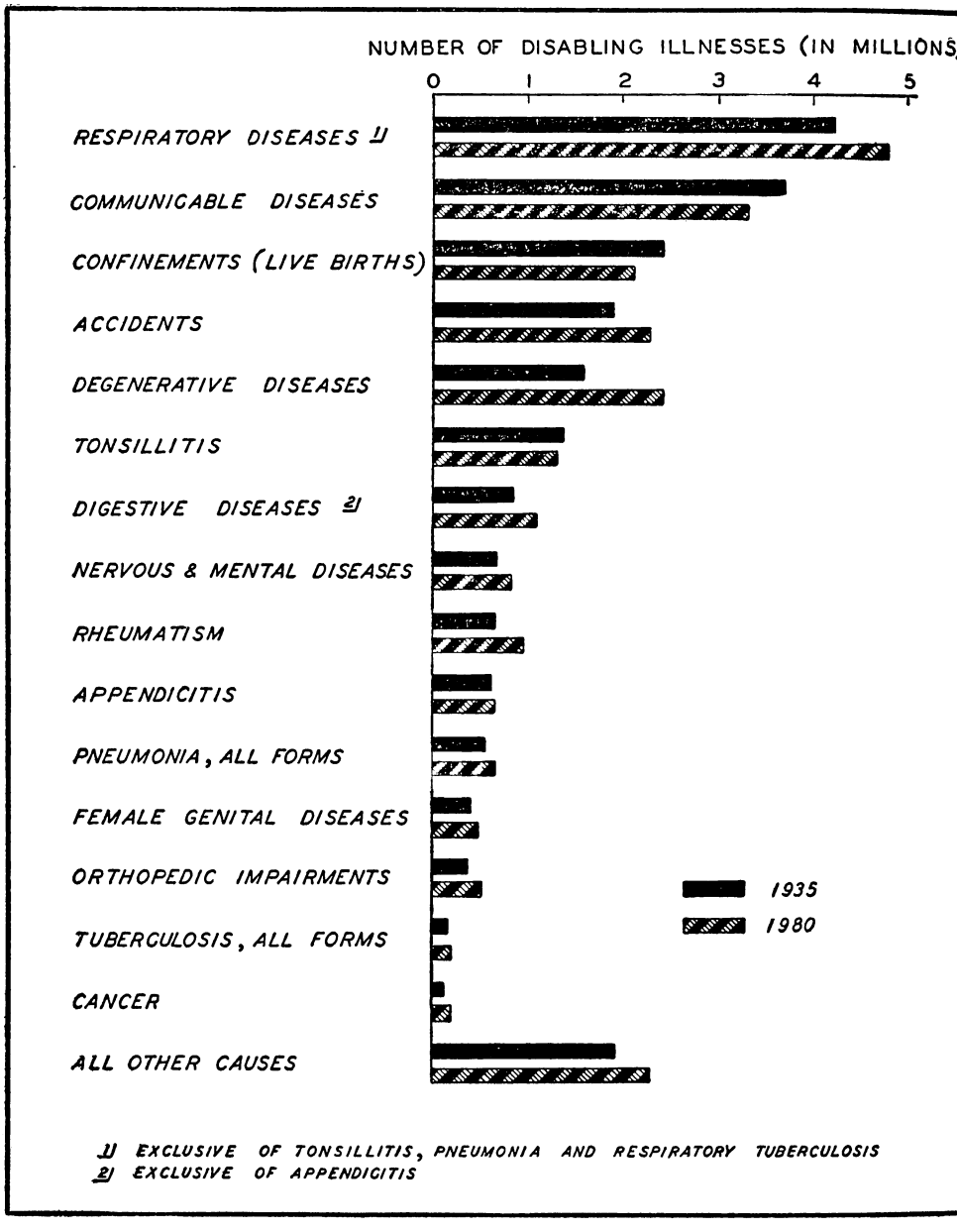
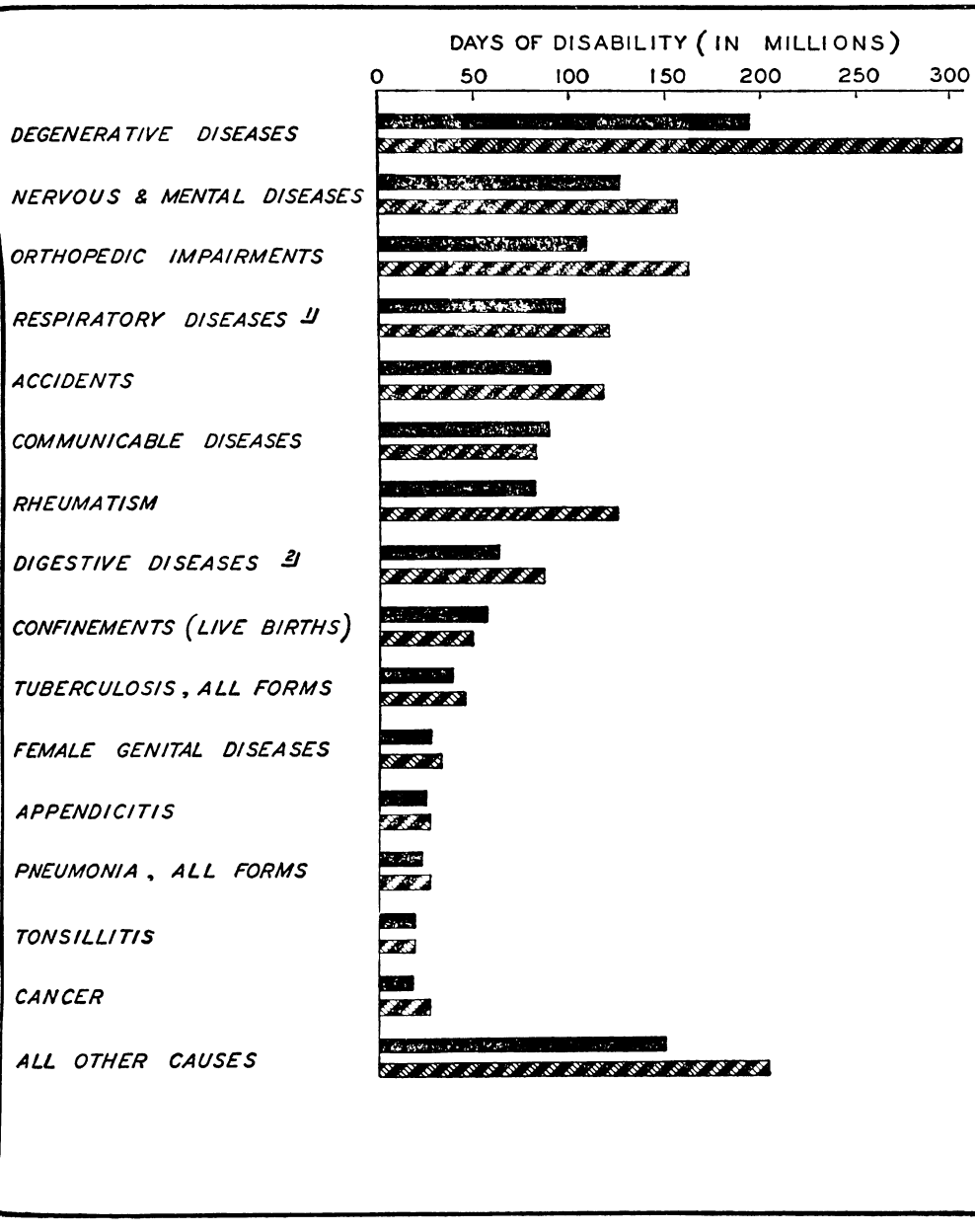


Fig. 2. Number of disabling illnesses and days of disability in a twelve-month period in the United States in 1935 and 1980 according to cause, estimated on the basis of the frequency and disability rates observed in cities of 100,000 and over



canvassed in the National Health Survey, 1935-1936, adjusted for age. (The method of estimating the data relating to confinements terminating in live births is described on page 375 of the text.)

notable difference between the effect of aging of the population on illnesses and the resultant days of disability arises from the difference in rank of the characteristic chronic diseases of the advanced ages with respect to their frequency and severity, as measured by duration. These diseases account for a large volume of disability. Thus, aging would produce both a high relative and absolute increase in the days of disability accruing from these causes. Furthermore, the increased volume of chronic disability would not be reduced to any measurable degree by the decrease in the volume of disability at the younger ages, since the diseases characteristic of this period, while frequent in occurrence, are short in duration.

The Effect on Services for Care of the Sick

The effect of an aging population on the services required in the prevention of disease and the treatment of the sick is a subject of major interest in connection with future population trends. Will an aging population produce significant changes in the amount of service given by the private physician in home and office practice, and in the volume of hospital patient days? What will be the effect of an aging population on bedside nursing care of the sick? How will an aging population alter the existing program of preventive services provided by health departments and official and nonofficial nursing agencies?

A basis for speculation concerning trends relating to services for care of the sick is again provided by the results of the canvass of white persons in thirty-one large cities included in the National Health Survey. The experience of this population with respect to medical and nursing care of disabling illness in a twelve-month period is summarized in Appendix Tables 2A-D, in which disabling illnesses of the various categories have been classified by age according to diagnosis.[16]

[16] Additional data relating to the receipt of medical care as observed in the National Health Survey are included in Perrott, George St.J. and Holland, Dorothy F.: Health as

(Continued on page 373)

Special note should be made of the nature of the data relating to hospitalized illness shown in Appendix Table 2B. As noted previously, disabling illnesses due to tuberculosis and nervous and mental disease were incompletely enumerated in the National Health Survey. As a result, the survey records relating to medical and nursing care of these two groups of patients understate the true incidence of these patients in the various categories, as well as the frequency of services received. This deficiency is particularly marked with respect to the volume of hospital patient days for the tuberculous and mentally diseased as observed in the survey. For this reason, the experience of all patients hospitalized for the treatment of tuberculosis, nervous or mental disease has been excluded in subsequent computations. Thus, the "total number of hospital patients" and the "total number of hospital patient days" as employed in the following discussion do not represent the incidence of hospital patients and the frequency of hospital days for illness of all causes, as shown in Appendix Table 2B, but represent the experience of all patients exclusive of the tuberculous and the mentally diseased. This exclusion results in a residual group of patients which approximates those treated in general hospitals. The approximate composition of this group should be emphasized, since it is evident that patients with tuberculosis, nervous and mental disease who may have been treated in general hospitals are excluded by the procedure adopted. The records of the National Health Survey do not make possible an exact segregation of general hospital patients.

The general effect of an aging population on medical and nursing services and hospital facilities may be predicted by comparing the distribution of patients of the several categories, and the corresponding services, according to the causes of illness for which the services were received, as shown in these tables. Patients attended for illness due to the communicable diseases, tonsillitis and appendicitis, and confinement cases, occurred with high frequency in the periods of childhood, youth, or early adult life, and were relatively infrequent among older adult patients. Cancer, the degenerative

an Element in Social Security. *The Annals of the American Academy of Political and Social Science,* Philadelphia, March 1939, 202, and Britten, Rollo H.: Receipt of Medical Services in Different Urban Population Groups. *Public Health Reports. (In Press.) See also* the publication noted in footnote 10.

diseases, diseases of the digestive system (exclusive of appendicitis—in the classification used here, chiefly chronic in nature), rheumatism, and orthopedic impairments were among the major causes of illness of patients in middle and old age, and were relatively infrequent diagnoses among younger patients. In this experience, patients attended for the types of illness which were characteristically high in frequency at the younger ages, outnumbered patients treated for the chronic diseases of middle and old age in each medical and nursing category.

In respect to the volume of medical and nursing services absorbed, the relative position of these two groups of patients was reversed. The communicable diseases accounted for 14.2 per cent of all patients treated by physicians outside the hospital, but utilized only 7.8 per cent of all physicians' services. Tonsillitis (including operations on the tonsils or adenoids) accounted for 11.8 per cent of all hospital patients (exclusive of the tuberculous and all mental and nervous cases) but for only 1.6 of all hospital days of care. Hospitalized confinements terminating in live births represented 20.8 per cent of all hospital patients, but only 12.4 per cent of all hospital patient days were absorbed by this group. On the other hand, patients treated for diseases of the degenerative group represented only 9.5 per cent of all home, office, or clinic patients, but utilized 16.4 per cent of all services of this category. These diseases accounted for 7.6 per cent of all hospital patients and for 13.4 per cent of the patients attended by private duty nurses, but corresponding services for these patients represented, respectively, 13.1 and 23.0 per cent of the total. Similarly, patients treated for cancer, rheumatism, orthopedic impairments, or chronic diseases of the digestive system accounted for a disproportionately large amount of medical and nursing services. It may be expected, therefore, that aging of the population would tend to increase the number of services provided by physicians, general hospitals, and private duty nurses to a relatively greater degree than the number of patients.

Thus, more physicians, private duty nurses, and general hospital beds might be required for a given case load, as an indirect result of its changed age composition and the increased need for services for patients with the chronic diseases characteristic of middle and old age.

Estimates of the effect of the age composition of the population as estimated for 1980 on medical and nursing services for important causes of disabling illness are shown graphically in Figure 3. The age specific frequency rates of services for patients of the various categories classified by diagnosis, as shown in Appendix Tables 2A-D, have been applied to the estimated population of the United States in 1935, and to the 1980 population constructed on the basis of assumptions previously noted.

An exception to this procedure was made in estimating the number of confinements terminating in live births in the various categories, and services for these cases. The number of confinements terminating in live births attended by a physician in the hospital in 1935 was obtained from data published by the Bureau of the Census,[17] the number of hospital days of care for these patients being computed on the basis of the average hospital duration as observed in large cities canvassed in the National Health Survey (Appendix Table 2B). However, no published data were available concerning the total number of confinements attended by a physician (including care of patients delivered in the home, and home or office care of hospitalized patients, in the period prior to or following hospitalization), and the number of confinements receiving bedside care from a private duty or visiting nurse. Estimates relating to confinements of these categories therefore were derived from the experience of live births in the large cities canvassed in the National Health Survey (Appendix Tables, 2A, 2C, 2D), the actual number of live births occurring in the United States in 1935, increased to allow for under-registration, forming the basis for these estimates. It was assumed that the relative number of confinements receiving hospital, home, or office medical care, or bedside care from a private duty or visiting nurse, would undergo no change in 1980, but the absolute number of cases in

[17] United States Department of Commerce, Bureau of the Census, Vital Statistics, Special Reports, June 19, 1937, 3, No. 27, p. 135.

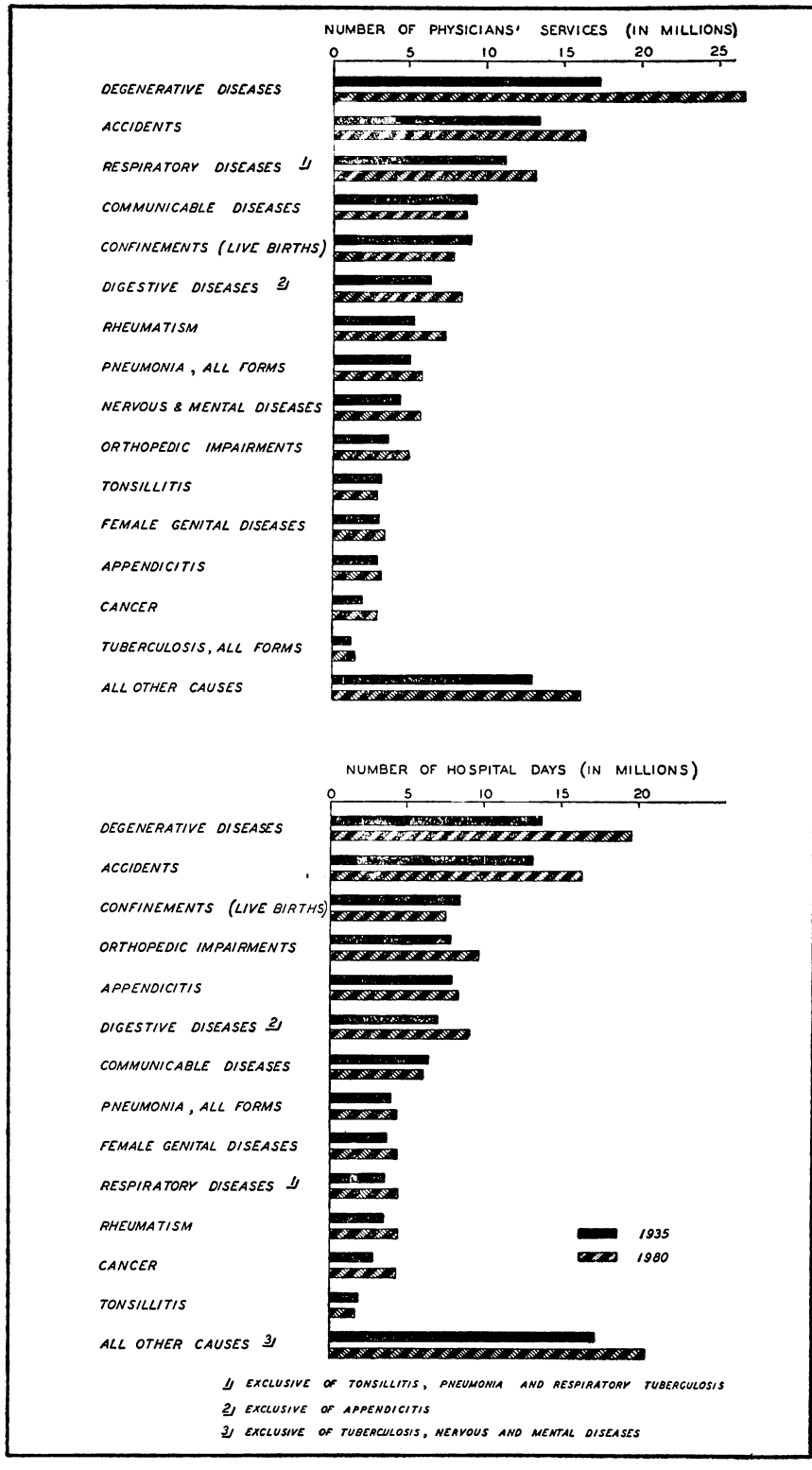
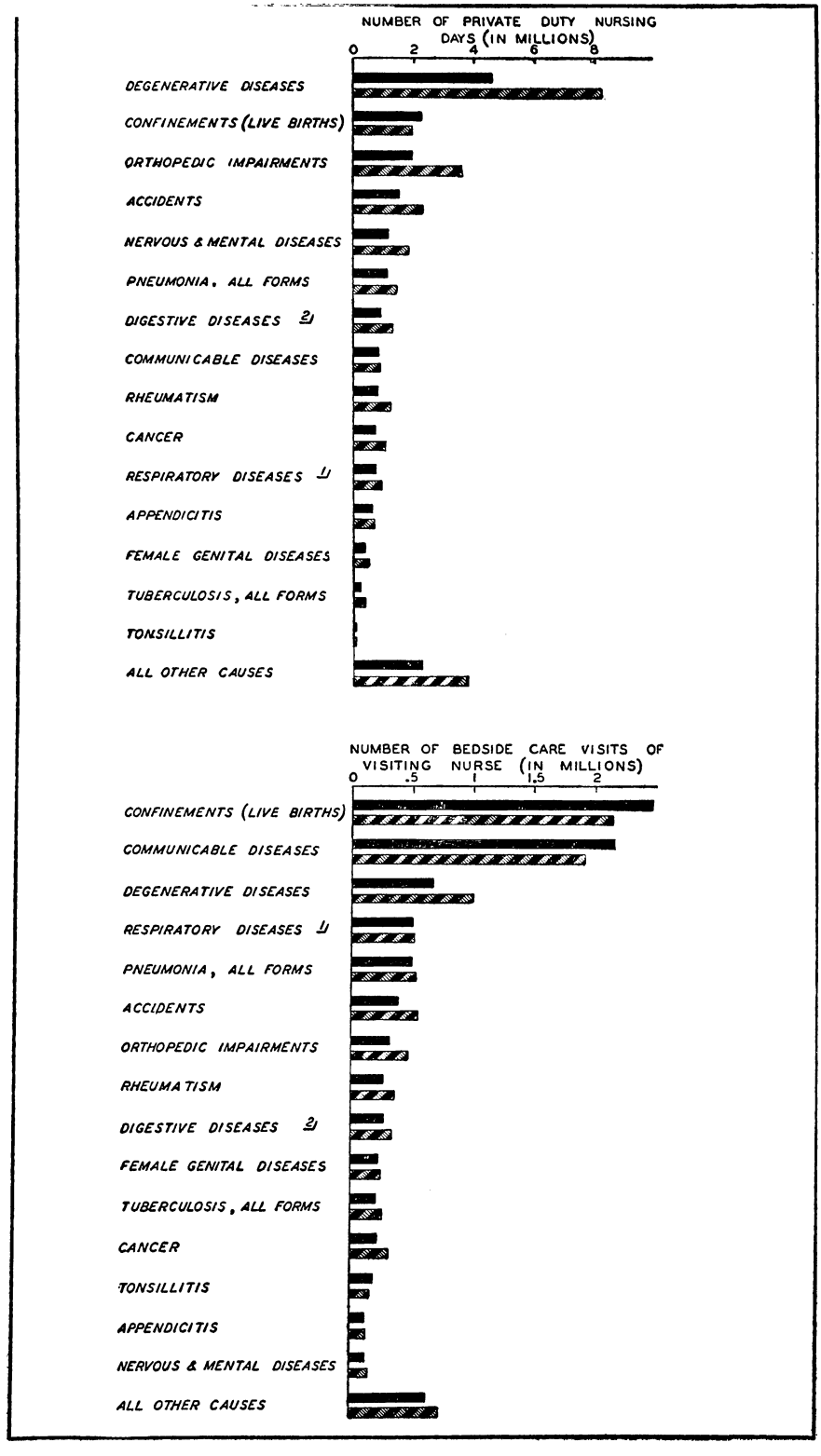


Fig. 3. Number of disabling illnesses receiving medical and nursing care in a twelve-month period and number of services in the United States in 1935 and 1980, according to cause, estimated on the basis of the experience of the National Health



Survey, 1935-1936, adjusted for age. (The method of estimating the data relating to confinements terminating in live births is described on pages 381 and 382 of the text.)

the various categories and the corresponding services were reduced in accordance with the decline in the birth rate assumed in the construction of the 1980 population.

The direction of the change between 1935 and 1980, i.e., an increase or decrease in services for patients with a given diagnosis, follows the pattern which has been observed in earlier estimates of the effect of a changed age structure on the future incidence of illness and death. Medical and nursing services for illness due to the degenerative diseases would be increased to a marked degree as a result of the aging factor alone, and services for patients with cancer, rheumatism, or the chronic diseases of the digestive system would show a generally similar trend. Taking the age specific frequency rates of services into account, by 1980, the chronic patients included in these four diagnostic groups would require services amounting to approximately 10.7 million consultations with a physician, 6.8 million hospital patient days, and 4 million days of care by a private duty nurse, in addition to the services which would be required if estimated solely on the basis of population growth. On the other hand, the increase in medical and nursing services for older patients with chronic disease would be offset, to a degree varying with the type of service, by the decrease in younger patients. Thus, in 1980, patients with acute communicable disease, tonsillitis, appendicitis, and confinement cases would require a total of approximately 27.1 million consultations with a physician, estimated solely on the basis of the increase in total population, but the number would be 4.4 million less if the age composition of the population were taken into account. Similarly, hospital days of care for patients with these diseases would be reduced in 1980 by 3.9 million days.

While the effect of population changes on institutional facilities required for care of the tuberculous and mentally diseased is incompletely measured by the experience of the National Health Survey in absolute terms, the relative nature of trends in these facilities is

more adequately represented by the survey data. Between 1935 and 1980, hospital patient days for the tuberculous would increase 10 per cent as a result of the changed age structure of the population (i.e., on the basis of estimates made by application of the age specific rates included in Appendix Table 2B), while the increase would amount to 12 per cent on the basis of total population growth. Thus, the assumed changes in age composition would tend to reduce somewhat the special hospital facilities required for care of the tuberculous. Hospital patient days for the group of patients with nervous and mental disease would show an increase of 21 per cent in this period as a result of aging of the population. However, the actual increase would be well in excess of this figure, since, in the Health Survey experience, the number of hospital patient days for the insane forms a relatively lower proportion of the total patient days of the nervous and mental group than in the general population. Dorn estimated the effect of aging of the population on the facilities of mental hospitals by applying the age-specific first commitment rates in these special hospitals in New York State (1929-1931) to the population of the United States in 1960 as estimated by Thompson and Whelpton. His results indicated that in 1960 the number of first admissions would be nearly twice as large as in 1930.[18]

The influence of a changed age structure of the population on the total case load of physicians, nurses, and hospitals measures the composite effect of the increase in patients of middle and old age, and the associated decrease in patients drawn from the younger age groups. Estimates of this nature are shown graphically in Figure 4. They are based on age specific frequency rates of patients of the several medical and nursing categories, and of the corresponding services, derived from the results of both the National Health Survey (Appendix Table 3A), and the survey made by the Committee

[18] Dorn, Harold F.: The Incidence and Future Expectancy of Mental Disease. U. S. Government Printing Office, Washington, *Public Health Reports,* November 11, 1938, 53, No. 45.

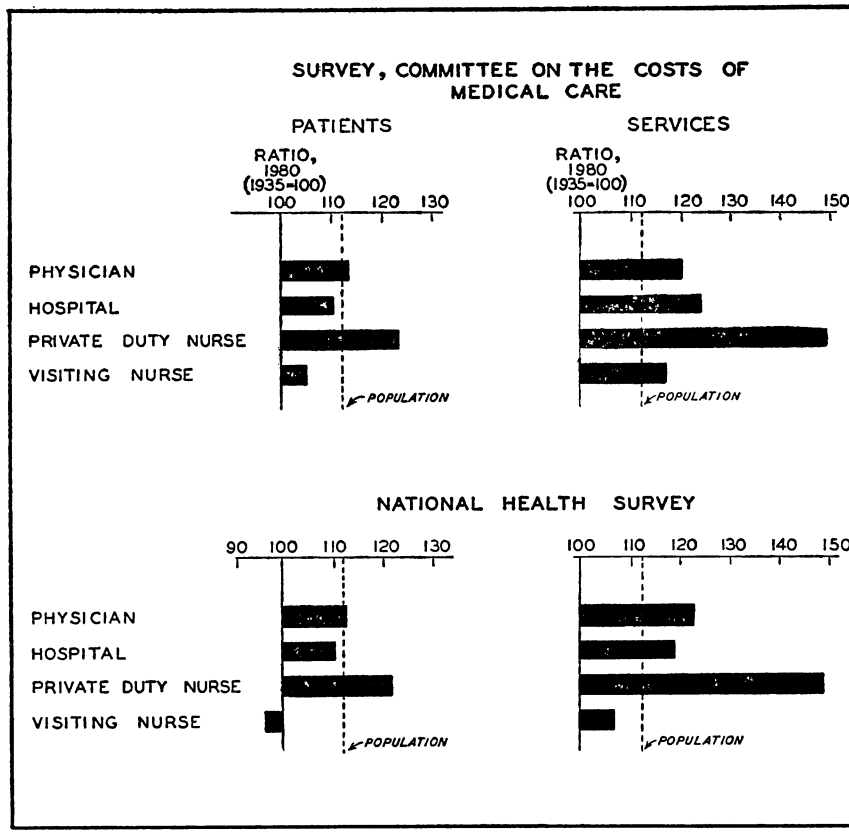


Fig. 4. Ratios of patients receiving medical and nursing care in a twelve-month period, and of the corresponding services, in the United States in 1980, to patients and services in 1935, estimated on the basis of the experience of the survey of the Committee on the Costs of Medical Care, 1928-1931, and the National Health Survey, 1935-1936, adjusted for age. Hospital patients (and services) are exclusive of the experience of hospitalized cases of tuberculosis, nervous and mental disease. The definitions of the several categories of patients are included in Appendix Tables 3A and B.

on the Costs of Medical Care in 1928-1931 (Appendix Table 3B). A comparison of this kind seemed of interest as an indication of the effect of population changes on the medical services for all types of illness (i.e., both disabling and nondisabling), recorded in the survey of the Committee on the Costs of Medical Care, as distinguished from the records of the National Health Survey which relate only to services for illness disabling for a minimum of seven consecutive days in a twelve-month period. Estimates based on the

Committee's data have additional value since the surveyed families were drawn from large and small cities and rural areas, while the results of the National Health Survey selected for these estimates relate only to surveyed families in cities of 100,000 population and over. The rates employed in estimates based on the results of the Committee's survey were obtained from an analysis of the Committee's data made by Collins, adjusted for the purposes of the present report.[19] In the estimates of the trend in hospital patients and hospital patient days the experience of all hospitalized illnesses in which tuberculosis, nervous or mental disease was the sole or primary cause of the illness has been excluded from the data of both surveys.

It has been assumed that the age specific frequency rates of patients receiving the various types of medical and nursing care, and of services received, as observed in these surveys, would prevail in 1980 for all patients except confinement cases, for which the following procedure was adopted. The total number of confinements terminating in live births in the United States in 1935 was estimated by increasing the actual number of live births reported in this year to allow for underregistration. For all categories except hospitalized patients, the distribution of confinements according to type of attendant at delivery, and the number of physicians' and nurses' services received in 1935 were estimated on the basis of (1) the experience of large cities included in the National Health Survey and (2) the survey of the Committee on the Costs of Medical Care. The number of confinements terminating in live births attended by a physician in the hospital was obtained from data published by the Bureau of the Census,[17] the number of hospital days of care for these patients being computed on the basis of the average

[19] The frequency rates of illness attended by a medical practitioner according to age, based on the results of the survey of the Committee on the Costs of Medical Care, were estimated from rates included in a report of the results of the Committee's survey as analyzed by Collins (Collins, Selwyn D.: Frequency and Volume of Doctors' Calls Among Males and Females in 9,000 Families, Based on Nation-wide Periodic Canvasses, 1928-31. *To be published in: Public Health Reports,* November 1, 1940, 55, No. 44).

The rates used in estimates relating to the receipt of hospital and nursing care are based on unpublished data from the survey of the Committee on the Costs of Medical Care made available from current studies of Dr. Selwyn D. Collins. *See also* footnote 8 for a general summary of the results of the survey of the Committee on the Costs of Medical Care.

hospital duration as observed in the survey of the Committee on the Costs of Medical Care. Thus, in the estimates based on the results of these surveys, the number of hospitalized confinements and hospital days of care for these patients is uniform, but the number of confinements of other categories and the corresponding services varies according to the experience of the survey under consideration. It was assumed that the number of confinements in the various categories, and the services received would form the same proportion of the respective totals in 1980 as in 1935, but the absolute number of the attended confinements and services for these patients in 1980 was reduced in accordance with the decline in the birth rate assumed in the construction of the 1980 population. The estimates made by the methods outlined were used as the basis for frequency rates of confinement cases and services therefor, in the estimated population of the United States in 1935 and 1980. These rates, taken as the equivalent of age-adjusted rates, when combined with the age-adjusted rates for patients and services of the several categories, exclusive of confinements, formed age-adjusted rates for all patients of each category.

As the results plotted in Figure 4 indicate, no material increase in the total case load of physicians in home or office practice, or of general hospitals would occur as the result of the assumed changes in age composition of the population between 1935 and 1980. The increment of patients in middle and old age would be balanced by the decline in younger patients. Hospital patients, exclusive of the tuberculous and mentally diseased, if estimated on the basis of age specific incidence rates, would be somewhat less numerous in 1980 than would be predicted with reference to the rate of population growth. However, as a result of aging of the population, the increase in the number of physicians' services would amount to 8 to 11 per cent more than the percentage increase in the population (8 per cent, data of the Committee on the Costs of Medical Care, 11 per cent, data of the National Health Survey) between 1935 and 1980. In this period, the factor of aging alone would account for an increase in hospital days of care (exclusive of patient days for the tuberculous and mentally diseased) amounting to 7 per cent, as

estimated on the basis of results of the National Health Survey, and 12 per cent, on the basis of the experience of the Committee on the Costs of Medical Care. Thus, the increase in the volume of physicians' services and hospital days of care resulting from the increment of older patients indirectly would alter the case load of physicians and hospitals, and additional medical personnel and hospital facilities might be required to maintain medical care at its present standards.

Among the various services for care of the sick, aging of the population would effect the greatest change in the field of private duty nursing. The factor of aging alone would produce a marked increase both in the number of patients of private duty nurses and the number of nursing days of care. On the other hand, patients receiving the services of visiting nurses would increase at a rate lower than the total population under the assumed changes in age composition. On the basis of the results of the National Health Survey, the volume of visiting nurse service would also increase at a rate lower than the rate of population growth if changes in age structure were taken into account. However, estimates based on the records of the Committee on the Costs of Medical Care show an opposite trend, the volume of the services of visiting nurses increasing as a result of changes in age composition between 1935 and 1980 at a relatively higher rate than that of the total population.

The Effect on Organized Health Services

The activities which form an established part of the program of health departments and nonofficial health agencies are directed in relatively small degree to health supervision of persons of middle and old age. This limitation is a natural consequence of the traditional restriction of public health services to those involved in the control of preventable disease. Thus, the changing age structure of the population may be expected to produce effects opposite in nature on public health and medical services. The incre-

ment of older persons would tend to increase the total volume of home and office medical services as well as the days of hospital care. On the other hand, a decline in the number of children, youth, and young adults would result in a reduction of the volume of preventive services which now receive the major emphasis of organized health agencies. Activities for the control of tuberculosis would share in this decline. The program for the control of venereal disease would be less affected since the decline in services for young adults would be balanced to some extent by an increase in services for those in middle age. Aging of the population will give impetus to the further development of activities in the control of pneumonia and cancer. Health supervision of the worker, and in particular, the worker of middle age, will receive increasing recognition as a strategic method of averting certain health problems of the aged.

General Implications

Solution of the health problems associated with aging of the population will require the intensive application of existing methods for the prevention of disease to a larger number of the population than is now receiving the benefits of preventive medicine. Health gains in inafncy and childhood have been chiefly responsible for the increase in average life expectancy, yet this field offers opportunity for further substantial improvement. Deaths of infants from congenital malformations and debility, birth injuries, and the broad group of the diseases of early infancy average about 63,000 annually, these conditions taken together ranking among the leading causes of death in the total population of all ages. Adequate prenatal and infant care is of demonstrated value in reducing both puerperal and neonatal mortality. School children and workers in industry afford opportunity for effective group health supervision. The specific attack on tuberculosis and the venereal diseases provides an additional approach to the health problems of young adults.

Yet at certain points, the provision of preventive health services alone leaves the greater part of the health problem unsolved. The maternity case requires competent attendance at delivery as well as supervision in the prenatal period. Control of the communicable diseases of childhood requires not only preventive measures, but treatment of the sick child. Tuberculosis and syphilis control involves both case-finding and adequate treatment of cases and their contacts when found. The characteristic chronic diseases of middle and old age are subject to control primarily through therapeutic measures. On the whole, organized health agencies assume relatively little responsibility for making these curative services available. Individual, rather than community, income is the chief determining factor in the receipt of medical care, and individual income is generally recognized to be inadequate for medical needs in a large proportion of the population, particularly among the aged.

A possible solution of this impasse lies in the employment of public funds to provide both preventive and curative services for those groups of the population unable to support the costs of such care from individual income. The promotion of such a plan through the system of Federal grants-in-aid would be achieved by a national health program such as has been proposed by the President's Interdepartmental Committee to Coordinate Health and Welfare Activities. The need for a comprehensive health program of wide scope is daily brought to the attention of the administrators of the various titles of the Social Security Act. Under the public assistance titles, there is no adequate means of providing Federal grants for medical care. The appropriations made available under Title VI (Public Health Work) have been insufficient to support more than the first steps in the development of public health services adapted to the needs of those in middle and old age. Disability insurance is a pressing need which will increase in importance as the population ages. Small grants are made under the Act for vocational rehabilitation but they by no means meet the needs in this field.

Finally, an important approach to the solution of this broad problem is offered through the extension of research in the cause and control of the chronic diseases characteristic of advanced life. Effective control of certain of these diseases, of which cancer is an outstanding example, is in part dependent on the demonstration of the etiologic agents involved. Opportunity should be provided for the appraisal of existing methods of diagnosis and treatment, and the exploration of new procedures designed to bring the chronic diseases under early control. But an equally fruitful field of research consists in the development of public health methods which will solve the unique problems involved in coordinating the control of the chronic diseases in the community health program.

[illegible] illness disabling for seven consecutive days or longer in a twelve-month period classified by diagnosis according to age, in 1,581,577 white persons[2] in thirty-one cities of 100,000 population and over canvassed in the National Health Survey, 1935-1936.

Diagnosis[3]	All Ages	Under 15 Years	15-24	25-64	65 and Over	All Ages	Under 15 Years	15-24	25-64	65 and Over
	Disabling illnesses per 1,000 persons					Days of disability per 1,000 persons				
All Causes	160.3	211.7	116.1	141.5	261.6	9,508	5,842	5,053	10,023	34,078
Communicable Diseases	25.5	93.4	8.0	3.6	2.0	634	2,146	208	157	134
Tonsillitis	10.0	25.7	8.2	4.6	.83	137	327	112	73	26
Pneumonia, All Forms	4.3	7.5	2.1	3.2	8.4	171	276	79	136	343
Other Diseases of the Respiratory System	32.8	40.7	24.0	31.1	43.9	780	642	437	838	1,901
Appendicitis	5.0	3.8	10.0	4.2	.88	196	125	365	186	59
Other Diseases of the Digestive System	7.0	3.2	2.9	9.0	17.0	518	94	144	707	1,700
The Puerperal State: Live Births	13.4	.021	25.1	16.9	—	311	.4	571	395	—
Other Puerperal Conditions and Female Genital Diseases	3.5	.10	3.6	5.3	.75	227	8	165	360	81
Cancer	1.0	.019	.036	1.2	6.2	143	2	6	170	919
Rheumatism	5.3	1.2	1.4	6.8	21.3	665	81	111	761	3,948
Degenerative Diseases	12.8	3.5	3.1	13.4	77.8	1,573	242	310	1,600	10,875
Tuberculosis, All Forms	1.3	.48	1.5	1.6	.87	318	91	345	422	200
Nervous and Mental Disease	5.4	2.6	4.0	6.6	9.3	1,034	444	832	1,272	1,913
Orthopedic Impairments	2.9	1.2	1.5	2.9	14.5	879	286	379	872	5,012
Accidents	15.0	10.8	12.4	16.5	27.0	735	354	494	855	1,969
All Other Causes	15.1	17.3	8.3	14.6	31.0	1,186	723	495	1,218	4,999

See footnotes following Appendix Table 2 D.

Appendix Table 2A. Frequency rates of disabling[1] illness receiving care from a physician in the patient's home, the physician's office, or in a clinic, and of physicians' services, classified by diagnosis according to age, in 1,581,577 white persons[2] in thirty-one cities of 100,000 population and over canvassed in the National Health Survey, 1935-1936.

Diagnosis[3]	All Ages	Under 15 Years	15-24	25-64	65 and Over	All Ages	Under 15 Years	15-24	25-64	65 and Over
	Physicians' cases per 1,000 persons					Physicians' services per 1,000 persons				
All Causes	113.9	144.2	79.6	103.2	195.9	850.3	623.9	508.4	927.4	2,149.3
Communicable Diseases	16.2	58.4	5.0	2.7	1.6	66.1	203.6	27.1	23.1	16.6
Tonsillitis	7.8	20.0	6.2	3.7	.58	23.0	50.3	19.3	14.2	2.9
Pneumonia, All Forms	3.8	6.6	1.8	2.8	7.5	38.2	59.1	17.1	31.4	80.3
Other Diseases of the Respiratory System	19.5	24.4	13.2	18.6	26.7	87.9	82.8	56.5	93.9	152.6
Appendicitis	4.4	3.4	8.6	3.8	.72	23.0	14.3	40.8	23.0	4.0
Other Diseases of the Digestive System	5.8	2.5	2.3	7.5	14.0	52.5	10.9	17.4	74.1	134.3
The Puerperal State: Live Births	8.6	.013	15.8	10.8	—	49.3	.088	91.6	62.4	—
Other Puerperal Conditions and Female Genital Diseases	2.9	.088	3.0	4.4	.63	24.6	.91	23.7	37.6	4.7
Cancer	.83	.011	.029	.99	5.4	15.2	.16	.54	19.2	87.3
Rheumatism	3.8	1.0	1.2	4.9	14.0	43.2	10.2	12.1	56.8	151.7
Degenerative Diseases	10.9	2.8	2.5	11.3	66.8	139.7	25.0	24.7	151.6	871.0
Tuberculosis, All Forms	.84	.28	.91	1.1	.64	10.5	2.8	10.7	13.9	10.7
Nervous and Mental Disease	3.3	1.7	2.1	4.1	6.2	36.2	12.2	21.6	47.9	73.0
Orthopedic Impairments	1.7	.76	.73	1.7	7.9	29.4	10.9	11.4	34.6	114.4
Ac[illegible]					20.8	108.3	56.8	81.9	131.3	189.8

Appendix Table 2B. Frequency rates of hospitalized illness and of hospital patient days, classified by diagnosis according to age, in 1,581,577 white persons[2] in thirty-one cities of 100,000 population and over canvassed in the National Health Survey, 1935-1936.

Diagnosis[3]	All Ages	Under 15 Years	15-24	25-64	65 and Over	All Ages	Under 15 Years	15-24	25-64	65 and Over
	Hospital cases per 1,000 persons					Hospital days per 1,000 persons				
All Causes	49.3	41.6	51.9	51.4	52.2	1,260.7	739.6	1,109.9	1,472.0	1,930.0
Communicable Diseases	1.8	4.7	1.3	.71	.56	46.0	125.8	30.7	18.4	18.2
Tonsillitis	5.5	15.4	4.3	2.1	.25	13.3	33.0	10.3	6.7	1.4
Pneumonia, All Forms	1.5	2.7	.72	1.1	2.3	30.1	55.8	14.8	22.9	38.1
Other Diseases of the Respiratory System	1.5	1.2	1.7	1.5	1.7	29.3	24.1	23.9	33.0	33.1
Appendicitis	4.5	3.4	8.9	3.8	.64	61.9	45.6	113.6	57.0	13.9
Other Diseases of the Digestive System	2.5	.74	1.0	3.6	4.1	58.2	14.6	21.2	85.1	104.4
The Puerperal State: Live Births	9.7	.013	18.6	12.1	—	104.4	.12	195.7	131.4	—
Other Puerperal Conditions and Female Genital Diseases	2.1	.037	1.9	3.3	.49	31.4	.65	23.8	50.1	7.8
Cancer	.64	.013	.025	.85	3.2	23.8	.65	1.4	31.1	122.0
Rheumatism	.70	.32	.36	.90	1.5	29.7	17.0	14.0	37.1	62.5
Degenerative Diseases	3.6	1.5	1.2	4.0	15.6	110.5	45.0	32.7	122.8	513.9
Tuberculosis, All Forms	.80	.36	1.1	.95	.36	139.4	63.0	209.9	161.2	32.0
Nervous and Mental Disease	1.8	.99	1.4	2.2	2.0	280.3	78.0	205.5	392.9	303.4
Orthopedic Impairments	.74	.66	.65	.70	1.7	61.6	51.8	57.6	55.1	177.5
Accidents	5.6	4.2	5.2	5.9	9.3	104.9	61.9	80.1	116.3	256.0
All Other Causes	6.4	5.4	3.5	7.6	8.6	136.1	122.5	74.7	151.0	245.8

See footnotes following Appendix Table 2 D.

Appendix Table 2C. Frequency rates of disabling[1] illness receiving care from a private duty nurse,[5] and of nursing days, classified by diagnosis according to age, in 1,581,577 white persons[2] in thirty-one cities of 100,000 population and over canvassed in the National Health Survey, 1935-1936.

Diagnosis[3]	All Ages	Under 15 Years	15-24	25-64	65 and Over	All Ages	Under 15 Years	15-24	25-64	65 and Over
	Private duty nurses' cases per 1,000 persons					Nursing days per 1,000 persons				
All Causes	5.46	2.60	3.40	6.15	17.43	156.49	48.61	45.03	147.33	1,046.92
Communicable Diseases	.31	.80	.14	.15	.15	6.48	15.64	3.13	3.61	5.70
Tonsillitis	.12	.27	.067	.069	.056	.42	.87	.28	.27	.28
Pneumonia, All Forms	.50	.47	.25	.46	1.78	8.80	8.61	3.19	8.36	31.32
Other Diseases of the Respiratory System	.35	.28	.16	.39	.92	6.03	5.73	2.55	6.28	15.90
Appendicitis	.44	.25	.59	.51	.079	4.89	3.08	5.44	5.83	1.87
Other Diseases of the Digestive System	.31	.034	.078	.43	1.10	7.69	.78	1.30	10.55	29.81
The Puerperal State: Live Births	1.05	.003	1.54	1.47	—	12.48	.075	15.62	18.28	—
Other Puerperal Conditions and Female Genital Diseases	.21	.003	.11	.34	.10	3.22	.008	1.83	5.32	1.32
Cancer	.14	.003	—	.17	.88	6.39	.11	—	8.96	28.62
Rheumatism	.10	.013	.011	.12	.55	6.60	1.22	.17	7.90	37.25
Degenerative Diseases	.73	.061	.050	.60	6.87	35.92	1.11	.91	24.75	397.85
Tuberculosis, All Forms	.020	.005	.015	.023	.078	1.90	.10	.19	1.68	16.95
Nervous and Mental Disease	.13	.032	.053	.16	.54	9.42	.86	2.40	9.43	67.41
Orthopedic Impairments	.10	.023	.035	.081	.83	15.47	.81	1.09	9.04	183.05
Accidents	.36	.091	.17	.42	1.56	12.64	5.07	4.15	12.40	73.38
All Other Causes	.59	.25	.13	.75	1.93	18.13	4.54	2.78	14.66	156.24

See footnotes following Appendix Table 2 I.

of disabling[1] illness receiving bedside care from a visiting nurse, and of nursing visits, classified by diagnosis according to age, in 1,581,577 white persons[2] in thirty-one cities of 100,000 population and over canvassed in the National Health Survey, 1935-1936.

Diagnosis[3]	All Ages	Under 15 Years	15-24	25-64	65 and Over	All Ages	Under 15 Years	15-24	25-64	65 and Over
	Visiting nurses' cases per 1,000 persons					Nursing visits per 1,000 persons				
All Causes	12.31	29.53	8.10	6.53	7.79	64.34	93.71	46.73	52.45	108.96
Communicable Diseases	5.40	21.41	.98	.31	.079	14.94	57.43	3.34	1.46	.19
Tonsillitis	.48	1.65	.26	.085	.011	1.31	4.06	.77	.40	.10
Pneumonia, All Forms	.41	.97	.15	.24	.46	3.71	7.59	1.92	2.48	4.62
Other Diseases of the Respiratory System	.96	2.39	.47	.53	.52	3.76	7.91	2.14	2.57	2.68
Appendicitis	.15	.16	.26	.12	.011	1.09	.75	1.85	1.08	.079
Other Diseases of the Digestive System	.21	.22	.086	.23	.47	2.08	1.08	.61	2.63	5.75
The Puerperal State: Live Births	2.29	—	4.52	2.81	—	13.57	—	25.25	17.16	—
Other Puerperal Conditions and Female Genital Diseases	.22	.011	.22	.33	.045	1.81	.024	1.60	2.82	.40
Cancer	.08	—	.007	.10	.48	1.69	—	.11	2.20	8.95
Rheumatism	.15	.11	.061	.17	.49	2.10	.98	.67	2.45	7.90
Degenerative Diseases	.45	.28	.14	.41	2.63	5.33	2.06	2.10	4.96	32.75
Tuberculosis, All Forms	.25	.064	.34	.31	.18	1.75	.50	2.04	2.26	1.27
Nervous and Mental Disease	.13	.18	.10	.12	.12	1.02	.96	.57	1.18	1.25
Orthopedic Impairments	.12	.13	.057	.083	.58	2.40	1.40	.78	1.88	16.55
Accidents	.34	.40	.23	.30	.83	3.08	1.67	1.16	3.16	14.31
All Other Causes	.67	1.56	.22	.39	.87	4.70	7.21	1.81	3.76	12.14

[1] Disabling for seven consecutive days or longer in a twelve-month period. All confinements, fatal, and hospital cases are included without reference to the duration of disability.

[2] Exclusive of persons of unknown age or unknown income.

[3] The classification by diagnosis is made on the basis of the sole or primary cause of the illness. The diseases included in the broad diagnosis groups are as follows:

Communicable Diseases: chiefly the communicable diseases of childhood: measles, mumps, chickenpox, whooping cough, scarlet fever, and diphtheria.

Other Diseases of the Respiratory System: influenza, colds, bronchitis, pleurisy, sinusitis, asthma, hay fever, and other diseases of the respiratory system except tonsillitis, pneumonia, and respiratory tuberculosis.

Other Diseases of the Digestive System: indigestion, biliousness, diarrhea and enteritis, ulcer of the stomach or duodenum, diseases of the gall bladder or liver, and other diseases of the digestive system except appendicitis.

Other Puerperal Conditions and Female Genital Diseases: abortions, miscarriages, and stillbirths; complications of pregnancy; cysts of the ovaries, uterus, and tubes; displacement and lacerations of the female genital organs; pelvic inflammatory disease; and other nonpuerperal diseases of the female genital organs except cancer and nonmalignant tumors.

Degenerative Diseases: diabetes; cerebral hemorrhage and other forms of paralysis; diseases of the heart, arteriosclerosis and high blood pressure, and other diseases of the circulatory system, exclusive of hemorrhoids and varicose veins; nephritis and other nonvenereal diseases of the genitourinary system, exclusive of diseases of the female genital organs.

Nervous and Mental Disease: general paralysis of the insane and other forms of insanity; neurasthenia, locomotor ataxia, epilepsy, chorea and other diseases of the nervous system; and mental defects.

[4] In enumerating hospitalized illnesses, no limitation was imposed concerning the duration of the disability. Hospitalized illnesses include: (1) cases in which the hospitalized illness or injury was the sole cause of disability; (2) cases in which multiple causes were assigned to the illness, and hospital care was received for the primary, or any contributory, cause of the illness.

[5] Includes care in the home and special nursing care in the hospital.

Appendix Table 3A. Estimated frequency rates of disabling[1] illness receiving medical and nursing care, and of medical and nursing services, according to age, in a surveyed population, and estimated number of cases and services in the United States in 1935 and 1980. (Based on the experience of 1,581,577 white persons[2] in thirty-one cities of 100,000 population and over canvassed in the National Health Survey, 1935-1936.[3])

Medical Category	All Ages (Crude)	Age[8]				Estimated No. of Cases, Services in the United States (in 1,000's), Based on Age-Adjusted Rates[9]	
		Under 15 Years	15–24	25–64	65 and Over		
	Cases and services per 1,000 persons					1935	1980
Physician:[4]							
Cases	117.6	144.2	85.6	109.3	195.9	15,230	17,176
Services	871.4	623.9	543.6	962.4	2,149.3	109,946	135,238
Hospital:[5]							
Cases	43.2	40.3	42.4	44.6	49.9	5,514	6,102
Services	812.2	598.5	636.2	890.6	1,594.5	102,612	121,977
Private Duty Nurse:[6]							
Cases	5.9	2.6	4.0	7.0	17.4	751	915
Services	161.8	48.6	51.0	157.6	1,046.9	20,476	30,480
Visiting Nurse:[7]							
Cases	13.3	29.5	9.8	8.1	7.8	1,808	1,743
Services	70.1	93.7	56.4	62.1	109.0	9,220	9,846

[1] *See* footnotes 1 and 4, Appendix Table 2D.

[2] *See* footnote 2, Appendix Table 2D.

[3] The age specific rates shown here for all causes of illness are estimated rates, representing the combination of estimated rates relating to confinements terminating in live births, and observed rates, as shown in Appendix Tables 2A-D, for all other causes of illness. The proportion of confinements (live births only) in all categories except hospital patients, and the corresponding services received were estimated from the rates shown in Appendix Tables 1A, 2A, 2C, and 2D, but the actual number of live births occurring in the United States in 1935, increased to allow for under-registration (i.e., 2,434,000 live births) was taken as the base for these estimates. The number of hospitalized confinements in 1935 was obtained from data published by the Bureau of the Census (*see* reference 17), the number of hospital days being estimated on the basis of the average duration as observed in the survey of the Committee on the Costs of Medical Care. The estimated number of confinements in the various categories, and the corresponding services, derived as stated, were distributed by age in the proportions indicated by the rates shown in Appendix Tables 2A-D. The number of confinements terminating in live births in 1980, estimated at 2,132,000, in accordance with assumptions made in the construction of the 1980 population, was taken as the base for the estimates in 1980.

[4] Includes care by a medical practitioner in the patient's home, the physician's office, or in a clinic. Records of medical consultations for the purpose of instruction in prenatal hygiene were incomplete and were, therefore, excluded in coding the survey data.

[5] The frequency rates of hospitalized cases of tuberculosis and nervous and mental disease, and of hospital services for these patients, shown in Appendix Table 2B, have been excluded in all computations relating to hospital patients and days of care.

[6] *See* footnote 5, Appendix Table 2D.

[7] Includes bedside care only.

[8] Data by age in detailed periods are not available.

[9] Adjusted to the estimated age distribution of the United States in 1935 and 1980. The estimates for 1980 are based on adjusted rates which take into account the decline in births assumed in the construction of the 1980 population. They represent a reduction of the adjusted rates expected on the basis of the age specific rates included in this table, in the following proportions (percentage reduction of the latter rate in the category specified): physicians' cases, 2.2, services, 1.6; hospital cases, 3.0, services, 1.9; private duty nurses' cases, 5.6, services, 2.0; visiting nurses' cases, 5.3, services, 5.8.

Medical Category	All Ages[8] (Crude)	Age										Estimated No. of Cases, Services in the United States (in 1,000's), Based on Age-Adjusted Rates[11]	
		Under 5 Years	5-9	10-14	15-19	20-24	25-34	35-44	45-54	55-64	65 and Over	1935	1980
	Cases and services per 1,000 persons all causes (estimated)[10]												
Physician:[3]													
Cases	640	949	698	472	427	517	654	599	566	601	727	78,137	88,468
Services	2,537	2,561	2,129	1,620	1,668	2,478	3,060	2,812	2,752	2,983	4,957	336,881	403,143
Hospital:[4]													
Cases	56.6	48.6	61.2	42.9	41.0	65.0	79.3	59.2	43.0	40.1	66.1	7,144	7,874
Services	665.3	549.2	406.3	558.7	330.4	745.1	848.7	763.1	664.8	851.3	1,901.8	92,501	114,747
Private Duty Nurse:[5]													
Cases	23.4	13.8	14.0	11.4	13.1	27.7	37.9	29.0	20.6	31.2	69.1	3,311	4,087
Services	409.9	219.7	167.8	85.2	139.3	372.4	503.2	484.4	450.0	913.8	3,154.3	68,828	102,501
Visiting Nurse:[6]													
Cases	31.1	43.5	30.1	21.4	15.7	34.4	45.1	28.9	15.5	17.0	28.1	3,667	3,844
Services	209.3	191.9	116.7	124.3	92.2	231.6	363.1	244.5	140.3	167.7	510.0	27,760	32,366
	All causes (exclusive of confinements terminating in live births)[9]												
Physician:[7]													
Cases	622	949	698	472	420	475	589	573	565	601	727		
Services	2,378	2,561	2,129	1,620	1,606	2,127	2,472	2,613	2,743	2,983	4,957		
Hospital:[7]													
Cases	50.4	48.6	61.2	42.9	39.0	51.4	56.0	51.1	42.7	40.1	66.1		
Services	589.7	549.2	406.3	558.7	308.5	569.1	574.8	663.1	660.7	851.3	1,901.8		
Private Duty Nurse:[7]													
Cases	18.2	13.8	14.0	11.4	11.5	18.4	18.4	21.1	20.6	31.2	69.1		
Services	333.8	219.7	167.8	85.2	119.7	236.9	232.6	345.9	450.0	913.8	3,154.3		
Visiting Nurse:[7]													
Cases	22.2	43.5	30.1	21.4	12.1	13.7	15.1	15.5	14.6	17.0	28.1		
Services	140.7	191.9	116.7	124.3	64.3	83.5	132.8	137.4	128.6	167.7	510.0		

Appendix Table 3B. Estimated frequency rates of illness[1] receiving medical and nursing care, and of medical and nursing services, according to age, in a surveyed population, and estimated number of cases and services in the United States in 1935 and 1980. (Based on the experience of 39,185 white persons[2] in 130 urban and rural areas canvassed in the survey of the Committee on the Costs of Medical Care, 1928-1931.)

[1] Includes nondisabling illness, and illness disabling for one day or longer.

[2] Equivalent to 38,544 person years of life.

[3] Includes care by any medical practitioner, in the patient's home, the physician's office, or in a clinic, and care by a private physician in the hospital. Medical consultations for the purpose of instruction in prenatal hygiene are included.

[4] Exclusive of the experience of hospitalized cases of tuberculosis and nervous and mental disease.

[5] Includes care in the home and special nursing care in the hospital.

[6] Includes both bedside care and instructive service.

[7] Footnotes 3–6 above apply here except as they relate to live births which are excluded from these rates by definition.

[8] Includes a small number of unknown age.

[9] The source of the age specific rates shown for "all causes, exclusive of confinements terminating in live births" is as follows:

Illnesses attended by a *private duty nurse* and *visiting nurse:* unpublished rates as observed in the survey of the Committee on the Costs of Medical Care. *Hospitalized* illnesses:

(Continued on page 392)

unpublished rates as observed in the survey of the Committee on the Costs of Medical Care, exclusive of the experience of hospitalized cases of tuberculosis and nervous and mental disease. Illnesses attended by any *medical practitioner:* the frequency rates of illnesses of this category were estimated on the basis of rates observed in the survey of the Committee on the Costs of Medical Care (*see* reference 19). The rates available in this forthcoming publication include the age incidence of the total illnesses attended by (1) any practitioner, i.e., medical or nonmedical, and (2) nonmedical practitioners, with or without a medical attendant. These classes were not mutually exclusive with respect to attended illnesses, and it was necessary therefore to estimate the incidence of illness attended by medical practitioners. A special tabulation of the total illnesses, all ages, attended by nonmedical practitioners, with or without care from a medical practitioner, indicated that 76 per cent were attended by nonmedical practitioners only. By assuming that this proportion would obtain in each age group, the age incidence of illness attended by nonmedical practitioners only was estimated. These estimated rates were subtracted from the age specific incidence rates of illness attended by any practitioner (medical or nonmedical), thus deriving estimated frequency rates of illness attended by a medical practitioner. From the tabulations available, exact rates of this nature could not be computed. However, the frequency rates of services of the several categories as reported in this study relate to mutually exclusive groups. For the purposes of the present report, the age specific frequency rates of services received from medical practitioners were obtained by subtracting the rates relating to nonmedical practitioners from the rates relating to "any practitioner."

[10] The age-specific rates shown for "all causes, estimated," represent the combination of the age-specific rates for "all causes, exclusive of confinements terminating in live births" (*see* footnote 9) with estimated age-specific rates relating to confinements terminating in live births. The general procedure employed in making these estimates is described in the third footnote in Appendix Table 3A, but the experience of live births observed in the survey of the Committee on the Costs of Medical Care formed the basis for the estimates of the number of confinements attended by any medical practitioner, or by a private duty nurse or visiting nurse, used in Appendix Table 3B. The number of hospitalized confinements in 1935 was obtained from data published by the Bureau of the Census (*see* reference 17), the number of hospital days for these patients being estimated on the basis of the average duration as observed in the survey of the Committee on the Costs of Medical Care (12.1 days per hospitalized confinement terminating in a live birth). The age distribution of confinements of the various categories and the corresponding services was also based on the experience of the Committee's survey.

[11] Adjusted to the estimated age distribution of the United States in 1935 and 1980. The estimates for 1980 are based on adjusted rates which take into account the decline in births assumed in the construction of the 1980 population. They represent a reduction of the adjusted rates expected on the basis of the age-specific rates included in this table, in the following proportions (percentage reduction of the latter rate in the category specified): physicians' cases, .40, services, .74; hospital cases, 1.5, services, 1.2; private duty nurses' cases, 2.4, services, 1.5; visiting nurses' cases, 4.3, services. 4.0.

ADAPTING PROGRAMS OF SOCIAL WELFARE TO A CHANGING POPULATION

PHILIP KLEIN[1]

I SHOULD like to preface these remarks by saying that social scientists are still too lacking in conviction about the importance of so-called theoretical considerations. Abstract academic findings often have far greater practical importance than immediate palpable facts. This question of adapting programs of social welfare to a changing population is a good example of the sterility of separating theoretical analysis from practical measures. I think that the most important measures for meeting social welfare problems have their rational roots in the problems of population. It is not even a question of "adapting programs" but rather of constructing and creating them out of the significant happenings in population change.

A further premise upon which these remarks are based is that the most important area of social welfare is that which lies in the realm of economics. This is not to deny that there are other problems of social welfare, but to say that they are either corollary or of lesser significance or less pressing.

The reason why prosperity is not "just around the corner," why it *can not* be just around the corner lies chiefly in the population changes and in the field of technology, the two reacting upon each other, and creating the economic conditions of the present.

The principal socio-economic problems of which the general public is conscious and about which a great deal is heard from one or another combination of interests and articulate groups are:

1. That there is too much unemployment in industry, and that the income of the agricultural population is too low.

[1] From the New York School of Social Work.

This paper was presented at the Eighteenth Annual Conference of the Milbank Memorial Fund, April 2-3, 1940.

2. That opportunities for investment are restricted and thus the expansion of economic activity (sometimes called prosperity) prevented. Generally speaking, the Government is held responsible for this stagnancy.

3. That welfare services are getting too expensive: the nation cannot afford them; therefore resistance is offered to social security, relief, national health programs, improved school systems, etc., etc.

A system of social welfare measures cannot be both effective and permanent unless it takes full account of the difficulties implied in these three major economic complaints. I do not pretend in what follows to present new facts or even new relationships, but merely to emphasize that a social welfare system for this country must relate itself both to these economic complaints and to the underlying population facts that largely determine the underlying conditions of our economy.

I would put it as an axiom that growing economic activity depends upon growing consumer power. The consumer power can be either national or foreign; it can be either quantitative, that is, larger amounts of the same things, or qualitative, that is, an increase in standards of consumption. The practically continuous increase in basic prosperity of the United States may be reasonably understood in the light of its history of consistently increasing population, that is, consumer power together with the known rise in standards of living. It would be a natural inference, therefore, that if population increase is retarded and increase in consumer power diminishes, prosperity is also likely to be slowed up. This major change in population trend has actually taken place, and the check in expanding consumer power has arrived. It has been more pronounced in fact than it might have been because of the abnormal increase in production associated with the World War. This slowing down in the growth of national consuming power might not have had the pronounced retarding effect on prosperity if foreign markets had proportionately increased. That, however, has not

happened and expansion of production with its associated increase in investment opportunities has not occurred. It is, therefore, reasonable that something more than a temporary decrease in prosperity should set in.

And here is where the second major factor in population—the change in age distribution—comes in. The proportion in the population within the productive age has changed between 1870 and 1930 from 55.7 per cent to 63.4 per cent.[2] Proportionately, therefore, the same body of consumers has a larger body of producers to supply their needs. Relatively this is the same thing as if the consuming power had actually been reduced. Had the productivity per worker decreased proportionately, this result would not have followed; but as we know, the unit productivity has, on the contrary, greatly increased in both industry and agriculture, and therefore the reduction of consuming power relative to producing power is further accentuated.

But, again, this larger group in the productive age might not have been drawn into actual production, and so all might still be well. They might still be only consumers, even though in the productive age group. Actually, however, the number of gainfully employed *has* increased both absolutely and relatively: absolute numbers from twelve million in 1870 increased to forty-eight million in 1930; proportion in population increased from 32 per cent in 1870 to 40 per cent in 1930.[3] Thirty-two per cent means, on an average, 3.1 consumers for one gainfully employed, including the earner; 40 per cent means 2.5 consumers for one gainfully employed, including the worker, a reduction in ratio of consumers to producers of 20 per cent, to say nothing of increased productivity. Theoretically this might mean, and to some extent it does mean, an easing of the burden: for 2.5 people can more easily be supported

[2] Hurlin, R. G. and Givens, M. B.: Shaping Occupational Trends, a chapter in RECENT SOCIAL TRENDS IN THE UNITED STATES. New York and London, McGraw-Hill Book Company, 1933, p. 276.

[3] *Ibid.*, p. 271.

on the income of one person than can 3.1. That assumes, however, that the earner works and receives wages with the same regularity in 1930 as in 1870. By way of answer, we have had a growing unemployment trend for over two decades. With constriction of market and greater productivity of worker, employment shrinks, and the fewer dependents of an unemployed person have a harder time than the more numerous dependents of an earner. What expansion of activity can be expected when the relative number of consumers is decreasing? A great deal might still have come if the standard of living had risen sufficiently to add to the consuming power and if the purchasing power had similarly kept pace with this increasing capacity to consume. But purchasing power is derived from employment and farm income, and we see that the rate of employment has been consistently diminishing while farm population income compared with farm population has for similar reasons also been decreasing.

There is an abundance of data on these happenings in agriculture, most of them easily available in several publications of the National Resources Board.

If social welfare is dependent primarily on economic welfare, and if welfare measures are to be adjusted to these implications of population change, what measures might be rationally consistent with this movement? Recalling that the proportion in the older age group is increasing and in the younger age group decreasing, one might propose:

1. That the producing power be gradually concentrated in the group, say 20 to 55, leaving those under 20 and over 55 relatively as consumers. This would imply:
   a. A modified apprenticeship training prior to the age of 20.
   b. Gradual demobilization of employment beginning about 55, and accelerating to 65, through changing of hours, shifting of occupations, and recognizing superannuation in some cases to be equivalent to eligibility for old-age insurance.
2. Reduction of hours and increase of wages in the producing ages

(20 to 55), so as to spread employment, and distribute and maintain purchasing power.

3. Reorganization and replanning of occupational distribution, by shifting certain blind-alley types of occupation to the age group 50 to 65 as adapted to reduced earning capacity; creating part-time employment in the ages 50 to 65 with appropriate retirement adjustments; excluding the age group, 20 to 50, except among the handicapped, from these selected occupations.

4. Equalization of income among the rural and urban workers through wage and price adjustments and through removing as low-wage competitors, the aged and young workers.

And here is where the specific welfare programs come in, through the development of an educational system suited to the cultural and leisure time requirements of such a civilization, and of health and welfare services adapted to the changing population groups.

Of course, in any such plan which is unavoidably interwoven with population changes, we should have to answer certain questions, also implicit. For example:

Do we wish to counteract the recognized population changes by far-reaching measures that would keep the population increasing indefinitely, or until such time as we have discovered ways of restoring the producer-consumer ratio that had made increasing prosperity possible? These changes would have to be substantial to make a difference. They would involve supplementation of family wage, premiums on large families, bonus for additional children, etc. We would also have to decide whether this increase, which presumably is for purposes of maintaining the tempo of economic advance, is to be applied to all consumers, Negro as well as white, Indian, Mexican, foreign-born, as well as native.

Do we wish really to give economic equality to Negro and white, to agricultural and industrial worker, to manual and white-collar workers?

I should like at this point to pass over the second economic complaint relative to the restriction in possibilities of investment, and first consider the complaint about the expensiveness of welfare services. Here we deal with welfare as representing activities occa-

sioned by lack of income or other handicaps, or by the increasing standards of educational and cultural life. Continuing again on the assumption that the population trend, both as to age distribution and as to the numbers, is likely to continue as outlined, and adding a further assumption that readjustment of wages and hours may not be sufficient to adjust productivity to employment, welfare services would have to be regarded as:

> A way by which reasonable living on relatively low income can be made possible and more equitable, since services would be distributed in accordance with need rather than in accordance with earning power and would therefore interfere but slightly with the conflict in wage adjustment between employer and employee. In this conflict the consuming power of one worker compared with another does not enter, and each worker is an equal competitor and collective bargainer with his fellows. Through welfare services rather than through wages, then, the large family of a low-wage earner would be assured of as decent standards as would be the larger earner in a smaller family. The welfare services involved in this concept would include public housing, public medical care, extensive recreation programs, a far-reaching educational system.
>
> They would mean making possible the exclusion or partial exclusion from competitive employment of the young age group, the old age group, and that indeterminate age interval in which productivity decreases and either shift of occupation or part-time employment might be reasonable.
>
> Welfare service might be regarded also as an expanding area of employment, a market for absorbing particularly suitable personnel and an opportunity for expenditures on equipment, maintenance, etc.
>
> These services would represent one of the ways of raising the standard of living which would constitute part of the qualitative increase in consumption power, and multiply the commodity called "services" apace with stable commodities and other "visible" products. Much of the welfare program for children, youth, the aged, mothers, and the chronic ill would come in this category.
>
> They would constitute a stabilizing influence on the financial structure by the consumption of products through public expenditures, which are less subject to violent fluctuations than is competitive busi-

> ness. In other words, it is true that welfare services, especially when conceived in a comprehensive way *are* expensive. As "commodities" they reflect a higher level of living for individuals and social groups. Their purchase, through tax payment would draw upon the capital-labor economy as a sort of fixed charge. But these services seem to be also a *way out* of the impasse created by the ever-widening ratio between producing power and consuming power of other economic commodities. The absolute amounts expended on these services at the present out of the national income are almost negligible (as shown by Mr. Nathan's charts—reproduced in Social Security Bulletin). They must expand in the interest of economic solvency as well as in the interest of the clients to be served.

The postulate that public welfare services will have to expand far beyond their present scope, and that this expansion is as much an inevitable corollary of population change as it is an expression of welfare interest, renders the subject of investment difficulties pertinent to this discussion. For it is perfectly true that the kind of expanded social welfare program that we are talking about cannot be financed on the current philosophy of the place of capital in the system of distribution. Curiously enough, we do not hear much about lack of income for purposes of consumption in the higher income brackets or in general by those whose livelihood comes in returns from capital. The cry is rather that that part of the income obtained from profits which is not consumed, but is available for investment, cannot be reinvested for further profits. It is assumed that profits have a dual function of making possible high consumption standards and of making possible further profitable investment. The latter notion seems to be held quite independently of the former. I recognize that this is not the place for debating questions of a purely economic nature. The reason for including this point, however, lies in the fact that of all economic factors so often debated as bearing on this point, the effect of population is the only one that is consistently disregarded. The fact that investment for profit implies a consumer as well as producer is considered as some-

thing abstract and irrelevant as within the realm of pure economics and of practical politics, but not of practical economics.

In a recent syndicated article over Mr. Babson's signature, he makes reference to the sixteen billion dollars tied up in private capital which is kept from giving work to eight million unemployed, by implication through pure perversity. Disregarding for the moment the obvious fact that the breakdown occurred prior to the present Federal administration, this sort of analysis leaves entirely out of consideration the order in which products can be consumed: the fact that foods are already produced in overabundance, but cannot be distributed, that dwellings to meet mass demand are not recognized as suitable investment for private capital, and that there is no shortage in luxury products to meet the consumption needs of the upper brackets.

To come back to the main problem, it would seem clear that the social welfare program discussed here can be made possible only by fundamental reorganization of the distribution system. We may regard the present distribution in a simplified form as consisting of three parts, each seeking to expand so as to occupy a larger proportion of the total distribution. One of these is the return to capital, another the return to labor, the third, payment to government for protection and public services. The principal struggle between capital and labor can be interpreted as a pressure of these two divisions into each other's territory. The past few decades have presented a widening of the third division or belt—that part of economic distribution which goes to the government in taxes for public services and of course for public welfare services. The program of increased social services is predicated on the theory that this third belt will continue to be an increasing factor in the system of distribution, absorbing portions of the return to both labor and capital. At this point, the lessons from population change do not automatically give the answer as to whether the cost of services should draw principally from labor or chiefly from capital. That becomes a

question of philosophy and theory of government. Fascist and Socialist interpretations will give different answers. If it is true that purchasing power ought to be maintained or increased, then it would follow that public services must draw more extensively on the portion that now is the return to capital. If, moreover, that part of the return to capital which is not consumed but is waiting for reinvestment remains stagnant, then presumably the cost of social services must come in large part from this uninvestable capital either directly, or through some system of taxation.[4] The point I am trying to emphasize at any rate is that the difficulties of capital investment are also bound up with changes in population, with the associated facts of our socio-economic structure, and with the place of welfare services in our economy.

This persistent dwelling upon theoretical considerations rather than tackling the simple question of how to adapt programs of social welfare to changing population has been, as you realize, deliberate. These fundamental problems are, I think, from a practical point of view, of far greater importance than specific suggestions. They do, of course, imply certain specific proposals but I regard these as deriving their validity, their practicality, and their permanence entirely from whatever truth there may be in the theoretical considerations that lie behind them. A social welfare program adapted to these considerations would include then, by way of a brief resume, some such items as the following:

1. A continuous program of Federal public employment.

2. Completion of a system of social insurances including those of old age, the extension of unemployment insurance, etc., to all occupations, and the development of insurance against loss of income from sickness.

3. A reorganization of the educational and vocational program which by a combination of schooling and apprenticeship, would keep all persons under 20 out of the field of employment competition.

[4] It actually does, to a large extent, come from this source at the present through purchase of government bonds. The change in the proportion of sources of bank profits as between commercial loans and government bonds since 1929 is more than suggestive of this.

4. An organized plan for the demobilization of and special employment opportunities for the age group from 55 to 65, or even 70.

5. A reorganization of the entire system of taxation which would make possible:

a. Taxing where taxing capacity exists,

b. Expenditure where services are needed,

c. A concentration of taxation under the Federal Government in such a way that the issues raised as between services and economic system can become clear-cut and intelligible for discussion.

6. Administrative reorganization of relations between Federal, State, and local governments so as to make possible the correlation between employment, social insurance benefits, and welfare services, regardless of State and local boundaries and in full recognition of the fact that intra-national migration requires far-reaching administrative adjustments.

MEDICAL EVALUATION OF NUTRITIONAL STATUS[1]

II. MEASUREMENT OF VISUAL DARK ADAPTATION WITH THE ADAPTOMETER

ELEANOR P. HUNT AND CARROLL E. PALMER

INTRODUCTION

THE measurement of visual dark adaptation described in this report was part of a cooperative nutrition study, which was directed toward an appraisal of methods of investigating the nutritional status of apparently well persons. The purpose and scope of the study and procedures employed have recently been described (1).

In nutritional examinations, dark adaptation measurements are a basis of inference regarding the presence of nyctalopia, a condition of impaired retinal sensitivity under dim illumination, arising from avitaminosis A. The sensory phenomenon of dark adaptation, as expressed in threshold measurements, reflects the synthesis of photosensitive pigment and the corresponding recovery of sensitivity of the retina after exposure to light. The regression of threshold upon time in the dark describes the course of the individual's retinal recovery.

The present report on dark adaptation represents an attempt to obtain information on the accuracy of threshold measurements obtained with a particular adaptometer. The demarcation between adequacy and deficiency in vitamin A nutrition, we believe, cannot be defined satisfactorily until the accuracy of threshold measurements has been evaluated and the major factors other than vitamin A, contributing to the variability of threshold measurements are

[1] This paper is the second of a series from a cooperative investigation by the Milbank Memorial Fund; the New York City Department of Health; the United States Public Health Service, Division of Public Health Methods; and the Cornell University Medical College, Department of Public Health and Preventive Medicine and Department of Pediatrics.

The cooperating agencies have been assisted in carrying out this investigation by the Work Projects Administration for the City of New York, Official Project No. 65-1-97-21, W.P. 24, "Medical Evaluation of Nutritional Status."

identified. Such preliminary evaluation of the technique of measurement provides essential information whereby experimental error can be minimized and discriminating observations can be made with respect to such nutrition categories as may later be defined.

Material and Methods

The Adaptometer. Measurements of dark adaptation dealt with in this report were made with the adaptometer designed and described in detail by Hecht and Shlaer (2). This adaptometer is a device for exposing one eye of a subject to a light of standardized brightness (preadaptation) and for measuring the dark adaptation of that eye by determining, at specified intervals of time, the threshold of perception of light stimuli of measured intensity. An instrument, constructed according to the specification of Hecht and Shlaer, can be purchased in the commercial market.[2] So obtained, the adaptometer is considered complete for routine measurement of dark adaptation. Three of these adaptometers, carrying the manufacturer's serial numbers 5, 9, and 16, were obtained and used in the present study.

Procedure of the Test. Except for certain details which will be considered later, the test procedure used in the present study was that described by Hecht and Shlaer (2). The right eye of the subject was always tested unless it was missing or presented an obvious abnormality. The location of the retinal field involved both in preadaptation and in dark adaptation was determined by adjusting the light and dark fixation points so that the points were viewed 7° nasally. Preadaptation time was held constant at 3 minutes and covered a retinal area of approximately 35° in diameter. The flashes of light used during dark adaptation were adjusted at 0.2 second and covered an area 3° in diameter. The violet filter (Corning 511) was always used for the threshold determinations so that only wave lengths below 460 millimicrons were transmitted. Threshold

[2] From Mr. O. C. Rudolph, 55 Van Dam Street, New York, N. Y.

measurements were made during the first minute following pre-adaptation and thereafter at intervals of from 2 to 4 minutes for a period of from 30 to 40 minutes. The brightness of the adaptation light and of the test flash during dark adaptation was expressed in the logarithm of micromicrolamberts ($\mu\,\mu\,l$).

The classification of the several observations during a given adaptation into rod or cone, was accomplished by a consideration of the speed and velocity of adaptation during the first 15 minutes as well as the reported color of the image. We have found color reports under field conditions too inconsistent with expected results to serve as a certain basis for distinguishing cone and rod thresholds. The terms, cone and rod, are used in this discussion to refer respectively to thresholds before and thresholds after the first apparent plateau during adaptation, without implication as to its reality or its physiological significance.

The three adaptometers used in the study were operated in a dark room in which separate booths were arranged for each instrument. A partition in each booth, through which the eye piece of the adaptometer projected, furnished two cubicles, one for the subject and the other for the technician and adaptometer. By this arrangement the subject was completely shielded from stray light during the test. An adjustable chair, and an arm rest placed below the eye piece of the adaptometer, were provided for the subject.

The procedure of determining a threshold during dark adaptation was to obtain a series of verbal responses from the subject to a number of flashes of light given in fairly rapid succession. The threshold was the brightness, between narrow limits, which corresponded, respectively, to images seen ("Yes," response), and images not seen ("No," response). The technician reduced the limits as much as possible by varying the intensity of illumination in relation to the subject's verbal responses. In general, the brightness of the test flash was decreased when the subject's response was "Yes," and increased when the response was "No." The brightness record-

ed as the threshold was the critical level dividing "Yes" and "No" responses. The time, at which the critical level was obtained, was recorded as the observation-time of the threshold.

Before the beginning of the test, the technician explained its characteristics to the subject, mentioning the preadaptation period, and the subsequent dark adaptation in order to familiarize the subject with the test and his rôle in it. The technician also exhibited several flashes at different intensities and the subject was given some preliminary experience in responding, after each operation of the shutter, as to whether the test light had been seen or not. The subject was instructed also to view the dark point during light adaptation and the light point during dark adaptation, and inform the technician, in the latter case, when the point was more than just perceptible in order that the technician might maintain the light fixation point at the just perceptible level.

Technicians. The instruments were operated by three laboratory technicians under the supervision of a senior technician of the field service of the United States Public Health Service. Each of the technicians was instructed in the procedure of the test by the same supervisor and had field experience before making regular examinations.

Instrumental Variations

Experimental work with the three commercially procured adaptometers clearly indicated that comparable dark adaptation data would not be obtained from the three different instruments if they were used as purchased. For example, it was found that repeated tests made on the same subject with the same adaptometer were very similar. Other tests, on the same subject, made on a different adaptometer, were grossly and significantly different from those made on the first adaptometer. Since it was essential that data from the several adaptometers be directly comparable, a study was made of the sources of these instrumental variations. As a result of this study, and the changes subsequently made in the instruments, it

was found possible to obtain comparable results with the three different adaptometers. The elimination of differences between the adaptometers is of interest as a special case of the more general problem of maintaining comparability of data from different laboratories using this type of adaptometer. Uniformity of apparatus and procedure will promote the collection of comparable data and minimize the purely technical sources of difference which are often confounded with nutritional, biological, or regional factors.

Differences in Optical Parts. The first source of instrumental variation involved differences in the composition of the "neutral" wedge and filters which are parts of the intensity control assembly. The adaptometers having serial numbers 5 and 9 were found to be equipped with Wratten gelatin-between-glass wedges while the wedge in instrument number 16 was made of Jena glass. The set of "neutral" filters for adaptometer 5 were Wratten gelatin-between-glass while those for instruments 9 and 16 were Jena glass. After some use, the gelatin-between-glass wedge and balancer of adaptometer 5 were found to have become noticeably faded and the cementing material was affected. It is well known that the physical properties of gelatin-between-glass units are impermanent and their calibrations accordingly unstable. Since the calibrations of glass wedges and filters can be depended upon, all gelatin-between-glass parts were replaced by glass parts.

Calibration of Violet Filters. The second source of instrumental variation involved the density factors of the violet (Corning 511) filters which are used during the dark adaptation part of the test. According to the data supplied by the manufacturer these factors for the filters in instruments 5, 9, and 16 were, respectively, 3.011, 2.721, and 2.723. A check of the calibrations at the United States Bureau of Standards[3] resulted in the following values: 2.932, 2.932,

[3] The method of calibration used at the United States Bureau of Standards depends on a determination of spectral distribution of transmission on a recording photoelectric spectrophotometer. The transmission factors for incandescent lamp light at 2700°K were computed from these data and using I.C.I. luminosity factors. (3)

and 2.943 for the filters from instruments 5, 9, and 16, respectively. Differences between the maker's density factors and those obtained at the Bureau of Standards apparently derive from different methods of calibration. The practical results of adopting the new calibrations were: threshold values obtained on instruments 9 and 16 were dropped to the lower level characteristic of instrument 5 and the calibration of the chromatic filters was placed on a standard and more reliable basis.

Calibration of the Light Source. A third type of variation arose in connection with the problem of estimating the brightness of the light source in the adaptometer. This source, which is used both in preadaptation and in the dark adaptation phase of the test, is a fixed ground-glass window of the lamp housing which is illuminated by an ordinary commercial 40-watt, inside-frosted tungsten filament lamp operated on a definite current, 115 volts. A precise measurement of the brightness of the light source is a necessary part of the operation of the adaptometer since the brightness value figures directly in the calculation of each threshold determination. The measurement of brightness is necessary also whenever a lamp burns out, or is replaced, and is desirable from time to time as a check on changes in the lamp. Obviously, it is necessary that the user of the adaptometer be able to measure this brightness accurately. For this purpose, each commercial adaptometer is provided with a "standard reference lamp." The procedure of measurement involves a matching of the brightness of the light source of the standard lamp with that of the adaptometer. In actual practice this entails a heterochromatic match. In instrument 9, for example, the half of the field illuminated by the light source of the adaptometer was greenish in hue, whereas the other half of the field illuminated by the standard lamp appeared to be orange. The difficulty of matching brightness when the sources compared are different in color is well known (3).

Study of the use of the standard reference lamp in calibrations of

the adaptometer light source showed that estimates of brightness obtained by different observers were highly variable. It was found, for example, that three different observers estimated the brightness (log of $\mu\ \mu\ l$) of the source light of instrument number 16, as 12.606, 12.689, and 12.817, respectively. For instrument number 5, the same observers reported 12.364, 12.072, and 12.316 as the brightness. These results are mentioned to illustrate the range of results when the brightness of the adaptometer light source was repeatedly matched to that of the standard lamp as reference by different observers.

Table 1. Variance of measurements of brightness of the source when calibrated with the standard lamp of the adaptometer.

Source of Variation	Degrees of Freedom (Number)	Mean Square (log of $\mu\ \mu\ l)^2$
TOTAL	239	1.429
Between Different Observers	14	21.655*
Between Repeated Readings by Same Observer	222	.006
Combined Error of Observation	236	1.291

* $p<.01$.

To obtain a measure of error of this method of calibration of the source, an analysis of variance was made of 240 observations contributed by five different observers for light sources whose brightness was in the neighborhood of 12.00 log units. Each observation involved a match of the brightness of the source of the adaptometer with that provided by the standard lamp, by variation of the wedge setting of the adaptometer. Table 1 shows the variance of the observations for the same observer and for different observers. From this analysis it appeared that the variance of observations repeated by different observers, is 1.291. This estimate included the variance between different observers as well as the variability of repeated readings by the same observer. Since the variance of such observations was large, it follows that the actual brightness was subject to considerable uncertainty. Thus, for theoretical sample means of

fifteen repeated observations by different observers the chances were 19 to 1 that the actual mean brightness was within the interval ± .572 log units. The value ± .572 serves to indicate the extent to which the inferred brightness could vary and still be consistent with the sample observations.

The inability of different observers to arrive at results which correspond more closely made it necessary to find a more reliable method for the calibration of the light source of the adaptometer. Use of the Macbeth illuminometer, in place of the standard reference lamp supplied with the adaptometers, appeared to be satisfactory. An analysis of variance similar to that described above was made for observations obtained with this illuminometer. For theoretical sample means of fifteen repeated observations by three observers, the chances were 19 to 1 that the actual mean brightness was within the interval ± .01 log units. Observations with the Macbeth illuminometer provided, therefore, the highly discriminating information which is necessary regarding the brightness of the source of light in the adaptometer despite plurality of observers.

Other ways of obtaining reliable estimates of the light source in the adaptometer are of course possible. Thus the standard reference lamp might be modified to eliminate the heterochromatic comparison. Suitable filters would reduce the discrepancy in color between reference field and the light source of the adaptometer. The color difference between the reference and the adaptometer source would be reduced if the standard lamp were operated more nearly at rated current. If the latter expedient were adopted, the reference lamp of the standard would need to be housed so that its position could be varied. A combination of these or similar modifications would increase the reliability of results with the standard lamp.

Differences of Brightness in Preadaptation. Specifications for the adaptometer indicate that the 40-watt lamp operated at 120 volts will provide a source for preadaptation whose brightness is in the

neighborhood of 12.176 log units of $\mu\,\mu\,l$ (1,500 millilamberts). It is generally agreed that such small differences as might be found in the brightness of commercial 40-watt lamps would not materially affect the thresholds of light perception determined during dark adaptation. However, the effective brightness of the light source from such lamps may vary under operating conditions.

Estimates of the brightness of the preadaptation lights in adaptometers numbers 5 and 16 were made with the Macbeth illuminometer and found to be, respectively, 11.793 log units (approximately 620 millilamberts) and 12.024 log units (approximately 1,060 millilamberts). While this difference is not large, it is greater than could be explained by the random variation alone, of 40-watt, commercial tungsten filament lamps. Two questions are raised by this finding: First, what instrumental factors bring about the variation in different adaptometers? Secondly, do differences of this magnitude give rise to physiologically significant differences in dark adaptation?

A partial answer to the second question was obtained from an analysis of tests of 175 children made with instrument number 16 and of 179 children made with instrument number 5. Data from this analysis are shown in Table 2 and Figure 1. The means of threshold at successive minutes in the dark, following the slightly greater preadaptation of 12.024 log units on instrument 16, were consistently higher than the corresponding means after preadaptation on instrument 5 with 11.793 log units, except after 20 minutes in the dark.

If the difference in preadaptation brightness was much greater than in the above tests (0.231 log units), the differences in threshold values before 20 minutes in the dark were larger, and significant differences were found as well after 20 minutes in the dark. A number of individuals were tested with varying preadaptation brightness. Figure 2 illustrates, for two individuals, the course of dark adaptation following differences in preadaptation bright-

Minutes in the Dark	Instrument 16		Instrument 5	
	Preadaptation Brightness ($\mu\ \mu\ l$) 12.024 Log Units		Preadaptation Brightness ($\mu\ \mu\ l$) 11.793 Log Units	
	Cases Observed at Time Specified	Mean Threshold (Log of $\mu\ \mu\ l$)	Cases Observed at Time Specified	Mean Threshold (Log of $\mu\ \mu\ l$)
Cones				
.5	172	6.436	179	6.217
1.5	3	6.145	0	—
2.5	157	5.847	163	5.651
3.5	15	5.722	14	5.693
4.5	94	5.561	94	5.360
5.5	52	5.420	60	5.309
6.5	26	5.337	27	5.145
7.5	24	5.254	33	5.107
8.5	9	5.168	4	5.075
Rods				
7.0	58	4.693	54	4.406
8.0	46	4.230	52	4.046
9.0	50	4.051	46	3.779
10.0	81	4.006	88	3.852
11.0	56	3.678	74	3.475
12.0	52	3.719	46	3.396
13.0	84	3.470	82	3.366
14.0	63	3.352	65	3.186
15.0	46	3.218	55	3.114
16.0	78	3.181	75	3.024
17.0	56	3.100	56	2.994
18.0	49	2.902	48	2.811
19.0	61	2.936	59	2.907
20.0	54	2.831	60	2.833
21.0	48	2.779	53	2.698
22.0	51	2.714	49	2.740
23.0	56	2.656	54	2.631
24.0	56	2.607	66	2.629
25.0	51	2.597	49	2.598
26.0	58	2.552	54	2.569
27.0	55	2.508	54	2.511
28.0	50	2.511	61	2.510
29.0	59	2.457	50	2.493
30.0	56	2.463	65	2.447
31.0	48	2.436	43	2.496
32.0	51	2.409	60	2.438
33.0	50	2.445	59	2.436
34.0	58	2.423	51	2.469
35.0	50	2.398	62	2.437
36.0	53	2.414	56	2.424
37.0	47	2.422	35	2.434

Table 2. Mean threshold during dark adaptation after preadaptations differing in brightness by 0.23 log units.

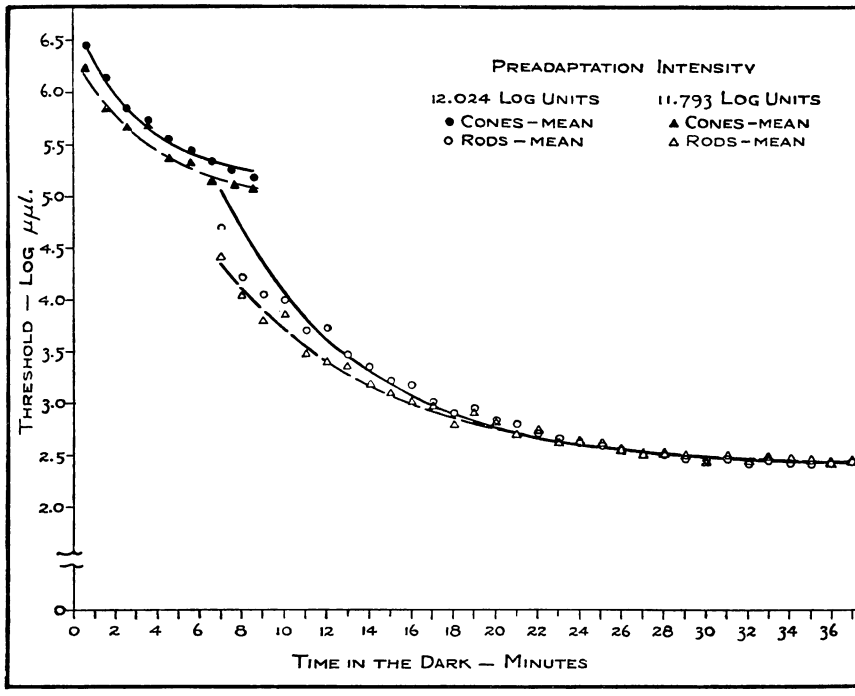


Fig. 1. Regressions of mean threshold during dark adaptation after preadaptation with lights differing in brightness (intensity) by 0.23 log units.

ness of approximately 0.5 log units. In the case of one subject (T. Z.), the differences in threshold, presumably due to preadaptation difference, were evident and large, until 28 minutes in the dark. The response of the other subject was similar. The discrepancy in the threshold curves illustrated by these subjects was representative of the results obtained for other subjects in a series of such tests. The analysis of this question in general indicated that if thresholds earlier than 30 minutes are to be used and compared, uniform preadaptation is indispensable.

Adjustment and Control of Brightness in Preadaptation. Since it appeared necessary, an attempt was made to adjust the preadaptation brightness of the three adaptometers to a uniform value. To date, this attempt is not considered entirely satisfactory.

A priori considerations indicated that the differences among the

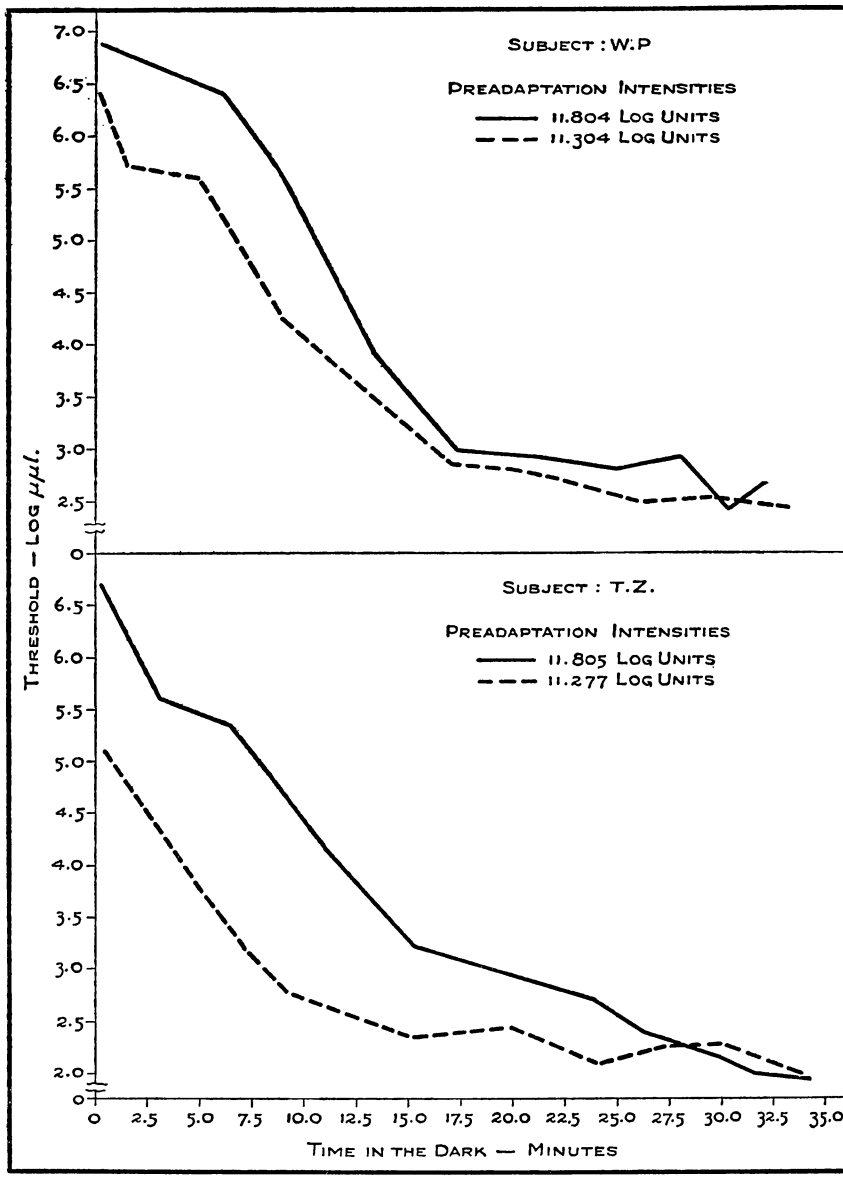


Fig. 2. Dark adaptation curves for two subjects (W.P., T.Z.) after preadaptations with lights differing in brightness (intensity) by approximately 0.5 log units.

three adaptometers were due to some combination of the following factors: (a) differences of one-quarter transmitting "neutral" filters

used during preadaptation, (b) position of the lamps as placed in their sockets, (c) distances of the lamps from the ground-glass windows of the housings, (d) differences in the thickness or composition or installation of the ground-glass windows. Although no study of the relative importance of these factors has been made, it was likely that they accounted for a major part of the observed difference in the brightness of the preadaptation lights. While it probably would be most desirable to equalize the preadaptation brightness of the several instruments by varying the distance between the lamp and the ground-glass window of the housing, the structural changes required did not appear feasible without considerable alteration of the present design of the adaptometer.

The method finally adopted to equalize preadaptation brightness for the present study was an adjustment of the operating current by means of a manually-controlled rheostat and voltage regulator assembly attached to each adaptometer. It was found that the maximum uniform brightness to which the three adaptometers could be adjusted, by variation of operating current, was 12.002 log units (1,004.4 millilamberts). The reference standard of brightness, while adjusting the operating current of the individual adaptometers, was the Macbeth illuminometer, set to provide 1,004.4 millilamberts. The one-fourth transmitting "neutral" filter was in its position for preadaptation, while the brightness of the adaptometer light source was matched to that of the reference standard, by the requisite adjustment of operating current. Thus, the adjusted current compensated differences between the one-fourth transmitting "neutral" filters as well as those from sources previously mentioned. When illuminated by a 40-watt lamp, the window of the lamp housing of adaptometer 5 did not yield the desired 12.002 log units of preadaptation brightness. A 50-watt lamp has been installed in this adaptometer. Table 3 summarizes the details of the operating conditions.

In the case of instrument 16, the adaptometer lamp was operated

Instrument Number	Working Lamp (Watts)	Operating Current (Volts)	Brightness of Source (Log of $\mu\mu l$)	Density of ¼ Transmitting "Neutral" Filter (Log of $\mu\mu l$)	Preadaptation Brightness (Log of $\mu\mu l$)
5	50	111.4	12.522	.520	12.002
9	40	109.1	12.512	.510	12.002
16	40	106.7	12.529	.527	12.002

Table 3. Operating conditions of different adaptometers, modified to obtain uniform brightness of preadaptation.

at approximately 13 volts below rated current. The respective operating currents of the other instruments fell short, also, by smaller amounts of the rated voltage. A change of 10 volts causes a change of about 100 degrees in color temperature for the 40-watt, 120 volt, inside-frosted lamp and a corresponding slight decrease in the transmitting factor of the violet filter. The color temperature of the 40-watt lamp, such as that installed in adaptometer 9, for example, is in the vicinity of 2,700°K when rated current of 120 volts is applied to the terminals. The density assigned to the violet filter at this color temperature was 2.932. At 2,600°K the density of the same filter would be 2.971. The small change in density was a negligible source of variation in threshold compared with the differences attributable to discrepancy in preadaptation brightness when the adaptometers were operated without compensating adjustments of current. The adjustment of current alone was adopted temporarily as the most feasible expedient to bring about uniform preadaptation brightness.

A preadaptation brightness of 12.00 log units (approximately 1,000 millilamberts) was selected primarily because of structural characteristics of the adaptometers and certain operating conditions which obtained in the present study. In order to make possible the direct comparison of dark adaptation data from different laboratories, there obviously must be general agreement among workers in the field to use this or some other standardized brightness value.

Errors of Measurement

The accuracy of the dark adaptation test, like other physiological tests, is dependent upon a complex of factors which may be grouped together under the general heading of "errors of measurement." For example, the accuracy of a particular threshold during dark adaptation is dependent upon the accuracy of the technician's reading of the wedge setting, upon the subject's attention at the moment of the flash of light, upon the precision with which the subject followed instructions during the preadaptation phase of the test, and upon many other variable factors. An attempt has been made to measure several of the more obvious sources of errors of measurement in the adaptometer test.

Variation in the Perception of the Test Light During Dark Adaptation. Determination of the threshold during dark adaptation must depend to some extent on the subject's interpretation of how bright the test light must be before he reports that he is just able to see it. That is, subjects probably differ considerably with respect to their definition of perceptible and nonperceptible flashes of light. Further, the same subject may change during the course of a test his definition of what is perceptible. A limited set of observations was made with a carefully trained subject to determine the magnitude of this source of variation.

After a period of 30 minutes in the dark, the subject was asked to respond to each of four successive series of flashes according to the following four respective grades of perceptible test flashes:

1. Images which were just perceptible as a presence, or perhaps a glow, but without form and without luminous effect.
2. Images which were definitely perceptible, more than a glow, but still without form and only a slight luminous effect.
3. Images which were characterized by a slight form effect, not well defined, and only faintly luminous.
4. Images which were bright and with form sufficiently well defined to be described as approaching a circle.

For each class of image the subject was shown the usual short series of flashes. The threshold was determined for each of the image groups in the order given. The results show that there was a gradual elevation of the threshold as the definiteness of the image increased with respect to form and luminous effect. The means of these thresholds, in each image group, are summarized in Table 4.

Table 4. Mean threshold according to subject's definition of perceptible image.

Definition of the "Image Perceived," Controlling "Yes" Response of the Subject	Number of Observations	Mean Threshold (Log of $\mu\mu l$)
1. Just Perceptible, Form and Color Absent	9	2.647
2. Definitely Perceptible	9	2.879
3. Form Present	13	3.134
4. Bright Image with Form	12	3.298

The means differ significantly although the number of observations in each group was small. After 30 minutes in the dark a trained subject reported the threshold of just perceptible images to be 2.647 log units. The average of definitely perceptible images was 2.879 log units, or 0.232 log units above the average of just perceptible images. The average for images that were definitely bright with form (Class 4) was 3.298, or 0.651 log units above the average of just perceptible flashes.

At the present time no information is available on the extent to which untrained individuals may change their subjective definition of a just perceptible flash during the course of a single dark adaptation test; nor is there information on the differences among different individuals as to their personal criteria of how bright a flash of light must be before they report it as being just perceptible. It seems possible, however, that in routine dark adaptation tests a difference among different individuals of as much as .5 log unit in the threshold after 30 minutes may be due to differences in subjective criteria of perception.

The above analysis and interpretation is of special interest in con-

nection with the distribution of threshold responses for different individuals. Lindquist (5), Hecht and Mandelbaum (6), and others have presented data which indicate that the variability of threshold values of presumably normal persons after 30 minutes in the dark covers a range in the neighborhood of 1.0 log unit. A substantial proportion of this range, therefore, may be due to variation in the subjects' criteria of perceptible flashes.

Variation of Threshold Determinations for a Given Individual. To obtain information on variations characteristic of the subject, and his response to the test, duplicate tests have been made for eighty-three subjects. Each subject was tested twice, the second test following the first test after a lapse of 20 minutes, during which the subject was permitted to leave the dark room and move about at ease in the laboratory. In some instances, subjects sat quietly in the laboratory between repeated tests. The instrument, observer, and test procedure were identical for first and second tests of the duplicate set. The only difference between the first and second tests was one of order. To obtain an estimate of difference in threshold values at several observation times, the observations were made at certain specified times during the test. They were at .5, 3.5, 6.5, 9.5, 12.5, 15.5, 18.5, 21.5, 24.5, 27.5, 30.5, and 33.5 minutes in the dark. The actual observation time of the threshold might vary by $\pm$ 30 seconds from the time specified. This range of tolerance was more than sufficient, and in practice the actual observation time corresponded to the specified time within a few seconds.

One or two of the eighty-three subjects had had previous experience with the adaptation test. For the other subjects, the duplicate tests were the only adaptations experienced. There were sixty-one men and twenty-two women in the group. Their ages ranged from 20 to 65 years. It is likely that the response of this group to the test may be regarded as typical of the performance of lay subjects who are average in interest and intelligence.

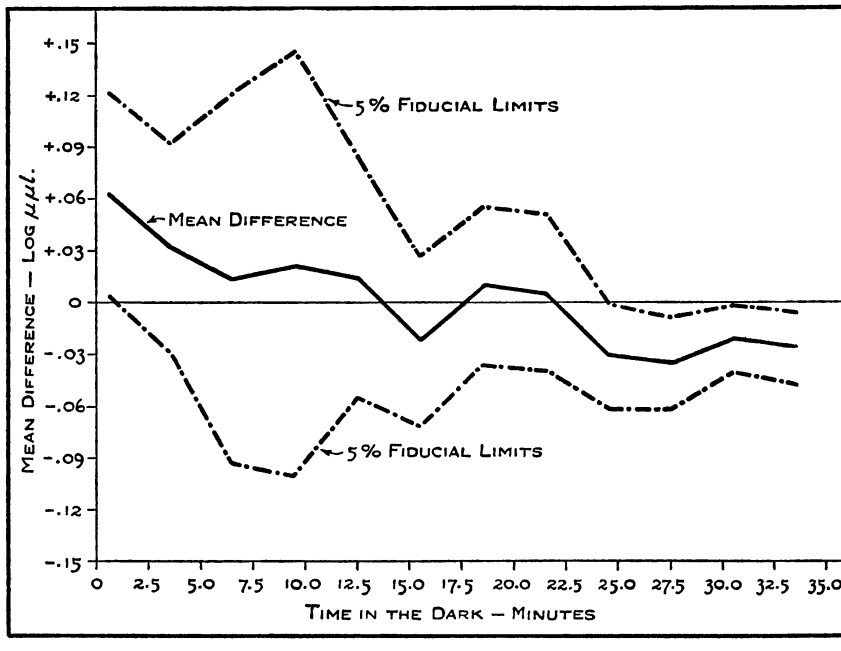
In Table 5 are shown the mean difference, its standard error

Minutes in the Dark	Cases Observed at Time Specified	Difference in Thresholds (Log of $\mu\mu l$)					
		Mean	Standard Deviation (s)	$\frac{s}{\sqrt{2}}$	Standard Error	Range	Fiducial Limits 5 Per Cent
.5	83	+.063	.2657	.1879	.0292	−1.44 + .73	+.005 +.121
3.5	83	+.032	.2772	.1960	.0304	−1.23 +1.00	−.028 +.092
6.5	83	+.014	.4899	.3464	0538	−1.95 +1.48	−.093 +.121
9.5	83	+.022	.5636	.3985	.0619	−2.01 +1.62	−.101 +.145
12.5	83	+.014	.3161	.2235	.0347	− .84 + .97	−.055 +.083
15.5	83	−.022	.2276	.1609	.0250	− .73 + .64	−.072 +.028
18.5	83	+.010	.2155	.1524	.0236	− .49 + .43	−.037 +.057
21.5	83	+.006	.2072	.1465	.0227	− .48 + .56	−.039 +.051
24.5	83	−.031	.1387	.0981	.0152	− .50 + .34	−.001 −.061
27.5	82	−.035	.1212	.0857	.0134	− .52 + .21	−.008 −.062
30.5	83	−.021	.0872	.0617	.0096	− .34 + .17	−.002 −.040
33.5	82	−.026	.0912	.0645	.0101	− .43 + .12	−.006 −.046

Table 5. Difference in threshold, at corresponding times in the dark, between determinations in two consecutive dark adaptation tests.

and the standard deviation of the distribution of differences, and other data, according to the time in the dark at which the thresholds

Fig. 3. Mean difference in threshold, at corresponding time in the dark, between duplicate dark adaptation tests. (First test minus second test.)

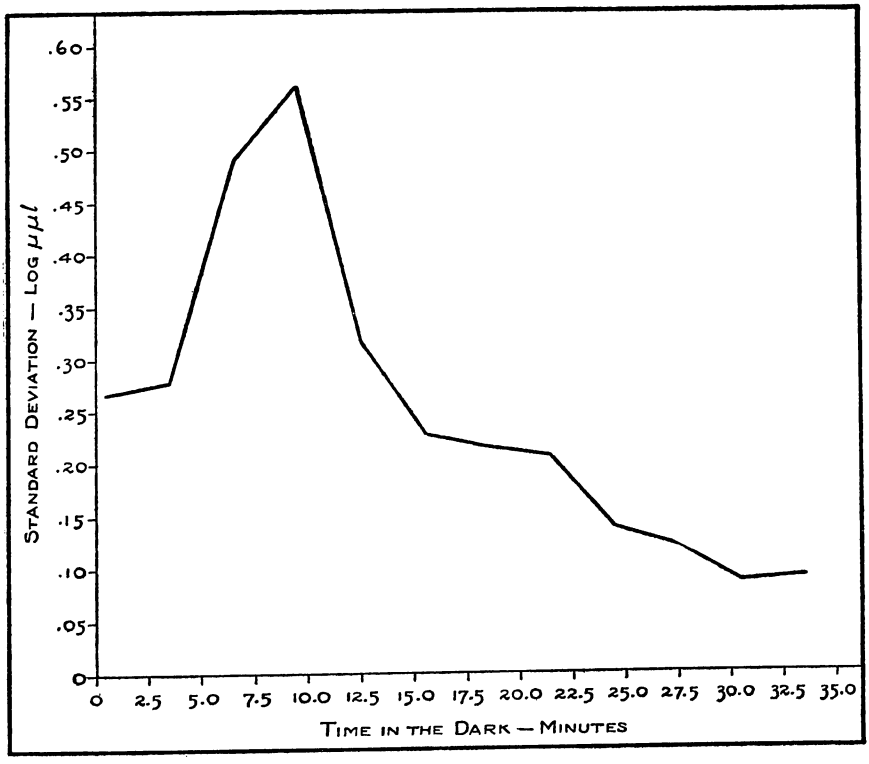


were determined. In computing the difference, at any given time, between the first and second tests, the value of the threshold obtained for the second test has been subtracted from the value obtained during the first test.

In Figure 3 the mean difference and its 5 per cent fiducial limits, at successive observation times, are shown. At 0.5 minute the threshold was significantly higher in the first test of the pair of duplicates. At 24.5 minutes and later, the threshold was significantly higher in the second test.

Figure 4 shows the trend of the standard deviation of the difference between duplicate tests. The variability increased rapidly to a maximum of 0.56 log units at 9.5 minutes, after which there was an equally rapid decline to approximately 15.5 minutes, and a con-

Fig. 4. Standard deviation of the difference in threshold, at corresponding time in the dark, between duplicate dark adaptation tests. (First test minus second test.)



tinued slower decline to a minimum of 0.09 log units at 30.5 and 33.5 minutes. Thus, relatively large differences were common earlier in the test. If the extreme variations are considered as shown in the range, it is found that the discrepancy between duplicate readings for the same individual may equal or exceed a whole log unit at 9.5 minutes or earlier. At 30.5 and 33.5 minutes the total range of observed differences did not exceed .5 log unit and the majority of differences were in the interval $\pm$ .10 log units.

From the standard deviation of the difference, at each observation time, the variability of a hypothetical population may be estimated from which the repeated observations may have been drawn. Such variabilities are shown in column 5 of Table 5. If these variabilities are regarded as a measure of experimental error, it is evident that only larger differences in threshold can be distinguished from error before approximately 25 minutes. When judging changes in the individual's threshold, or when attempting to evaluate individual and group differences, more discriminating observations can be made after 30 minutes in the dark.

The observed differences and their variabilities are conditional upon the standard routine of the test in these examinations. A less detailed standardization of procedure would be expected to lead to even greater and more variable differences. Also, if preadaptation brightness, the size and position of the test field, duration and color of test object, and other specifications of the test were altered, the correspondence between duplicate tests would no doubt vary widely from the present findings.

It is worthy of note that the larger differences between duplicate thresholds and therefore the less reliable observations were obtained at the time when cone adaptation was slower and rod adaptation was presumably most active.

The significantly lower value of the threshold at 0.5 minute for the second test may well reflect a learning process during the duplicate tests.

By the end of the first test, the subject had experienced the just perceptible flash of the nearly dark-adapted eye. Such flashes lack form and color and the image is often a presence without other well-defined characteristics. It is not unlikely that persons who have experienced the image of the just perceptible final flashes, do, on retest, revise their concepts of seen and not seen, so that at the time of the second test, affirmative responses are given earlier to marginal images which would at first have been reported as not seen. It should be considered also that the subject may become conditioned to the sound of the shutter and doubtful images may be reported as seen when actually the response is to the sound of the shutter.

Summary

In the present study, field experience with the adaptometer described by Hecht and Shlaer indicates that certain modifications and extensions of the original specifications are desirable if comparable results are to be obtained for different instruments within a given investigation and for different instruments in different laboratories. In brief, the following suggestions are made:

1. To ensure stable calibrations of the wedge and "neutral" filters, these parts of the intensity control system should be made of glass. The impermanence of gelatin-between-glass is well known and no assurance can be given, even if the original calibrations are accurate that they will remain so.

2. A check of the calibration of chromatic filters in commercially procured instruments is desirable. The error of calibration of these filters can be reduced by employing a standard procedure of calibration, less dependent upon the visual idiosyncracies of the individual observer.

3. Use of the "standard reference lamp" supplied with the adaptometer indicates that estimates of the brightness of the light source, obtained with this standard, differ significantly according to the observer. Either another reference standard should be used or the present one modified. In the present study, estimates of brightness with the Macbeth illuminometer appeared to be satisfactory.

4. As now constructed, the preadaptation brightness of the adaptometer cannot be controlled conveniently. Adjustment of the operating current, by means of a manually-controlled rheostat and voltage regulator assembly attached to each adaptometer, was adopted temporarily in the present study as the most feasible expedient to bring about uniform preadaptation brightness. Data are presented which show that uniform preadaptation brightness is essential if comparable results during dark adaptation are to be obtained with different instruments.

Under the heading of "errors of measurement," the results of two experiments are reported:

1. Variation in the subjective criteria of perceptible light flashes may be of sufficient magnitude to account for a considerable proportion of the variation among different individuals in final threshold values obtained after 30 minutes of dark adaptation.

2. Study of duplicate adaptometer tests indicates that there is a marked difference in the reliability of threshold measurements for different periods during dark adaptation. The variability of duplicate tests increases rapidly from 30 seconds to a maximum at 9.5 minutes and thereafter declines to a minimum of ± 0.09 log units after 30 minutes of dark adaptation.

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