

ALTERNATIVE APPROACHES TO THE ESTIMATION OF THE NUMBER OF CENTENARIANS IN THE UNITED STATES

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Centenarians are a subject of interest and curiosity to most people. Newspapers generally publish accounts of an individual's one hundredth birthday along with interviews about the centenarian's "philosophy of life" and what the centenarian thinks enabled her or him to live so long. In addition to this public curiosity, there is interest on the part of the scientific community. Gerontologists have long been interested in persons who live to be 100 or more years of age in order to secure information that might increase understanding of the aging process and on the characteristics of persons who succeed in living to an extremely high age.

The number of people who are 100 years old or over in the United States is not known exactly. Reporting and processing errors associated with the age question in the 1970 Census are believed to be responsible for a large overstatement of the number of centenarians. The work reported in this paper suggests that about 95 percent of the 106,000 reported centenarians in the 1970 Census are in fact less than 100 years old. The counts in the 1960 and 1950 Censuses appear to show smaller excesses of centenarians; these excesses resulted principally from exaggerated reports of age on the part of the extreme aged.

Four bases of estimating the number of centenarians, with variants, for 1970, 1960, and 1950 are described in this paper: (a) tabulations from "Medicare" records; (b) the forward-survival method; (c) the vital statistics method; and (d) population reconstruction from death statistics. The direct use of Medicare tabulations is not possible for 1960 and 1950 and the vital statistics method was not applied for 1950. Preferred estimates of the number of centenarians were then derived by weighting the resulting individual estimates.

Age misstatements by respondents and failure to enumerate centenarians must have affected the count of centenarians in 1970. However, the overstatement of the number of centenarians in that census appears to have resulted principally from a misunderstanding on the part of certain respondents as to the proper manner of filling out the census forms and from the processing problems associated with these improperly completed forms. Examination of some questionnaires showed that respondents born in the January-March quarter occasionally marked the circle to the right of the column designated "month of birth" rather than the circle to the left, as required. This mark would indicate birth in the decade of the 1860's and, as a result, the person would be counted as 100 years of age or more by the optical sensing devices used to read the census questionnaires. This quarter of birth is lined up directly with the decade of the 1860's for the first person listed, the third person listed, etc. The actual age of a person assigned an age over

100 as a result of this error may have been considerably less than 100.

DATE OF BIRTH				
5. Month and year of birth and age last birthday Print	6. Month of birth Fill one circle	7. Year of birth Fill one circle for first three numbers Fill one circle for last number		
Month -----	<input type="radio"/> Jan.-Mar.	<input type="radio"/> 186-	<input type="radio"/> 192-	<input type="radio"/> 0 5
	<input type="radio"/> Apr.-June	<input type="radio"/> 187-	<input type="radio"/> 193-	<input type="radio"/> 1 6
	<input type="radio"/> July-Sept.	<input type="radio"/> 188-	<input type="radio"/> 194-	<input type="radio"/> 2 7
Year -----	<input type="radio"/> Oct.-Dec.	<input type="radio"/> 189-	<input type="radio"/> 195-	<input type="radio"/> 3 8
		<input type="radio"/> 190-	<input type="radio"/> 196-	<input type="radio"/> 4 9
Age -----		<input type="radio"/> 191-	<input type="radio"/> 197-	<input type="radio"/> 5 0
Month -----	<input type="radio"/> Jan.-Mar.	<input type="radio"/> 186-	<input type="radio"/> 192-	<input type="radio"/> 0 5
	<input type="radio"/> Apr.-June	<input type="radio"/> 187-	<input type="radio"/> 193-	<input type="radio"/> 1 6
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Year -----	<input type="radio"/> Oct.-Dec.	<input type="radio"/> 189-	<input type="radio"/> 195-	<input type="radio"/> 3 8
		<input type="radio"/> 190-	<input type="radio"/> 196-	<input type="radio"/> 4 9
Age -----		<input type="radio"/> 191-	<input type="radio"/> 197-	<input type="radio"/> 5 0

The overcounts of centenarians in censuses before 1970 are believed to result principally from age misstatements by respondents. No verification is required when an individual reports his or her own age or the age of other members of the household in the census. At the "younger" ages (e.g., below 75), the reporting of age is reasonably accurate, at least in terms of 5-year age groups, and most errors of overstatement of age are offset by errors in the other direction. ^{1/} However, there is a tendency on the part of respondents, either the individuals, their relatives, or other fellow-householders, to overstate the ages of persons in extreme old age.

There are many stories of elderly individuals aging fifteen or more years between decennial censuses; the following anecdote is a humorous example of age misstatement:

In the matter of prolonging human life, science has played no part whatever. Take the history of one Bessie Singletree....

On her twenty-seventh birthday Miss Singletree became twenty-four years of age and was married. At thirty-five she was thirty. At forty she was thirty-nine until she was close to fifty.

At fifty Bessie was forty; at sixty, fifty-five. At sixty-five she was sixty-eight and on her seventieth birthday everyone said Grandmother Singletree was pretty chipper for an octogenarian. At seventy-five she had her picture in the paper as the oldest woman in the county, aged ninety-three. Ten years later she passed away at the ripe old age of one hundred and nine. ^{2/}

The matter of accuracy of age statements must also be born in mind when evaluating estimates of the "true" number of centenarians because the estimates themselves employ census and other data involving reports of age; these include data from prior censuses, death statistics, and "Medicare" enrollments. Specifically, the tendency for gross age misreporting may affect estimates based on components which rely on direct statements of age made either by the reported centenarian, some other member of his or her household, or a relative or friend. Hence, the problem of age misreporting affects all of the estimating procedures discussed below.

Estimates of Centenarians in 1970

Tabulation of Medicare Records

"Medicare" records show 7,341 centenarians as of April 1, 1970 (Table 1). This figure is based on a tabulation of persons who reported a date of birth prior to April 1, 1870.

The ages reported by Medicare enrollees are not commonly validated at the extreme ages. Age verification has been required from the beginning of the program to determine eligibility,^{3/} but it has been aimed primarily at establishing whether a person had attained age 65. Because of the problem of unverified ages, the Medicare figures may greatly misstate the actual number of centenarians and, in particular, may tend to overstate the actual number.

Survival from Prior Censuses

One estimation procedure involves "projecting" the population at one census date to a later date through the use of appropriate survival rates. The accuracy of estimates prepared in this manner depends upon the accuracy of the initial population and the survival rates. The initial population can be either the population 90 years old and over or the population 80 years old and over, depending on which census is used. Age statements in the census are presumably somewhat more accurate at these "younger" ages than for centenarians. On the other hand, some error is contributed by the error in the survival calculations. On balance, the projected number of centenarians in 1970 based on the 1960 or 1950 Census is believed to be a more accurate estimate than the direct report in the 1970 Census. Specifically, the estimate of the number of individuals 100-104 in 1970 calculated as survivors of the population 80-84 in 1950 is less likely to be an overstatement of the number of individuals 100-104 in 1970 than an estimate based on direct statements of age made in 1970.

The choice of life tables from which the survival rates are computed is crucial to this estimation procedure. The mortality rates in the United States official life tables are based on the experience of Civil War veterans who had been on pension rolls for many years, so that the reported ages of death and of the population are considered reasonably reliable. Furthermore, both the numerator and denominator of the rates

are drawn from the same universe, so that the rates can be considered fairly accurate.

Estimates of the number of centenarians in 1970 derived by the forward-survival method using life table survival rates are lower than the estimates made by any of the other methods. Applying survival rates from the 1959-61 official U. S. life tables to the 1960 Census population aged 90 and over (in quinquennial age groups by race and sex) yields an estimate of 3,395 centenarians in 1970. If the 1950 population aged 80 and over is carried forward to 1960 with survival rates from the 1949-51 U. S. life tables and then further "projected" to 1970 with rates from the 1959-61 U. S. life tables, an estimate of 3,222 centenarians is obtained.

The mortality rates for Civil War veterans used in closing out the U. S. life tables are, however, out of date; for example, someone as young as 15 in 1860 would have reached 100 in 1945. With improvements in medical technology and care for the aged, it is possible that mortality of the extreme aged has decreased and that survival rates have increased. Mortality rates calculated from Medicare records for both the deaths and the population at risk do indeed strongly support this view.^{4/} Applying survival rates based on Medicare data to the population 90 and over in 1960 yields a much higher estimate of centenarians in 1970—7,713.

Inasmuch as the ages reported in Medicare records are not completely validated, particularly the very high ages, these survival rates may also suffer from serious error. In particular, Medicare survival rates are believed to understate the mortality of the extreme aged. The actual mortality of the extreme aged probably falls somewhere between the official death rates and the Medicare mortality. The survival estimate using Medicare rates is, therefore, viewed as an upper limit on the number of centenarians in 1970.

Vital Statistics Method

The number of centenarians at any census date may also be estimated by subtracting from the group aged 90 and over at the previous census the registered deaths occurring in the intervening decade to these age cohorts. An estimate of the number of centenarians in 1970 may be obtained by subtracting from the population aged 90 and over in 1960, the sum of one-half the deaths to persons aged 90 in 1960 plus all deaths at ages 91 and over in 1960, plus one-half of the deaths to persons aged 91 in 1961 plus all deaths at ages 92 and over in 1961, and so on through 1969. This method may be summarized in equation form as

$$P_{100+}^{t+10} = P_{90+}^t - \sum_{i=0}^9 \left(\frac{1}{2} d_{90+i}^{t+1} + \sum_{j=1}^{\omega} d_{90+i+j}^{t+1} \right) \quad (1)$$

where P_m^t = population at age m in year t ; d_k^t = deaths at age k in year t ; and ω = the highest recorded age at death minus $(90 + i)$. This method assumes zero net international migration.

As in the vital statistics method of estimating net migration, ^{5/} this technique is very sensitive to errors in the components. Small percentage errors in the initial population and in the numbers of deaths may lead to large errors in the estimates of the final population, particularly if these errors are in opposite directions (i.e., are additive). This is especially true in the case of centenarians since the total number of deaths over the decade is very close to the initial population and, in effect, a residual is being estimated. Many of the errors can be attributed to the fact that statements of the age at death of the extreme elderly are often exaggerated by relatives or friends; furthermore, no verification of age is required on death certificates. Because of the sensitivity of this method to errors in the data and because of the magnitude of these errors, the vital statistics method does not prove to be satisfactory for estimating the number of centenarians. In fact, the estimate of white female centenarians in 1970 based on the 1960 Census and deaths for 1960-69, as well as the corresponding estimate based on the 1950 Census and deaths for 1950-69, is negative.

Population Reconstruction Using Deaths

Another method uses only death statistics to estimate centenarians and hence avoids the problem of the sensitivity of the vital statistics method to errors in the population data. This is the method of population reconstruction using deaths, or the "method of extinct generations," devised by Paul Vincent.^{6/} This method identifies each death with a particular cohort determined by the year of birth of the cohort. The population at a certain age for a particular date is then equal to the sum of all deaths that occur at or after that age within the same cohort up to its extinction. To estimate the number of centenarians for a given date, the deaths for all age cohorts 100 and over on that date are summed in each subsequent year until all the age cohorts have been reduced to zero.

All the centenarians alive on say, January 1, 1950, were born in 1849 or before. Half of the deaths of persons aged 100 in 1950 can be assumed to occur to the 1850 birth cohort and half to the 1849 birth cohort. Accordingly, half of the deaths at age 100 in 1950 can be assigned to the population 100 and over on January 1, 1950, to allow for part of the loss through death in this population during 1950. Furthermore, all of the deaths to persons aged 101 and over in 1950 belong to the 1950 "generation" of centenarians.^{7/} In 1951 half of the deaths to persons aged 101 and all the deaths to persons aged 102 and over are taken to belong to the 1950 generation of centenarians. The process is repeated for each succeeding year, until the generation dies out completely. This method may be summarized in equation form as

$$P_{100+\omega}^{t+\omega} = 0 = P_{100+}^t - \sum_{i=0}^n (\frac{1}{2}d_{100+i}^{t+i} + \sum_{j=1}^{\omega} d_{100+i+j}^{t+i})$$

$$P_{100+}^t = \sum_{i=0}^n (\frac{1}{2}d_{100+i}^{t+i} + \sum_{j=1}^{\omega} d_{100+i+j}^{t+i}) \quad (2)$$

where n is a sufficient number of years to insure the extinction of the generation and the remaining symbols have the same general meaning as before.

In order to be certain that the complete generation of centenarians has been reconstructed, it is necessary to have data on the number of deaths at age 100 and over by age for about ten years. Since death statistics for single ages over 100 are available only through 1973, it is not possible to reconstruct the 1970 generation of centenarians completely from reported data.^{8/} Two methods of using the available data and estimating the missing data are employed here. The first method is to reconstruct the population 100 years old and over in 1970 by using the death statistics for 1970-73 and assuming that the number and distribution of deaths at ages 100 and over would remain unchanged in subsequent years. Under this procedure the estimated number of centenarians in 1970 is 8,211.

The second method of completing the reconstruction of the centenarian population with an incomplete series of death statistics is based on a mathematical analysis of the pattern of the recorded death statistics employed in the reconstruction of the centenarian populations in 1950 and 1960. If the logarithm of the number of deaths to a generation of centenarians in each calendar year is plotted against the midpoint of the minimum age of the generation in that year, the result approximates a straight line. For example, the white male centenarian generation of 1950 experienced 240 deaths with a minimum age midpoint of 100.5 in 1950, 157 deaths with a minimum age midpoint of 101.5 in 1951, 103 deaths with a minimum age midpoint of 102.5 in 1952, and so on. The linear correlations between the logarithms of the annual numbers of deaths and the minimum ages are extremely high for all the race-sex groups for the generations of 1950 and 1960 when the line is fitted to four data points (the number available for estimation in 1970) and when the line is fitted to 10 points (the approximate number necessary to obtain a direct estimate of the initial size of the generation). The correlation coefficients range from -.978 for the 1950 generation of Negro-and-other-races males (using 4 data points) to -.999 for the 1950 generation of white females (using 10 data points); most coefficients are in the vicinity of -.99.

Because of the high linear correlation, it is possible to estimate closely the number of deaths to a generation of centenarians from an equation, fitted by least squares, of the form

$$\ln(d) = m \cdot (a-100) + b \quad (3)$$

where a is the midpoint of the lowest age of the generation in the year, d is the number of deaths to the generation during the calendar year, and b

and m are, respectively, the y-intercept of the equation (age = 100) and the slope ($m < 0$). However, it is not necessary to compute d for each year separately. By taking anti-logarithms, equation (2) can be transformed into

$$d = e^{m \cdot (a-100) + b} \quad (4)$$

The area under this curve for all ages over 100 represents the total deaths occurring to the generation of centenarians and hence the initial size of the generation; thus,

$$D = \int_{a=100}^{\infty} d = \int_{100}^{\infty} e^{m \cdot (a-100) + b} da \quad (5)$$

where D represents the initial size of the generation. Because m , the slope of the fitted line, is negative, the integral in equation (5) has a closed-form solution which permits the estimation of the number of centenarians in a given year from the parameters of equation (3). The estimate of centenarians based on this method is derived from the equation

$$D = -\frac{e^b}{m} \quad (6)$$

The parameters for equation (6) can be obtained separately for each race-sex group; furthermore, any number of points from two to the maximum number available may be used to estimate the parameters. Fitting the equation to all four data points², 1970 to 1973, we obtain 7,854 as the estimate of the number of centenarians in 1970. This estimate is only slightly lower than that obtained using the assumption of a stationary population.

Synthesis of the Estimates of Centenarians in 1970

Our acceptable estimates of the number of centenarians in 1970 fall approximately in the range 3,000-8,000. Four of the estimates are grouped at the upper end of the range; the remaining two fall at the lower end. The four largest estimates are the Medicare figure, the forward-survival estimate based on 1960 Census data and Medicare death rates, and the two population reconstructions using deaths (estimated by least-squares and by an assumption of stationarity). These four all rely heavily at some point on a statement of age made by the reported centenarian or a close relative or friend. Because of this dependence on self-designation as a centenarian, these estimates can be expected to overstate the number of centenarians somewhat.

The remaining two estimates, derived by applying life table survival rates to previous census counts, are, as was noted earlier, believed to be understatements of the true number of centenarians in 1970. The death rates used to compute the 1949-51 and 1959-61 official U. S. life tables are out of date and may be too high, so that the resulting estimate of centenarians for 1970 may be too low.

Although even the acceptable estimates of

centenarians in 1970 are subject to substantial error, they do provide a range of figures which may reasonably be expected to bracket the true number and hence to provide a basis for arriving at a preferred estimate. The preferred estimate of the number of centenarians in the United States in 1970 is 4,800, a figure well within the range of the individual estimates but closer to the lower limit of the range. Of the total, 32 percent are estimated to be male and 19 percent Negro-and-other-races.

Estimates of Centenarians in the 1960 and 1950 Censuses

The 1960 Census shows 10,369 centenarians; of these, 37 percent were male and 27 percent Negro-and-other-races. Comparison with estimates made by using the same techniques as used for the 1970 estimates indicates that the census figures for 1960 substantially overstate the true number of centenarians.

Forward-survival of the population 90 years of age and over in 1950, by quinquennial age groups, by means of life table survival rates, was used to produce two sets of estimates. First, survival rates from the 1949-51 official U. S. life tables were applied to the 1950 population. This procedure yielded an estimate of 2,438 centenarians in 1960 (Table 2). Second, averages of 1949-51 and 1959-61 life table survival rates were applied to the 1950 population. This procedure gave an estimate of 2,668 centenarians in 1960. For white males and for Negro-and-other-races these estimates agree closely or approximately with those obtained by Myers on the basis of similar techniques, but for white females, and hence for all classes, these estimates are well below those obtained by Myers (3,700 for all classes). ¹⁰ Myers' high estimate for white females appears to be the result of a computational error; note that even the estimate for white females made by population reconstruction techniques is a little lower than Myers' estimate.

One set of estimates was also made for 1960 by the vital statistics method. The figures were unreasonably high and showed an unreasonably large proportion of males. Like the figures for 1970 derived by this method, they have been rejected.

Sufficient annual data on deaths by age are available to permit estimating the number of centenarians in 1960 directly by population reconstruction techniques. ¹¹ The estimate obtained from the 1960-73 data is 5,365; of these, 33 percent are male and 40 percent Negro-and-other-races. Estimates made using equation (3), fitted by least-squares to data for various numbers of years, are all quite close to the estimate obtained directly from the deaths reported for all the years (Table 2). As noted above, the population reconstruction method has a strong tendency to overestimate the centenarian population because it is based on direct age statements (on death certificates). Accordingly, the estimates based on the forward-survival

method are believed to be closer to the actual centenarian population in 1960. A preferred estimate of the number of centenarians in 1960, representing an average of the above estimates weighted toward the forward-survival estimates, is 3,300. Of these, 35 percent are estimated to be male and 23 percent Negro-and-other-races.

The 1950 Census count of centenarians was 4,447, with 37 percent male and 55 percent Negro-and-other-races. Again, this is believed to be an overstatement of the number of centenarians then alive. In spite of the poorer health and living conditions of blacks relative to those of white, and the much smaller number of blacks in the general population, more centenarians were reported among the black population than among the white population.

Estimates of centenarians made by the population reconstruction techniques agree closely with the 1950 Census figures in total number and distribution. An estimate made by the authors with annual death statistics for 1950-1973 is 4,617;¹² an estimate made by Rosenwaike with 1951-1964 data is 4,373;¹³ and an estimate based on equation (3) fitted to various numbers of points is 4,506. These are believed to be overestimates of the actual number of centenarians in 1950. The agreement between the census figures and the estimates suggests that the pattern of age misstatements in the 1950 Census was generally consistent with the pattern of age misstatements for the ages given at death over the period 1950-60.

A much lower estimate of the number of centenarians in 1950 was obtained by use of the forward-survival technique with 1940 Census data and survival rates from the 1939-41 U. S. life tables. This estimate is 1,807 centenarians; of these, 34 percent were male and 36 percent Negro-and-other-races. Myers, using similar methods, estimated about the same number of centenarians in 1950—1,693. A preferred estimate of the number of centenarians in 1950, taking into account the range delimited by our previous calculations but assigning principal weight to the lower estimates, is 2,300. Of these, 35 percent are estimated to be male and 41 percent Negro-and-other-races.

Conclusion

Several different methods can be employed to estimate the number of centenarians in each of the past three censuses. Those methods which do not rely on direct statements of age by the reported centenarians themselves or their immediate families are likely to give the more accurate estimates. Our preferred estimates of the number of centenarians for the past three census years are: 4,800 for 1970, 3,300 for 1960, and 2,300 for 1950. All methods depend to some extent on unvalidated reports of age at the extreme upper ages, and hence all of the estimates are subject to large relative errors, as are the corresponding estimates by sex and race. They do clearly reflect the considerable overstatement of centenarians in recent U. S. censuses and the fact that only a negligible portion of our population

survives to the age of 100.

Overstatement of age in the census data and in most of the estimates is apparent from the estimates of the number of black centenarians. It may be maintained that the proportion of blacks who are centenarians should probably be no larger, or only slightly larger, than the proportion of blacks in the total population (11 percent in 1970) or, more reasonably, the proportion in the population 65 and over (8 percent). In fact, given the generally poorer living conditions among blacks and lower life expectancy at birth and most other ages, the proportion would be expected to be less. On the other hand, in the view of the lower death rates recorded for blacks than for whites at the very high ages and the possible role of selective factors affecting a population subject to excessive environmental stresses, the proportion of blacks could, in fact, rise with increasing age at the very high ages.

A tendency to overreport age among the extreme aged is apparently characteristic of populations in general. Excessive reporting of centenarians has been especially noted among groups with generally lower levels of living and poorer health conditions, and particularly with poorer registration systems or poorer vital statistics reporting. Bowerman found an extremely high correlation between the proportion of reported centenarians in a State in the 1930 Census and the proportion of the population which was illiterate.¹⁴ The tendency to exaggerate age appears to be especially great among illiterate or semi-literate populations in which much of the history and tradition of the society are handed down orally. Medvedev notes that concentrations of longevity are reported for the U.S.S.R. mainly in isolated areas where traditional life styles are maintained; he raises serious questions about the validity of the reports.¹⁵

Until a complete population register or vital registration system has been in existence in a country for at least 100 years, it is unlikely that the true number of centenarians can be known. At least another three-quarters of a century has to pass for this to occur in the United States. Under these circumstances, census reports of centenarians can hopefully be validated against birth certificates.

Already, Social Security data and Medicare data are beginning to become available which make possible more meaningful analyses of mortality among the extreme aged in the United States. The Social Security rolls and the Medicare rolls cover nearly all aged persons, but age assignment at the higher ages, as stated before, is subject to considerable question. Most of those whose ages were precisely verified (i.e., at the beginning of the program) are now just reaching 100 years of age; in 10 years the survivors, if any, of the group will reach 110 years of age. Their records should provide high quality data on the mortality experience of the group which should aid greatly in the estimation of the true number of centenarians. Possibly also, within a few decades, the Social Security files will permit fairly close measurement of the number of centenarians since, by that time, most persons identified as centenarians in the files will have had their ages precisely validated.

Footnotes

1. U. S. Bureau of the Census, 1970 Census of Population and Housing, Evaluation and Research Program, PHC(E)-11, Accuracy of Data for Selected Population Characteristics as Measured by the 1970 CPS-Census Match, January 1975, Table 1.
2. Norman Ingersoll, Saturday Evening Post, April 18, 1936, quoted in Walter G. Bowerman, "Centenarians," Transactions of the Actuarial Society of America, 40(102), 1939, p. 378.
3. United States Office of the Actuary, Social Security Administration, "Mortality of Charter Beneficiaries," by Francisco Bayo and Margaret A. Lannen, Actuarial Note No. 78, August 1972.
4. Francisco Bayo, "Mortality of the Aged," Transactions of the Society of Actuaries, 24(68), 1972, p. 21.
5. U.S. Bureau of Census, The Methods and Materials of Demography, 3rd printing, by Henry S. Shryock, Jacob S. Siegel, and Associates, U.S. Government Printing Office, 1975, pp. 628-630.
6. Paul Vincent, "La mortalité des vieillards," Population, 6(2), April-June 1951, pp. 181-204.
7. The population 100 and over on January 1, 1950, 101 and over on January 1, 1951, 102 and over on January 1, 1952, etc. is called here the 1950 generation of centenarians.
8. U. S. Department of Health, Education, and Welfare, Public Health Service, National Center for Health Statistics. Vital Statistics of the United States, annual volumes 1950-1971 and 1972-1973 (forthcoming).
9. For Negro-and-other-races females only two points were used because the other estimates were unreasonably high.
10. Robert J. Myers, "Validity of Centenarian Data in the 1960 Census," Demography, 3(2), 1966, pp. 470-476.
11. The reported distributions of deaths by age, sex, and race in 1962 and 1963 were adjusted slightly because New Jersey reported deaths only by age and sex in those years.
12. Because death statistics for certain years were not published by age, sex, and race for ages over 100, the following adjustments were made:
 - (1) Total deaths to persons aged 100 and over, by race and sex, for 1950-1952 were distributed pro rata by the average age distribution of deaths 100 and over in 1953 and 1954 for each race-sex group.
 - (2) Deaths by age and sex to persons aged 100 and over in 1958 were distributed by race according to the average of the race distributions in 1957 and 1959 for each age-sex group.
13. Ira Rosenwaike, "On Measuring the Extreme Aged in the Population," Journal of the American Statistical Association, 63(321), March 1968, pp. 29-40.
14. Bowerman, op. cit.
15. Zhores A. Medvedev, "Caucasus and Altay Longevity: A Biological or Social Problem," The Gerontologist, 14(5), October 1974, pp. 381-387.

Table 1. Alternative estimates of the population 100 years old and over, by sex and race: April 1, 1970

Estimation method	All classes	White		Negro-and-other-races	
		Male	Female	Male	Female
<u>Number</u>					
Census count ^{1/}	106,441	46,015	42,965	8,323	9,138
Medicare records ^{2/}	7,341	1,508	4,209	513	1,111
Forward-survival					
From 1960 with 1959-61 life table rates	3,395	1,109	1,985	121	180
From 1950 with 1949-51 and 1959-61 life table rates	3,222	1,090	1,795	136	201
From 1960 with Medicare rates	7,713	1,606	4,263	651	1,193
Population reconstruction ^{3/}					
Stationary assumption	8,211	1,387	3,957	958	1,909
Least squares ^{4/}	7,854	1,441	4,173	661	1,579
Preferred estimate	4,800	1,250	2,650	300	600
<u>Percent</u>					
Census count ^{1/}	100.0	43.2	40.4	7.8	8.6
Medicare records ^{2/}	100.0	20.5	57.4	7.0	15.1
Forward-survival					
From 1960 with 1959-61 life table rates	100.0	32.7	58.5	3.6	5.3
From 1950 with 1949-51 and 1959-61 life table rates	100.0	33.8	55.7	4.2	6.2
From 1960 with Medicare rates	100.0	20.8	55.3	8.4	15.5
Population reconstruction ^{3/}					
Stationary assumption	100.0	16.9	48.2	11.7	23.2
Least squares ^{4/}	100.0	18.3	53.1	8.4	20.1
Preferred estimate	100.0	26.0	55.2	6.2	12.5

^{1/} U. S. Bureau of the Census, 1970 Census of Population, General Population Characteristics, Final Report PC(1)-B1, U. S. Summary, Table 50 and Appendix B.

^{2/} Persons whose race or sex were not reported have been distributed pro rata; figures include 165 persons whose sex was not reported, 864 whose race was not reported, and 5 persons whose race and sex were not reported.

^{3/} For January 1, 1970.

^{4/} Fitted equations use four data points except for Negro-and-other-races females (two points).

Table 2. Alternative estimates of the population 100 years
old and over, by sex and race: April 1, 1960

Estimation method	All classes	White		Negro and other races	
		Male	Female	Male	Female
<u>Number</u>					
Census count	10,369	2,755	4,783	1,075	1,756
Forward-survival					
From 1950 with 1949-51 life table rates	2,438	803	1,368	100	167
From 1950 with average life table rates	2,668	840	1,512	115	201
Myers' estimate	3,684	794	2,628	93	169
Population reconstruction ^{1/}					
Direct, 1960-73 deaths	5,365	977	2,266	768	1,354
Least squares					
Fitted to three points	5,508	1,006	2,315	851	1,336
Fitted to ten points	5,346	947	2,304	755	1,340
Preferred estimate	3,300	875	1,675	275	475
<u>Percent</u>					
Census count	100.0	26.6	46.1	10.4	16.9
Forward-survival					
From 1950 with 1949-51 life table rates	100.0	32.9	56.1	4.1	6.8
From 1950 with average life table rates	100.0	31.5	56.7	4.3	7.5
Myers' estimate	100.0	21.6	71.3	2.5	4.6
Population reconstruction ^{1/}					
Direct, 1960-73 deaths	100.0	18.2	42.2	14.3	25.2
Least squares					
Fitted to three points	100.0	18.3	42.0	15.5	24.3
Fitted to ten points	100.0	17.7	43.1	14.1	25.1
Preferred estimate	100.0	26.5	50.8	8.3	14.4

^{1/} For January 1, 1960.

Table 3. Alternative estimates of the population 100 years old and over, by sex and race: April 1, 1950

Estimation method	All classes	White		Negro-and-other-races	
		Male	Female	Male	Female
<u>Number</u>					
Census count	4,447	807	1,200	858	1,582
Forward-survival					
From 1940 with 1939-41 life table					
rates	1,807	430	726	184	467
Myers' estimate	1,693	463	774	149	307
Population reconstruction ^{1/}					
Direct, 1950-73 deaths	4,617	735	1,265	899	1,718
Rosenwaike's estimate	4,373	(NA)	(NA)	(NA)	(NA)
Least squares estimate					
Fitted to three points	4,849	701	1,254	732	2,162
Fitted to ten points	4,573	708	1,239	863	1,763
"Best" fit ^{2/}	4,506	711	1,254	845	1,696
Preferred estimate	2,300	500	850	300	650
<u>Percent</u>					
Census count	100.0	18.1	27.0	19.3	35.6
Forward-survival					
From 1940 with 1939-41 life table					
rates	100.0	23.8	40.2	10.2	25.8
Myers' estimate	100.0	27.3	45.7	8.8	18.1
Population reconstruction ^{1/}					
Direct, 1950-73 deaths	100.0	15.9	27.4	19.5	37.2
Rosenwaike's estimate	100.0	(NA)	(NA)	(NA)	(NA)
Least squares					
Fitted to three points	100.0	14.5	25.9	15.1	44.6
Fitted to ten points	100.0	15.5	27.1	18.9	38.6
"Best" fit ^{2/}	100.0	15.8	27.8	18.8	37.6
Preferred estimate	100.0	21.7	37.0	13.0	28.3

(NA) Not available

^{1/} For January 1, 1950.

^{2/} Seven data points were used for white males and Negro-and-other-races females, three for white females, and eight for Negro-and-other-races males.