EXAMINATION OF THE PUERTO RICAN

LONGEVITY ADVANTAGE

FINAL PROGRESS REPORT

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SECTION 1

INTRODUCTION

The developing countries of the world have experienced unprece-
dented improvement in mortality since World War II. Yet by the 1970s the
disparity in average expectation of life at birth, a traditional mea-
sure of health status, between the less developed and more developed
nations remained great: almost 20 years (United Nations, 1979; Shanas
and Maddox, 1976). In one less developed area, Puerto Rico, progress
in reducing mortality has apparently been so rapid that present life
expectancy at birth does not greatly differ from that of the advanced
industrialized nations. Life expectancy is so high, according to the
available statistics, that the population of Puerto Rico currently ap-
pears to be one of the most longevous in the world.

The particularly successful campaign to reduce mortality at all
age levels in Puerto Rico has been reported by leading demographers.
Kingsley Davis (1956) has summarized the situation: "This achievement
is the result of modern sanitation, better medical treatment, and a
higher level of living . . . Puerto Rico has telescoped into a few
years the health progress made in advanced countries over several de-
cades." Stolnitz (1956) in a similar vein, has observed that: "In
Puerto Rico, where expectation of life at birth rose by about 12 years
between 1940 and 1950 . . . the annual rate of increase was greatly
above, generally by several times, the highest changes recorded by
western populations." By 1960, the length of life expected at birth
had reached 67.3 years among Puerto Rican males and 72.1 years among
Puerto Rican females, some 22 and 25 years, respectively, above the

level two decades earlier (Stolnitz, 1967). Johnson (1967) attributes

these spectacular gains to be the benefits of public health campaigns

in which environmental sanitation and improved housing conditions were

among the major targets.

Légaré (1967) seems to have been the first to observe, in the 1960s,

that as a result of the considerable decline in adult mortality in Puerto

Rico, the average expectancy of life at age 45 had risen to a level com-

parable to that in developed countries recognized as being among the

most longevous:

> During the last twenty-five years, the expectation of life
> at age 45 has risen in most countries of the world. In five
> countries it is at least thirty-one years of age: these are,
> in descending order, Norway, Puerto Rico, the Netherlands,
> Sweden and Israel. These five countries are the only ones which
> have an expectation of life over thirty years for males at age
> 45. . .

Data available for the early 1970s show the pattern described by

Légaré has continued (United Nations, 1975). Furthermore, figures pub-

lished for the period 1969-71 show that life expectancy among both males

and females in Puerto Rico exceeded that for males and females in the

United States. The Puerto Rican advantage in expectation of length of

life was especially noteworthy at age 45 (United Nations, 1975; National

Center for Health Statistics, 1975). The figures shown in Table 1 indi-

cate that at age 45, average expectation of life among males in Puerto

Rico exceeds that for males in the United States by 3.1 years; for fe-

males the Puerto Rican figure is 1.1 years higher.

The importance of determining the accuracy of current mortality

rates for Puerto Ricans is significant for several reasons. First, given

the recent substantial reduction in the fertility rate, there is a general

problem of the future aging of the population of Puerto Rico. As

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TABLE 1. Expectation of Life, Selected Populations, by Age and Sex

Age and Sex	United States			Puerto Rico
	Total	White	Nonwhite	
BIRTH				
Male	67.0	67.9	61.0	69.0
Female	74.6	75.5	69.1	75.2
45 Years				
Male	27.2	27.5	24.6	30.3
Female	33.1	33.5	29.8	34.2

Spiegelman and Erhardt (1974) have succinctly stated: "Improved chances
of survival have increased the numbers brought to the later ages of life,
thereby enlarging the problems . . . relative to the social, economic and
medical care needs of the aged; the problems are being accentuated by the
rise in the longevity of the aged." Associated with this phenomenon is
the concomitant question of whether the recent mortality trend in Puerto
Rico is unique or a prototype of a pattern soon to be repeated in other
developing parts of Latin America.

Comparison of the death rates of Puerto Ricans, both those living
on the island and those who have migrated to the U. S. mainland, with
the rates for non-Puerto Rican groups in the United States can be im-
portant in explaining variations in levels of mortality among different pop-
ulation subgroups. Racial and ethnic groups must be considered not only
for the influence of genetic and biological constitution upon mortality pat-
terns but also in light of the poorly understood relative effects of
cultural, envioronmental and social factors (Bradshaw and Fonner, 1978).

Socioeconomic status is widely acknowledged to be an important de-
terminant of longevity. In an excellent review of the literature,
Antonovsky (1967) found a continuing disparity in mortality between the
lowest and other socioeconomic groups. Kitagawa and Hauser (1973),
analyzing a study of a large sample of deaths in the United States in
1960 that had been matched with census records, concluded: "the relatively
high mortality of the United States compared with other advanced nations
is undoubtedly in large measure a reflection of the high mortality of

the disadvantaged in the nation - the lower socioeconomic groups of white and the even more disadvantaged groups." Yet the average life expectancy figures for Puerto Ricans in 1969-71 apparently are not in accord with this socioeconomic explanation.

Alers (1978) in a recent report on the Puerto Rican community living in the United States observed that "by almost any measure Puerto Ricans are virtually the most disadvantaged minority in the nation." However, on the basis of socioeconomic level, the differences between life expectancy figures for Puerto Ricans and U.S. blacks are striking. At age 45, for example, life expectancy in Puerto Rico exceeds that of U.S. nonwhites (largely blacks) by more than 4 years (and in addition, exceeds that of U.S. whites). Questions of comparability of data for the United States with that for Puerto Rico are avoided by investigating the experience in the one registration area where data on decedents of Puerto Rican birth and of other backgrounds are routinely collected, coded, and tabulated in a comparable manner: New York City.

The age-adjusted death rates per 1,000 for population groups in New York City in 1959-61 among persons 5 years and over were as follows (Grove, 1968):

Sex	Whites	Nonwhites (chiefly black)	Born in Puerto Rico
Male	13.1	16.0	10.0
Female	9.3	11.6	8.2

Males and females born in Puerto Rico exhibited lower mortality than other major groups residing in the city. Since "occupationally, educationally, and in terms of income, Puerto Ricans are at the very bottom

of the urban stratification heap," (Alers, 1978) an explanation for the low mortality of middle-aged and elderly Puerto Ricans must include examining patterns of age misreporting within the Puerto Rican population.

Several hundred thousand Puerto Ricans migrated to the United States during the 1940s, 1950s and 1960s (Maldonado, 1976). Until the decade beginning in 1970 in-and-out migration in Puerto Rico almost exclusively involved exchanges with the United States: by 1970 about one-quarter of all persons born in Puerto Rico were living in the continental United States. The majority of those Puerto Ricans seeking better economic conditions settled in New York City. Migration tends to be highly selective in terms of age and sex; this makes distinguishing patterns of age reporting unreliable by only looking at the island population. A combined population of Puerto Ricans living on the island and those on the mainland should assist in giving a more accurate figure of age and sex composition and better indicate the recent trends in mortality, as well as identifying errors in age reporting in the census and vital statistics.

The examination of the potential effect of age misreporting is essential as demographers are presently pointing to the Puerto Rican high life expectancy in terms of reliable age reporting. Vaupel et al.(1979), for example, have written that "... Puerto Rico which, among countries for which good mortality statistics are available, is the world's leader in life expectancy at age 65." Before accepting as an accomplished fact the extraordinarily favorable Puerto Rican longevity experience it would seem prudent to carefully investigate the evidence.

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SECTION 2

METHODS OF PROCEDURE

A. Data Sources

1. Death Statistics

As Siegel and Passel (1979) have observed: "Puerto Rican birth and death rates are available for several decades and life tables have been compiled periodically since the early part of the century. These data can serve as bench marks, against which various data and measures for the Puerto Rican population...can be compared."

The statistics of deaths occurring in Puerto Rico by age, sex, and cause for the three-year periods around decennial censuses, 1959-61 and 1969-71, were obtained from the National Center for Health Statistics and the Commonwealth of Puerto Rico Department of Health. New York City is the only source of machine-readable data on deaths within the United States during these years of persons born in Puerto Rico. This source is representative of the mortality statistics for the continental United States because the majority of Puerto Ricans who migrated to the mainland reside in New York City.

The published statistics relating to Puerto Ricans by the New York Department of Health are minimal; therefore unpublished tabulations were obtained from the Director of the Office of Biostatistics of the Department of Health of the City of New York.

2. Census Statistics

Statistics of population are essential as denominators in the calculation of age-specific death rates. Published data on the Puerto

Rican population by age and sex from the 1960 and 1970 censuses were utilized. (U.S. Bureau of the Census, 1962, 1973). The published report on Puerto Rico provides figures by single year of age up to age 84. To evaluate the accuracy of age reporting it is necessary to have single year figures for persons 85 and over. The 1970 figures by single year of age in Puerto Rico were obtained from the U.S. Bureau of the Census computer summary tape files. In addition, in order to obtain selected details from untabulated data, some tabulations prepared from public use samples of the 1970 decennial census were acquired.

B. Method of Analysis

Age-specific death rates utilized in demographic studies are reliable and accurate only if the data from which these measures are derived, population and death statistics, are reliable and accurate. Appraisal of the quality of the statistics collected in decennial enumerations and death registration of Puerto Ricans was the essential first step in determining the degree of confidence which may be given to the published rates. Puerto Rico has a long history of vital registration going back to the nineteenth century. Janer (1945) accepted the death reporting as complete, even those statistics reported in the decade before American rule.

Procedures for appraising the accuracy of the census population data and vital statistics reporting have been developed and tested by demographers associated with the United Nations and with the U. S. Bureau of the Census and have been described in a number of publications (United Nations, 1955; Shryock and Siegel, et al., 1973; Barclay, 1958.) Therefore, these standard procedures are only briefly discussed.

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1. Comparison of observed population data by age and sex with "expected" numbers.

This research examines the age-sex composition reported at successive censuses to see how well it corresponds to known patterns of age-misreporting. The expected numbers are derived from data from the previous or succeeding census by allowing for appropriate numbers of deaths and migrants. To illustrate, the "expected" population aged 75-79 years in 1970 should equal the sum of those aged 65-69 years in the 1960 census minus the deaths among this cohort plus the net migration that occurred in the ten-year intercensal period. The ratio of this "expected" number to the 1970 census count of persons 75-79 years shows the extent of agreement or disagreement of the two figures. Such balancing equations may be applied to the various age and sex subgroups individually and in this study the focus will be on persons in the middle and older age groups. Once the necessary calculations have been done, it remains for the investigator to determine the source of the discrepancies, if any. Are there coverage or age reporting errors in one or both of the census counts, the death statistics, or the migration counts? When the errors have been isolated, "corrected" figures can be presented that more accurately reflect reality.

Another method to compute the "expected" population over age 45 is to apply life table survival rates to the age-sex groups as reported in the earlier census, add net migration to the result, and compare the total with the observed values in the later census. "Corrected" counts can then be produced as above. "The results of this type of

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analysis essentially indicate general patterns and types of errors in
the data, but they are sometimes useful in identifying specific age-
sex groups which are strongly affected by coverage and reporting errors"
(Siegel and Passel, 1979).

2. The examination of age classification in single year and five year
intervals.

The effects of age misstatement, particularly "age heaping," the
tendency of respondents to report ages with certain terminal digits
(e.g., zeros, fives) at the expense of others (Shryock and Siegel, 1973),
are most readily viewed by examining single year of age statistics. A
strong preference for reporting age in digits ending in zero or five was
measured by applying Myers' Blended Index (Shryock and Siegel, 1973).

Whereas single year age distributions may display gross inaccuracies,
when the data are aggregated into five-year intervals many of the report-
ing errors are absorbed to give a reasonably accurate age distribution.
Age ratios can be utilized to evaluate the quality of the count by age
group. An age ratio is defined as "the ratio of the population in the
given age group to one-third of the population in the age group itself
and the preceding and following groups, times 100" (Shryock and Siegel,
1973). Any significant deviation from 100.0, if not accounted for may
then be attributable to age errors in the census.

The method used in determining the accuracy of the distribution of
Puerto Rican population by 5-year age intervals is age ratio analysis.
For this purpose an age ratio is defined as:

$$\frac{5^P a}{1/3(5^P a - 5 + 5^P a + 5^P a + 5)} \times 100$$

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If there have been no extreme fluctuations in past births, deaths, or migration, then the three age groups centered on $_5P_a$ should almost form a linear series. Age ratios should tend to approximate 100 over a range of age intervals. The expectation of 100 assumes that coverage errors are about the same in each age group and that reporting errors in one age group are offset by complementary error in adjacent age intervals. Therefore, deviations from 100 will reflect net age-misreporting plus net differences in coverage. If the deviation is small, age ratios are a valid indicator of net reporting errors. They cannot be taken as valid indicators of gross misreporting for particular groups. An overall age-accuracy index can be constructed by taking the average absolute deviation of age ratios from 100, using all age intervals (Shryock and Siegel, 1973).

3. Census survival ratios

Analysis of consistency in the number of persons recorded at different ages in two successive censuses by means of so-called census survival ratios is helpful in revealing errors in census age data. "Census survival ratios for a population group measure jointly the effects of both mortality during an intercensal period and shifts in net census errors for age cohorts in the two censuses. . . The computation of census survival ratios for a population requires, at a minimum, data distributed by age for the population from two censuses " (Siegel and Passel, 1979.) Since census survival ratios are best calculated for populations not subject to immigration or emigration during the intercensal period,

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an approximation of such a population was derived by utilizing data for the combined total population of Puerto Rican birth - those resident in the United States as well as on the island Commonwealth. Survival ratios between 1950 and 1960 and between 1960 and 1970 were calculated by dividing the number of persons in a five year cohort at the end of a decade into the number at the beginning of the decade; this was done separately for males and females.

4. Computation of sex ratios, the number of males per 100 females, for detailed age categories.

Siegel and Passel (1979) recommend this powerful method of analyzing census figures for coverage and reporting errors of age groups with "expected" sex ratios or sex ratios with known characteristics.

Since female mortality is somewhat less than that of males, the computation of sex ratios is of particular importance in determining if there is underenumeration of elderly females. Assuming complete registration of deaths, selective underenumeration by sex in a census results in an overstatement of death rates for one sex relative to the other. A recent study of 1970 census data for Mexico concluded a major omission of females between the ages of 45 and 84 years had occurred and further observed this pehnomena was probably widespread throughout Latin America (Cabre-Castello, 1977). The possible underenumeration of Puerto Rican females was studied.

5. Intercensal cohort analysis.

Intercensal cohort analysis uses a component estimating equation
to follow a cohort from one census to another. The comparison of
changes in intercensal cohort size to intercensal deaths gives an indi-
cation of registration completeness and the quality of age reporting.
Our study compared the size of open-ended cohorts (e.g., ages 45 and
over) in 1960 to the size of the same cohort in 1970 using the estimates
of the total population of Puerto Rican birth, derived by combining
figures for island and mainland residents.

The procedure used for estimating intercensal deaths by age for the
U. S. population of Puerto Rican birth is as follows: For 1970 the age-
specific death rates of the Puerto Rican born in New York City in 1969-
71 were applied to the total U. S. population of Puerto Rican birth by
age. Each sex was treated separately. For 1960 the estimated age-specific
death rates of the Puerto Rican born in New York City in 1959-61 were
applied to the total U. S. population of Puerto Rican birth by age and
sex. Estimated age-specific death rates were based on indirect standardi-
zation within broad age intervals. These intervals correspond to those for
which Puerto Rican deaths were tabulated in New York City in 1959-61:
ages 24-44 years; 45-64 years and 65 years and over. The "standard"
mortality function adopted was that of the Puerto Rican born in New York
City in 1969-71. Thus, deaths at ages 25-29 in 1960 were estimated as:

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$$_5N_{25}^{PR} \times \; _5M_{25}^{69-71} \times \; \frac{D_{25-44}^{60}}{40 \displaystyle\sum_{x=25} \; _5N_x^{NPR} \cdot \; _5M_x}^{\;69-71} \quad , \text{ where}$$

$_5N_{25}^{PR}$ = number of persons in the U.S., 1960, born in Puerto Rico

$_5M_x^{69-71}$ = age-specific death rate for persons in New York City, 1969-71, of Puerto Rican birth

D_{25-44}^{60} = average annual number of deaths in New York City, 1959-61, to persons of Puerto Rican birth in the age interval 25 to 44

$_5N_x^{NPR}$ = number of persons aged x to x+5 of Puerto Rican birth in New York, 1960

These procedures were applied separately for each sex. The U. S. population of Puerto Rican birth aged 75 and over in 1960 was assumed to be distributed by age as in 1970. For 1961-69 deaths by age were linearly interpolated between the 1960 and 1970 estimates for each sex. A time series of total New York City deaths of the Puerto Rican born showed this to be an acceptable assumption.

SECTION 3

RESULTS

In the sections which follow the results of the examination of the
Puerto Rican longevity advantage are described in detail, for each of
the five methods previously discussed.

A. Analysis of Age-Sex Composition

The population of Puerto Rico at the three censuses of 1950, 1960,
and 1970 was compared for accuracy of age reporting. Figures 1 and 2
show the percent age distribution for Puerto Rican males and females
aged forty and above in 1950. Excluding any effects from migration, a
marked pattern of "age heaping," or the tendency of respondents to re-
port ages with certain terminal digits (e.g., zeros and fives) at the
expense of others, is immediately apparent among Puerto Ricans in 1950.
There is a preference for ages ending in zero; the heaping of ages end-
ing in five is less pronounced. The tendency is to avoid other ages.
This pattern is evident among both sexes, but it is more extreme among
females, where the peaks are higher and the valleys lower.

Figure 3 and 4 show age distributions of Puerto Rican men and women
in 1960. Visually comparing these diagrams with figures 1 and 2, they
indicate a significant decline in the extent of age heaping between 1950
and 1960. The degree of difference between preferred and avoided ages
has been markedly reduced. Also, the pattern of digit preference shifted
from ages 0 and 5 to ages 4 and 9.   This difference reflects a change
in the census question and coding of age between 1950 and 1960, from a
query of age at last birthday to an item on month and year of birth

PUERTO RICAN MALES 40+
1950

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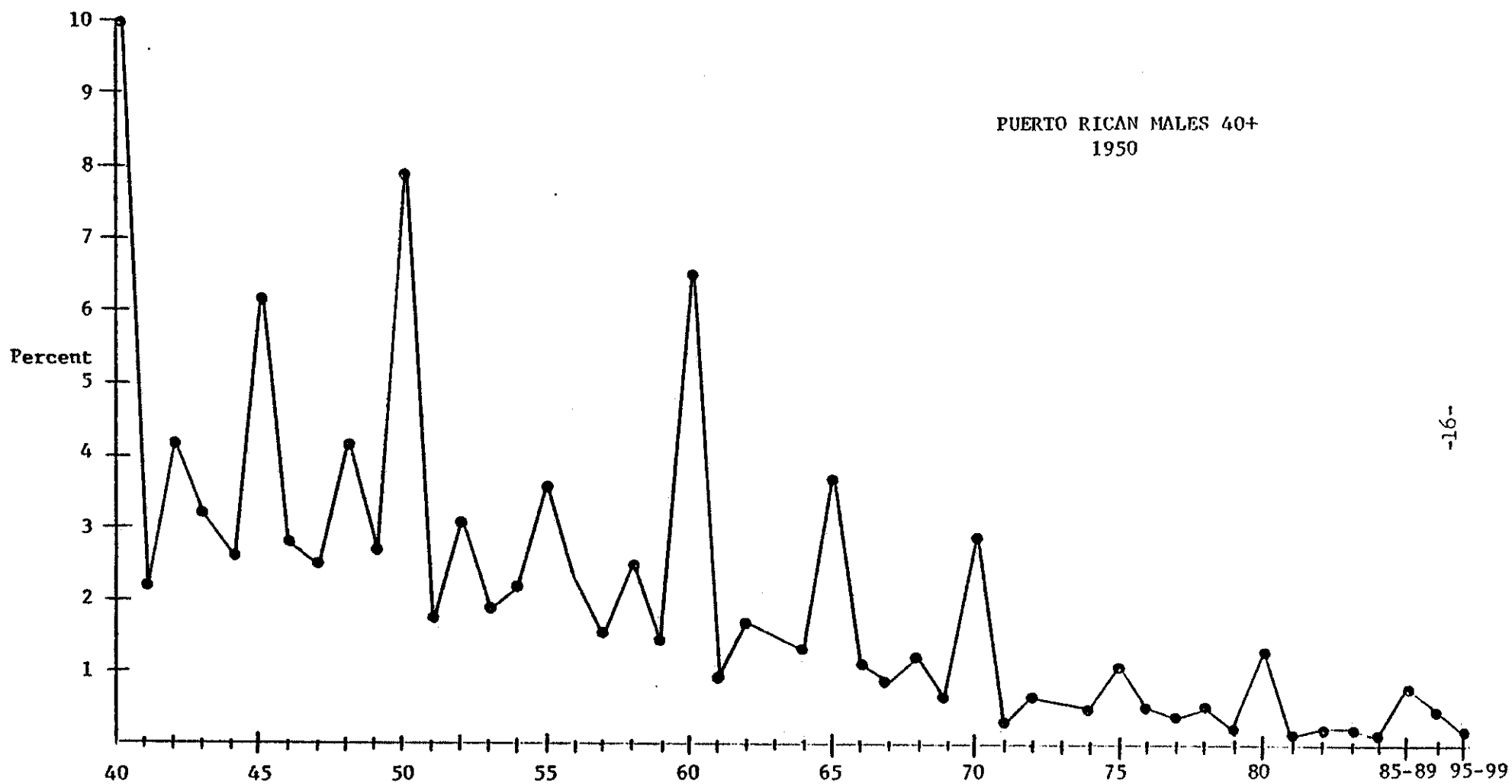
Figure 1.   Percent age distribution of Puerto Rican males aged 40 and above, 1950.
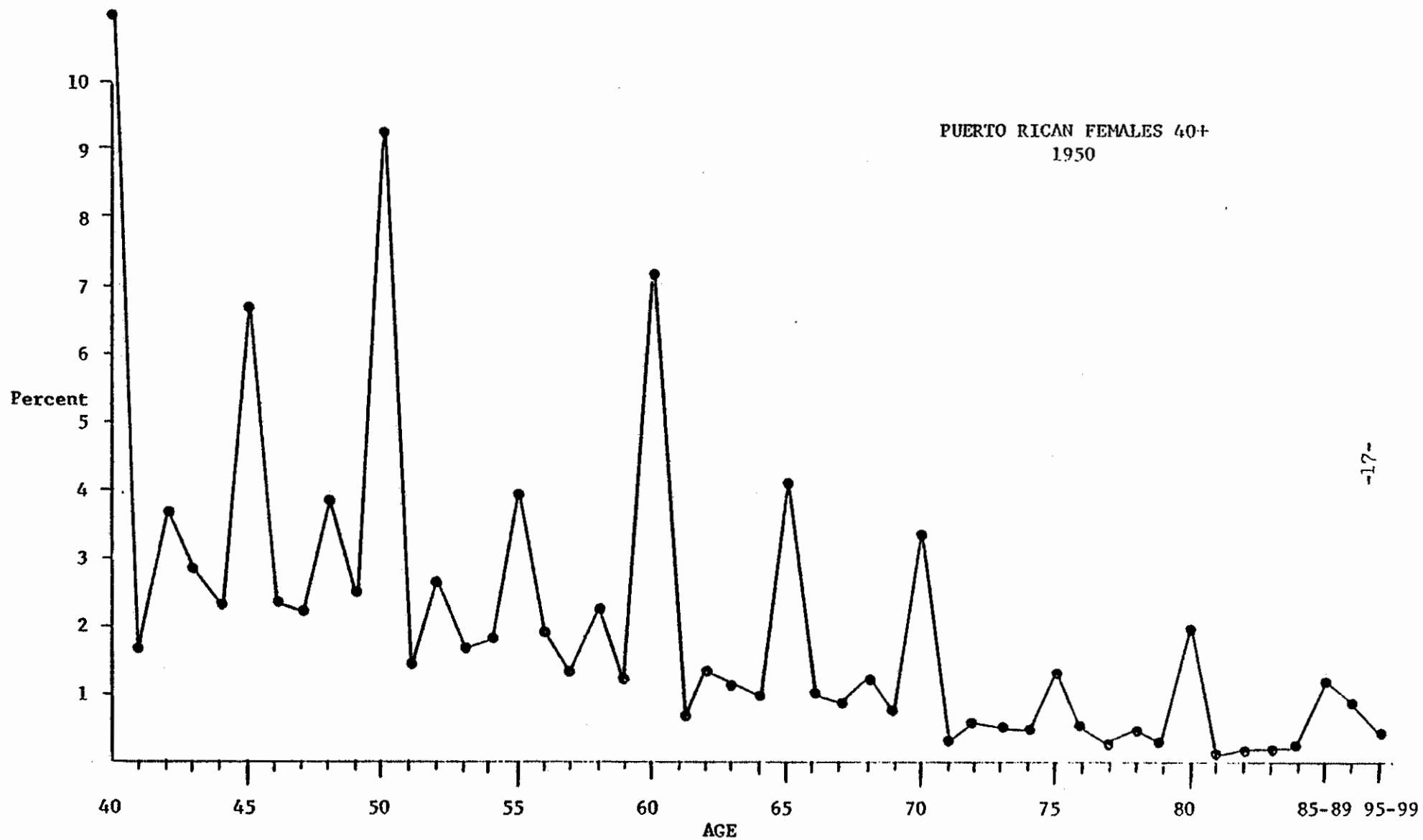
Figure 2. Percent age distribution of Puerto Rican females aged 40 and above, 1950.

Figure 3. Percent age distribution of Puerto Rican males aged 40 and above, 1960.
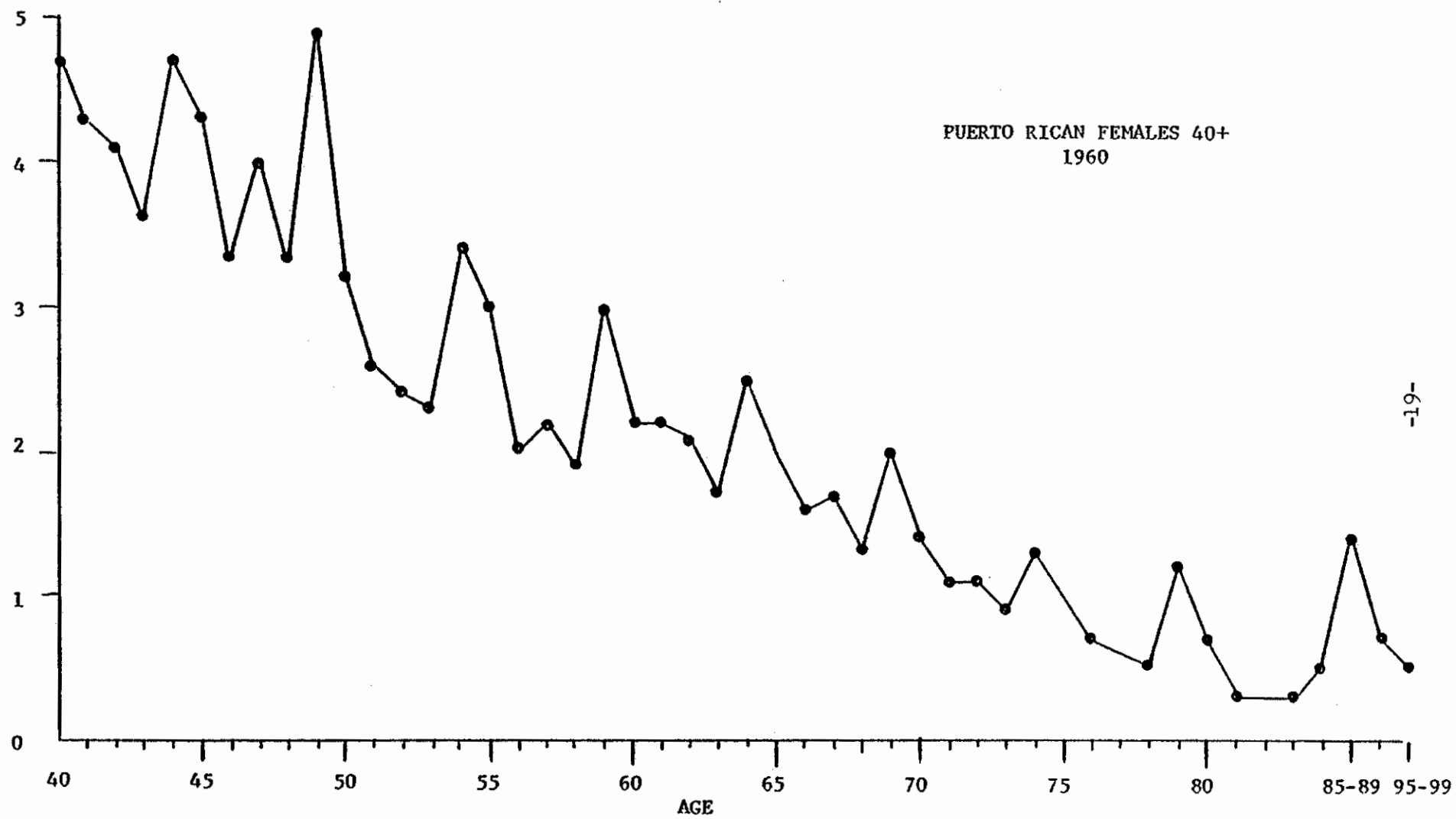
Figure 4. Percent age distribution of females aged 40 and above: Puerto Rico, 1960.

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(as well as age). The apparent heaping at ages ending in 4 and 9 actually indicates a preference for birth years ending in 0 and 5. This change in the question was probably responsible for the general improvement in accuracy. The pattern of age heaping once again appears to be more prevalent among females than among males, and is more pronounced at the older ages.

The corresponding age distributions for 1970 are presented in Figures 5 and 6. The decline in age heaping appears to have continued. Compared with the 1950 and 1960 censuses, the degree of age-to-age fluctuation is much less. Also, the apparent pattern of misreporting has reverted to heaping of ages ending in 0 and 5. The reason for this shift is not clear, but may be related to the introduction of self-enumeration in the 1970 census of Puerto Rico. On the census form a respondent is asked to write down his age and to fill in the machine-readable circles on month and year of birth (from which the age was actually determined).

If the respondent stated his age in a number ending in 0 or 5 he may have subtracted that value from 1970 to obtain date of birth and fill in the corresponding circles. This would produce a 0 - 5 type pattern of age heaping. Although age-misreporting has apparently decreased for both sexes, females still appear to be more prone to heaping, especially at older ages. Men and especially women, show a large increase in reported ages between 85 and 89. This development could result from an improvement in accuracy, higher survival rates among the aged, or it could represent an increase in over-reporting of age among the elderly.

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PUERTO RICAN MALES 40+
1970
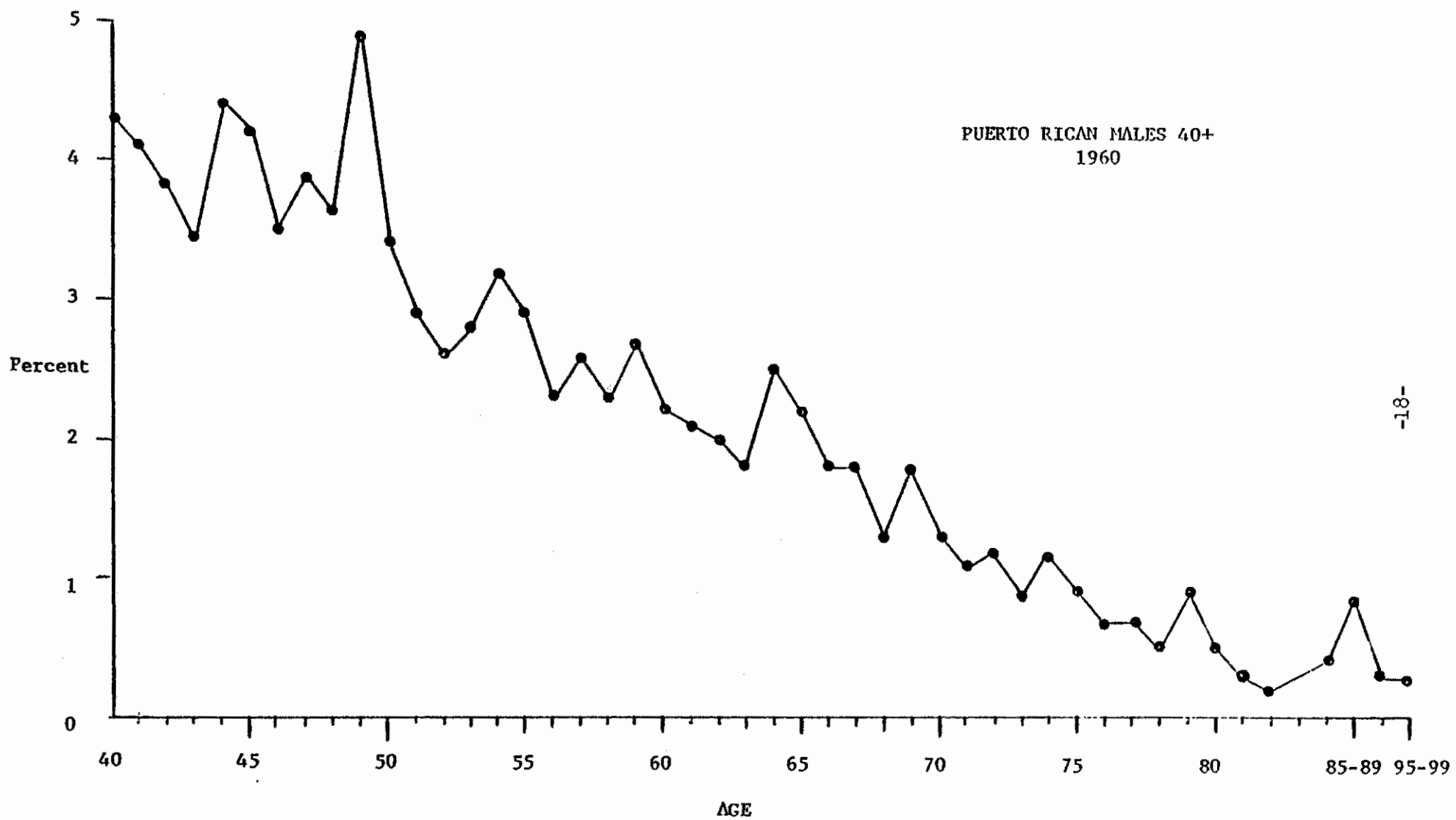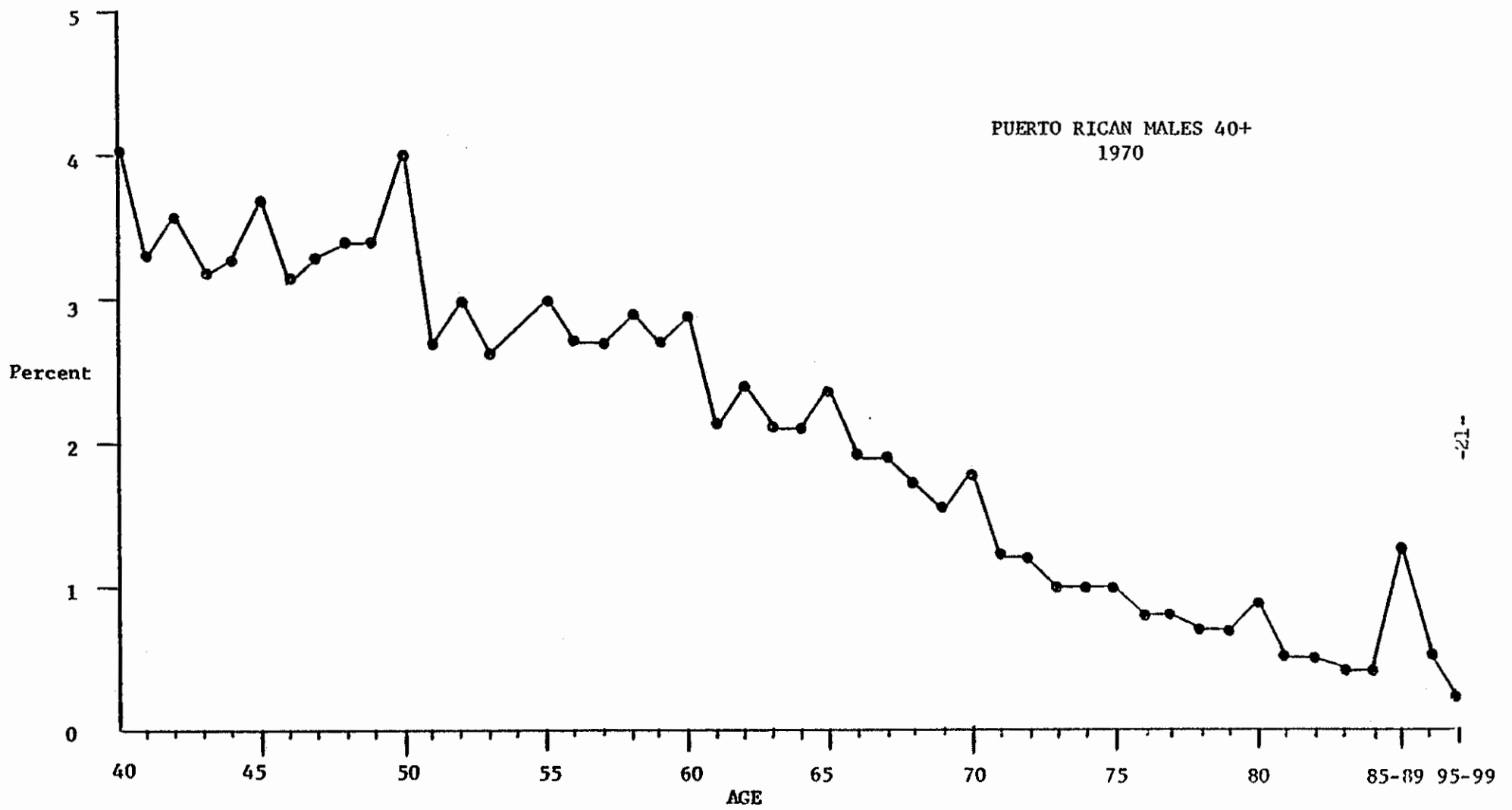
Figure 5. Percent age distribution of males aged 40 and above: Puerto Rico, 1970.
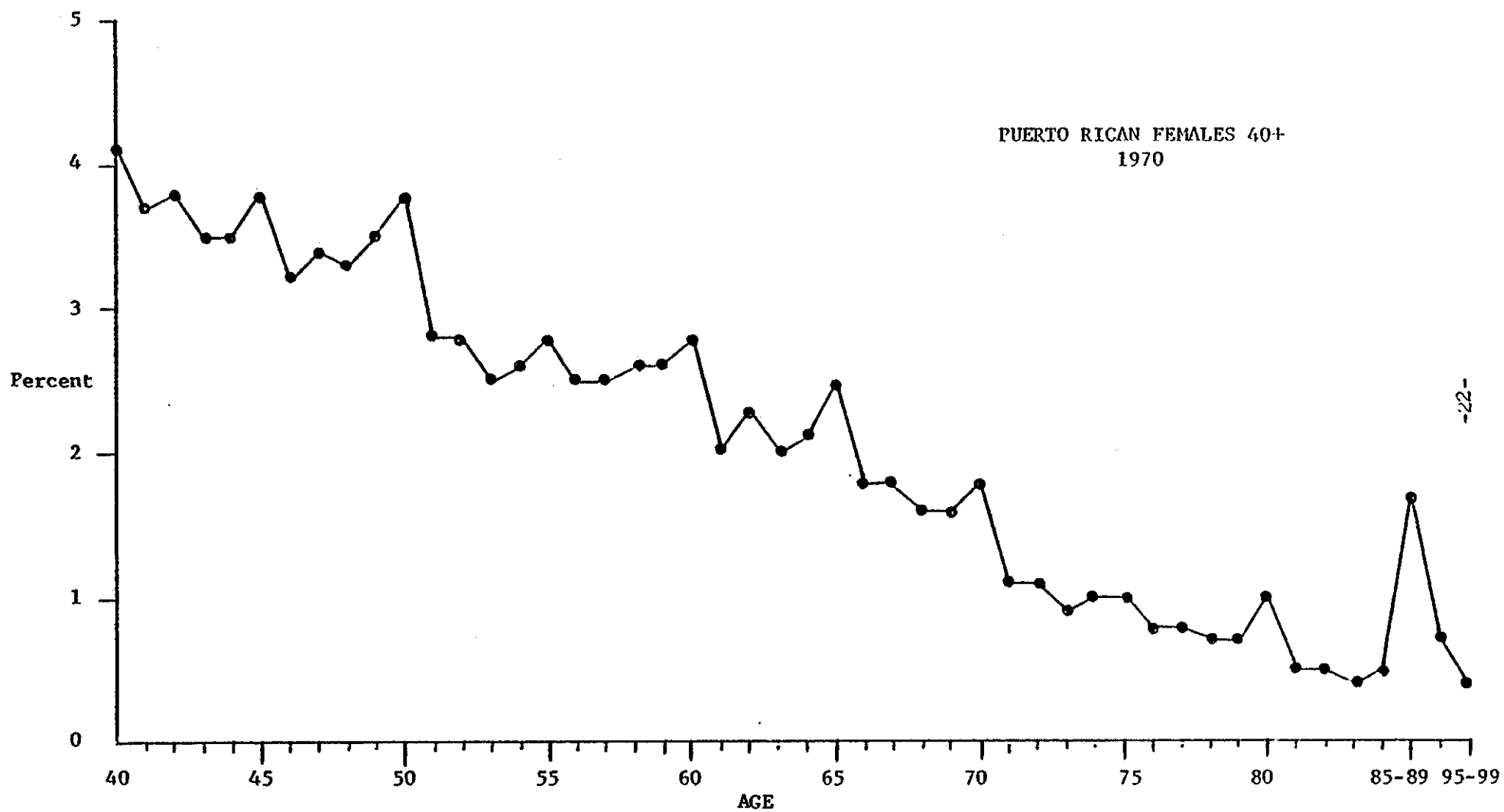
Figure 6. Age distribution of females aged 40 and above: Puerto Rico, 1970.

Changes in the extent of age heaping between 1950 and 1970 can be quantitatively described by measuring the difference between the age distributions as enumerated and those that would be expected if the age to age progression is smooth. In a population like Puerto Rico, which has had a consistently high fertility rate until recently, the shape of the age distribution will be determined primarily by the shape of the mortality schedule which shows a regular pattern. This is most consistent in ages over 40, which are the least affected by migration and are too old to be influenced by the recent declines in Puerto Rican fertility rates. Assuming that age-to-age changes can be approximated linearly over short intervals, then the ratio of those aged 50, as an example, to those aged 45-54 should be equivalent to 1 in 10. This implies, for all ages, about 10 percent of the population should have an age ending with each digit from 0 to 9.

Measures utilizing Myers' Blended Index, based on this principle, are presented in Table 2. This summary index is computed as one-half the sum of absolute deviations from 10.0 percent. If there were no age heaping, this value would approximate zero. Calculations have been done separately for ages from 10 to 84 and for ages 40 to 84, those of primary interest in this study. The expected value for each digit is ten percent. Table 2 generally confirms the earlier impressions made by examining the plotted age distributions. Age heaping at particular digits is greatest in 1950, but declines markedly through 1960 to 1970.

The summary index for Puerto Rico in 1950 was about the same as that for the entire United States in 1880 (Myers, 1954), but by 1970 it was

TABLE 2. Percent of Population of Puerto Rico with Ages Ending in Digits 0 to 9, Computed By Myers' Blended Method, 1950, 1960, 1970

Ages 10-84

Digit	1950			1960			1970		
	M	F	T	M	F	T	M	F	T
0	16.6	18.0	17.3	9.5	9.5	9.5	10.9	11.0	11.0
1	6.4	5.9	6.1	9.4	9.5	9.5	9.1	9.3	9.2
2	9.9	9.6	9.8	9.7	9.6	9.6	10.0	10.0	10.0
3	8.9	8.7	8.8	9.6	9.4	9.5	9.7	9.7	9.7
4	8.6	8.3	8.5	11.0	11.2	11.1	10.1	10.2	10.1
5	12.7	13.8	13.2	10.4	10.2	10.3	10.6	10.5	10.5
6	8.9	8.6	8.8	9.4	9.3	9.3	9.7	9.5	9.6
7	8.2	8.0	8.1	10.6	10.3	10.4	10.1	10.0	10.0
8	11.5	11.0	11.3	9.5	9.2	9.3	10.0	9.8	9.9
9	8.2	8.1	8.2	11.2	11.9	11.5	9.8	10.1	10.0
Summary Index	10.8	12.8	11.8	3.1	3.6	3.4	1.7	1.8	1.7

Ages 40-84

Digit	1950			1960			1970		
	M	F	T	M	F	T	M	F	T
0	25.5	30.0	27.7	9.7	10.1	9.9	12.2	12.1	12.2
1	4.6	3.7	4.2	9.1	9.0	9.1	8.9	9.0	9.0
2	9.0	8.0	8.5	9.1	9.0	9.0	10.0	9.8	10.0
3	7.1	6.1	6.6	8.9	8.5	8.7	9.1	9.1	9.1
4	7.1	6.2	6.7	11.7	12.2	12.0	9.8	10.0	9.9
5	15.8	17.8	16.8	10.6	10.3	10.4	10.7	10.8	10.7
6	7.6	6.7	7.1	9.0	8.4	8.7	9.3	9.1	9.2
7	6.3	5.5	5.9	10.1	9.9	10.0	9.8	9.7	9.8
8	10.5	10.1	10.3	9.2	8.4	8.8	10.2	9.3	10.0
9	6.6	6.0	6.3	12.6	14.2	13.4	10.2	10.6	10.4
Summary Index	21.8	27.9	24.7	5.1	6.9	5.8	3.2	3.3	3.2

slightly less than that for the entire United States in 1950 (Shryock and Siegel, 1973). This table also shows the pattern of digit preference which as noted before, shifted from 0 and 5 in 1950 to 4 and 9 in 1960, and then back to 0 and 5 in 1970. Finally age heaping is significantly worse in ages above 40 than in the population as a whole. The summary index for those aged 40 and above consistently runs at about twice the level obtained over all other ages.

Special tabulations prepared from the 1970 Census Public Use Samples for Puerto Rico enable us to take a closer look at misstatement in older ages. Figures 7 and 8 show the percent age distribution of males and females aged 60 and above for Puerto Rico in 1970. Table 3 presents percentages reporting ages ending in each digit and the corresponding Myers' Indices. From both the figures and the table a pattern of heaping on ages ending in 0 and 5 is evident. The degree of preference for these digits is greater either than in the population as whole or in the population above age 40. The Myers Index of 4.6 is roughly the level of digit preference found in the entire United States in 1920. Age heaping is more common among women than among men, and this differential appears to increase with age. Finally, the lack of upward peaks in the age curves at 75, 85 and 95 suggests a pattern of general heaping from the 7Cs, 80s, and 90s upward to ages 80, 90 and 100. The pattern is especially pronounced in the 90s, suggesting widespread overstatement of ages as 100 or more. Such a pattern of general overstatement would give a false picture of survival rates at the older ages, particularly among women.

PUERTO RICAN MALES 60+
1970
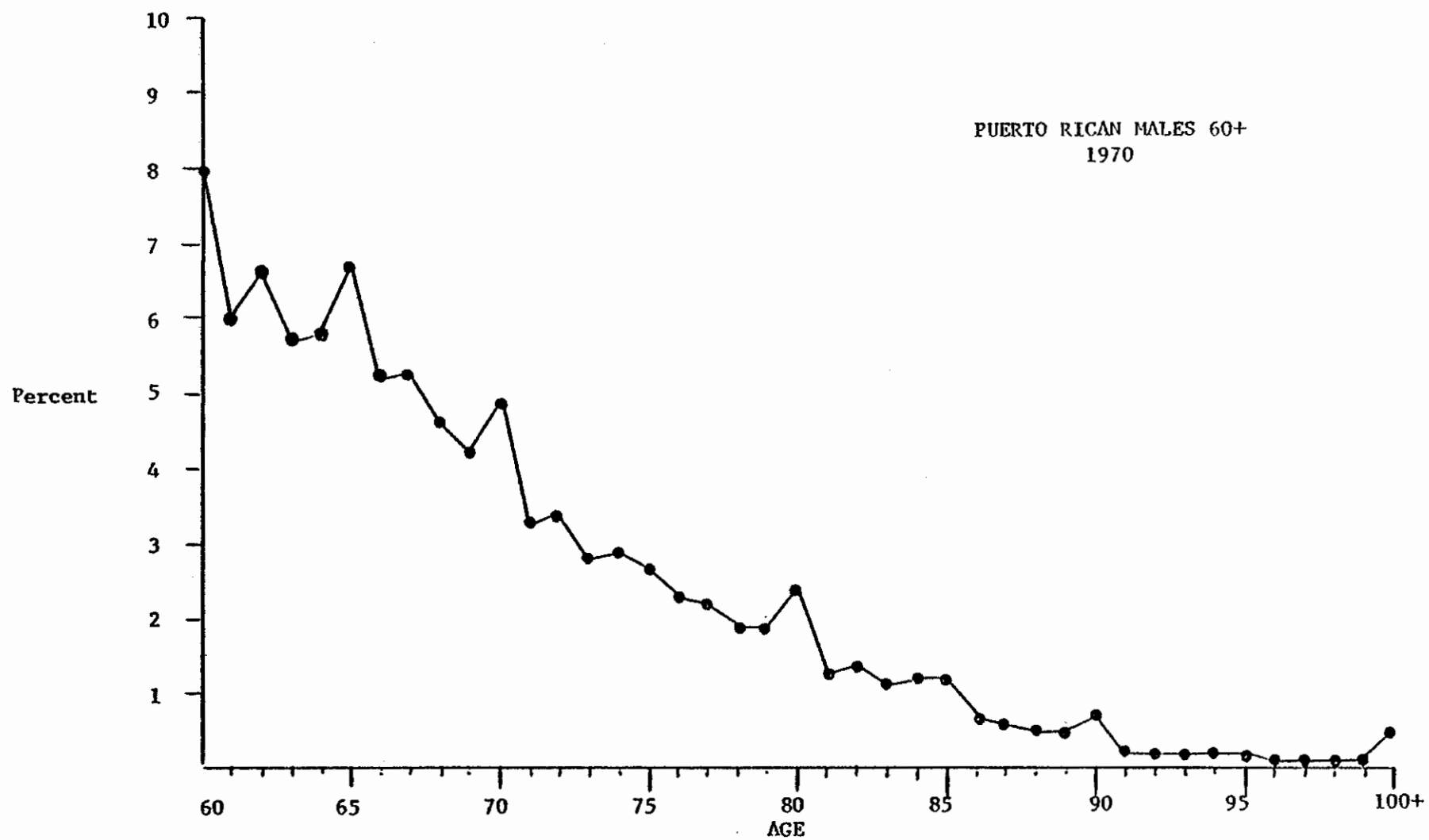
Figure 7. Percent age distribution of males aged 60 and above: Puerto Rico, 1970.
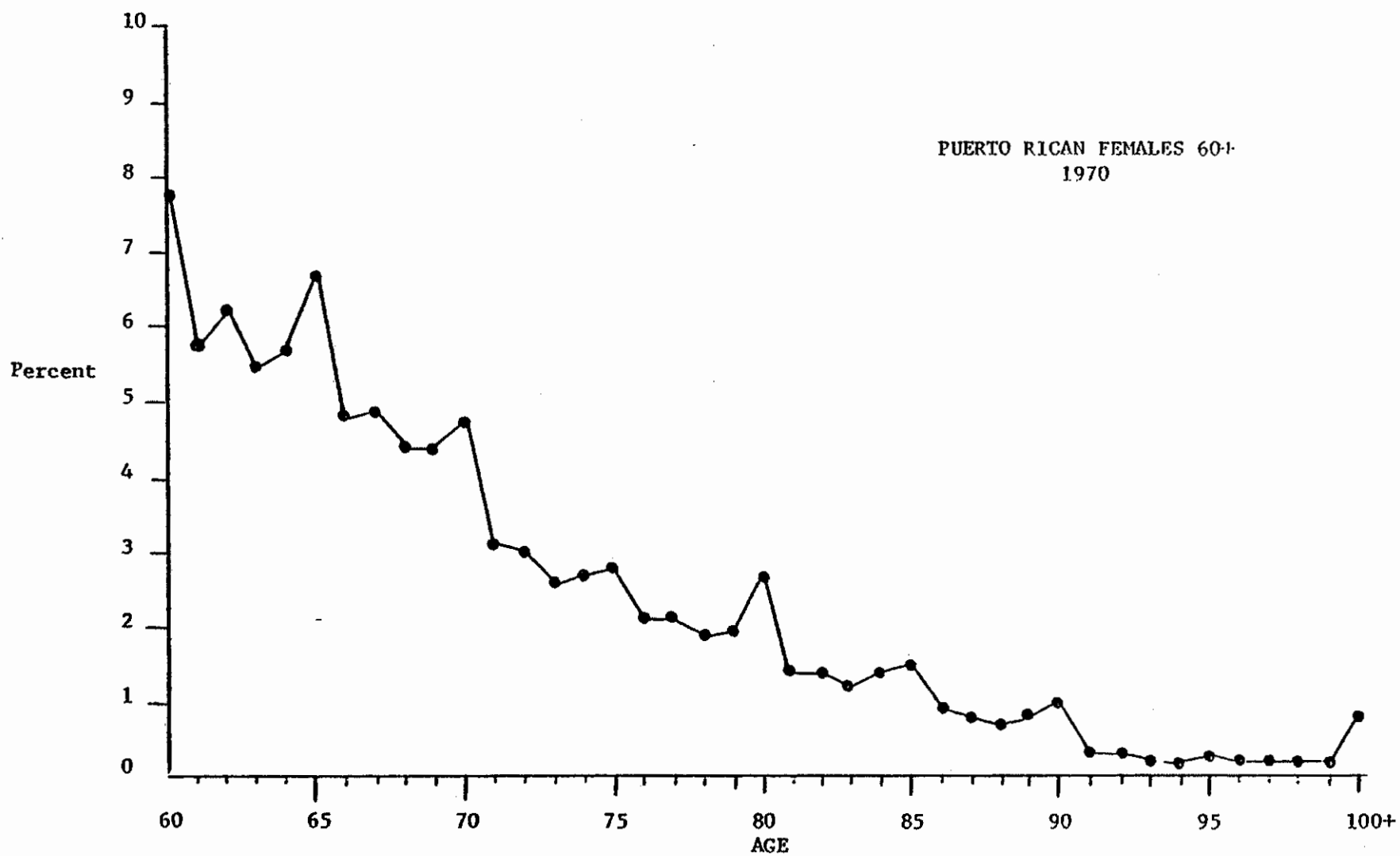
Figure 8.   Percent age distribution of females aged 60 and above: Puerto Rico, 1970.

TABLE 3:   Percent of Population of Puerto Rico Aged 60-99 Reporting Ages Ending
            in Digits 0 Through 9, Computed by Myers' Blended Method, 1970

Digit	Males	Females	Total
0	12.4	13.0	12.7
1	8.5	8.3	8.4
2	9.9	9.2	9.5
3	9.0	8.7	8.8
4	10.1	10.1	10.1
5	11.5	12.1	11.8
6	9.6	9.2	9.4
7	10.1	9.8	9.9
8	9.5	9.3	9.4
9	9.5	10.5	10.0
Summary Index	4.1	5.6	4.6

B. Age Accuracy in Five-Year Intervals: Age Ratio Analysis

From the results reported above, it is obvious that historically there has been a great deal of age misreporting in the Puerto Rican population by single years of age. While age heaping has lessened over time, it has apparently persisted at a significant level among the aged. A characteristic of Latin American age reporting is that while many people do not know their age accurately, they do know it approximately (United Nations, 1967). Consequently, while single year age distributions may display gross inaccuracies, when the data are grouped in five-year intervals many of the reporting errors are absorbed to give a reasonably accurate age distribution. Inaccuracies in five-year age distributions result from general heaping across interval boundaries, e.g., out of the 70s and into the 80s. This pattern of systematic over-reporting of age has more serious implications with respect to the estimation of mortality. This section examines the accuracy in the distribution of Puerto Rican population by five-year age intervals.

The large-scale outmigration of Puerto Ricans from the island to the U.S. Mainland between 1950 and 1970 had a significant effect on the age composition of Puerto Rico. Within the island population, age ratios (as computed by the method described on page 10) tend to deviate from 100 because of selective out-migration as well as age misreporting. To avoid the problem of the effect of migration, a closed population of those of Puerto Rican birth was constructed by combining the island and mainland populations of persons born in Puerto Rico. Results are generally presented here for this composite population as well as for the island separately.

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Figures 9 through 11 present the age distributions of Puerto Ricans in 1950, 1960 and 1970. These diagrams clearly depict the extreme selectivity by age of out-migration to the United States. The age composition of mainland Puerto Ricans peaks in the intervals 20-24 years and 25-29 years and then falls rapidly. In 1950, total out-migration was not sizeable enough to have significantly affected Puerto Rico's age distribution, but by 1960 and 1970 it was large enough to introduce important irregularities into the island population's age distribution. Also, a rapid decline in the fertility rate beginning in the 1950s produces a flattening out of the age distribution in the intervals below age 15 in 1960 and below age 25 in 1970.

Age ratios and age-accuracy indices are presented in Table 4 for the composite population of Puerto Rican birth. Age accuracy appears to have improved over the three censuses. By 1970, the accuracy index of 2.2 was comparable to that obtained in the United States as a whole in 1960. Again, net misreporting seems to be more extreme for females than for males, and in the older ages. In 1970, age ratios above age 40 suggest net under-reporting in the intervals 40-44, 50-54, 70-74, and 75-79, and net over-reporting in the age groups 45-59 and 65-69. The suggestion of net under-reporting in the 70s is intriguing especially given the previous findings showing a lack of heaping in the mid 70s, mid 80s, and mid 90s. If the apparent deficit in the intervals 70-74 and 75-79 were accompanied by an age ratio greater than 100 in the interval of ages 80-84, the interpretation of heaping from the 70s to 80 would be strengthened. Unfortunately, data are not available in five-year intervals over age 85, so the last age-ratio that can be formed is for the age group 75-79.
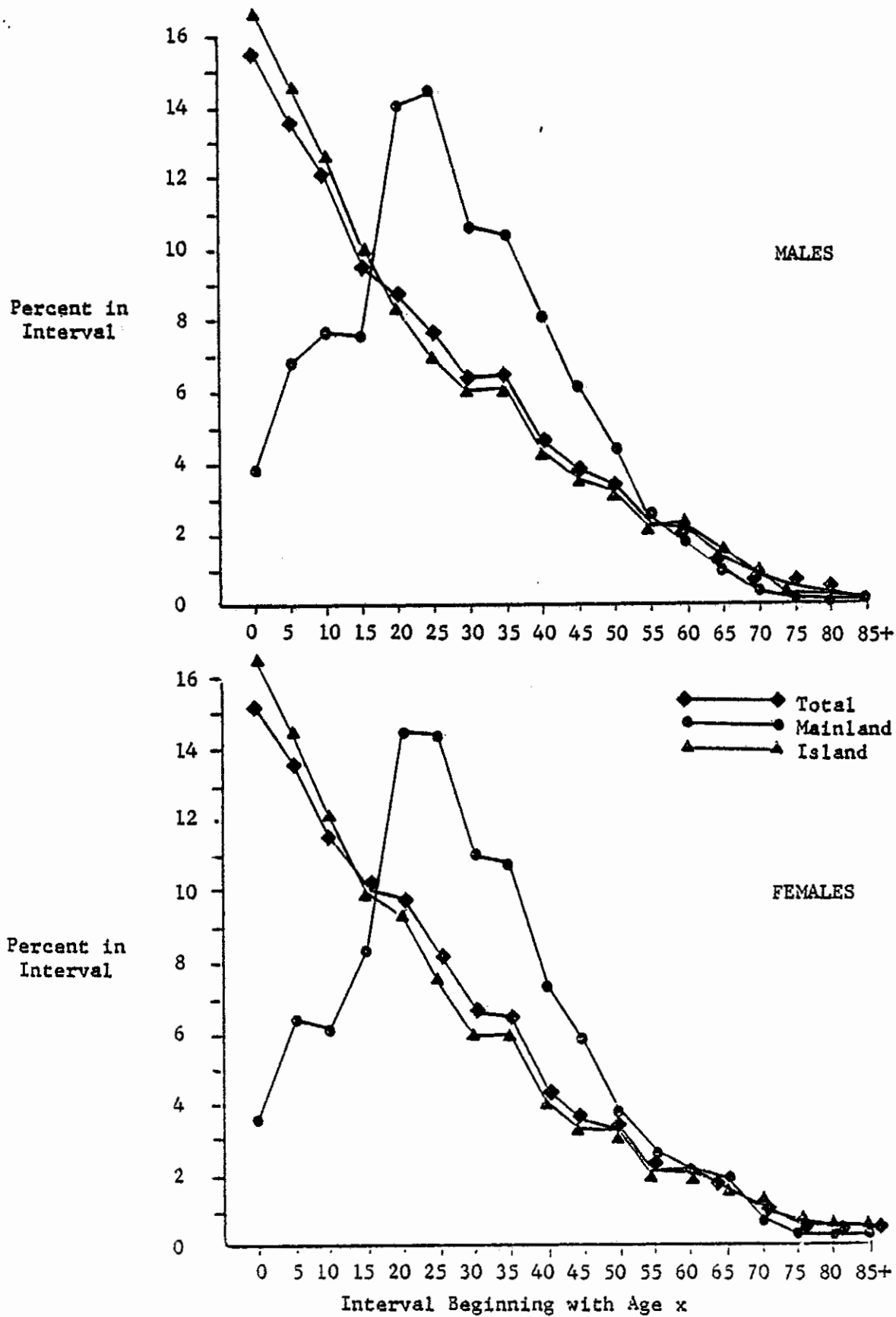
Figure 9. Age composition of the Puerto Rican born population in 1950.
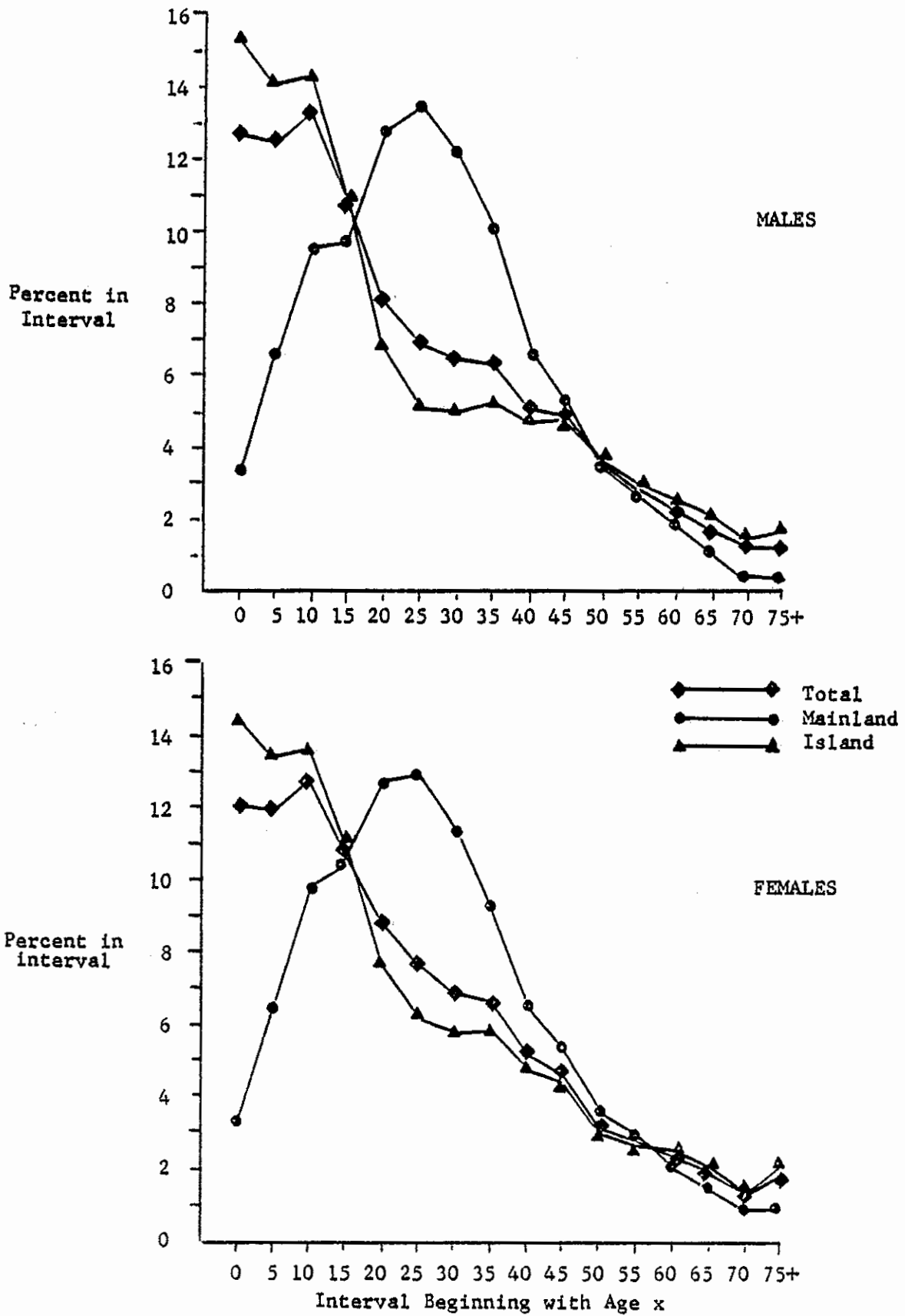
Figure 10. Age composition of the Puerto Rican born population in 1960.
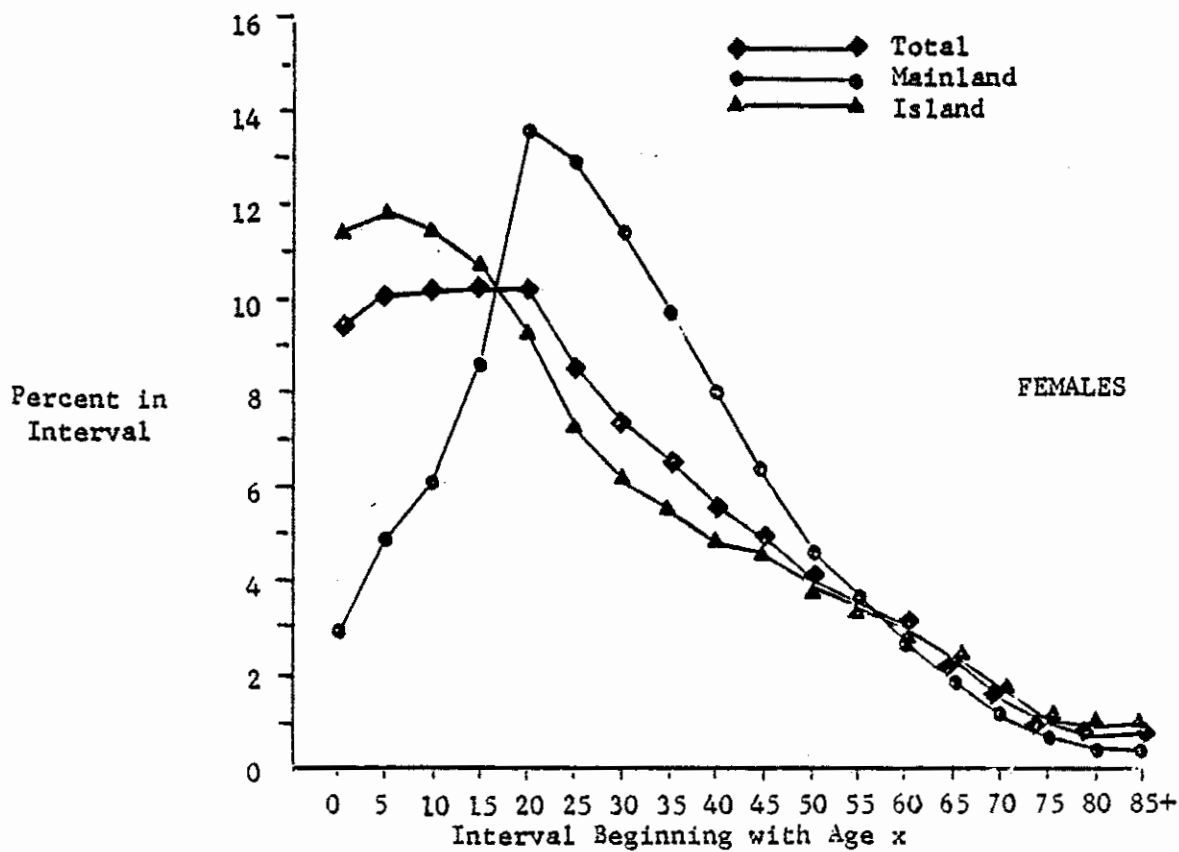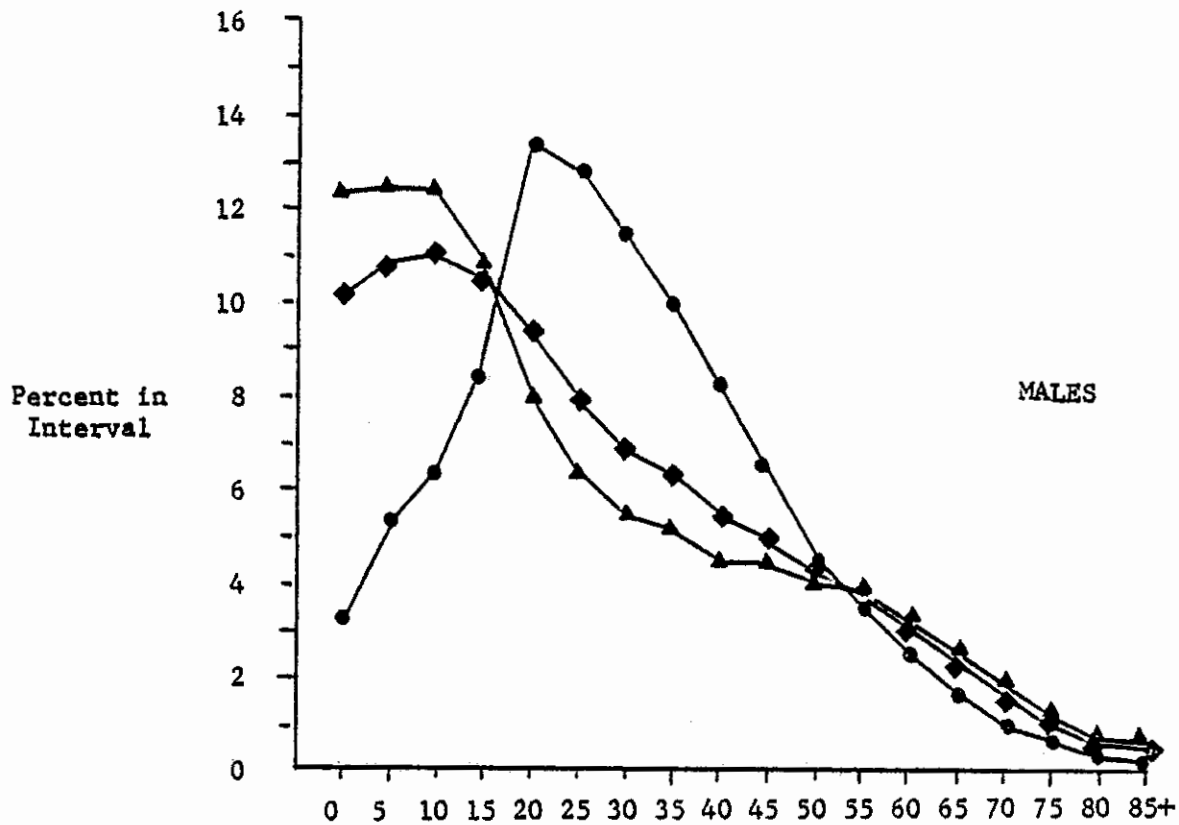
Figure 11. Age composition of the Puerto Rican born population in 1970.

TABLE 4:   Age-accuracy Indices for the Combined Population of Puerto Rican
           Birth (Island and Mainland): 1950, 1960, and 1970

	1950			1960			1970		
	M	F	T	M	F	T	M	F	T
5-9	100.2	100.8	100.5	97.2	97.1	97.2	101.9	102.3	102.1
10-14	101.9	98.3	100.1	109.6	108.2	108.9	102.2	100.1	101.2
15-19	94.8	95.9	95.4	100.0	99.6	99.8	102.2	99.9	101.0
20-24	101.2	105.3	103.4	93.9	97.1	95.6	100.4	105.9	103.3
25-29	99.7	100.1	99.9	96.8	98.1	97.5	98.5	98.3	98.4
30-34	94.4	91.7	93.0	99.3	98.3	98.8	98.5	98.1	98.2
35-39	110.5	113.0	111.7	105.1	106.2	105.7	101.3	101.3	101.3
40-44	93.4	90.2	91.8	94.0	94.0	94.0	97.5	97.3	97.4
45-49	96.7	95.4	96.1	108.4	107.7	108.0	101.5	102.6	102.1
50-54	107.8	110.5	109.1	93.8	98.7	91.8	98.3	97.4	97.8
55-59	84.9	82.9	83.9	99.5	98.9	99.2	102.4	99.4	100.9
60-64	114.3	111.4	112.9	98.9	102.9	100.9	99.7	101.2	100.4
65-69	93.4	99.8	96.6	102.3	101.5	101.9	100.0	102.8	101.4
70-74	97.3	95.7	96.4	95.7	94.3	95.0	97.6	92.0	94.7
75-79	82.3	80.5	81.4	97.5	99.5	98.6	92.1	95.6	93.9
Age-Accuracy Index 0-79	6.6	7.4	6.9	3.9	4.0	3.9	2.0	2.6	2.2
Age Accuracy Index 40-79	9.3	9.7	9.5	3.9	4.5	4.0	2.3	3.1	2.6

However, the five-year age distribution for the island population of Puerto Rico up to age 100 is available. Figures 9 through 11 illustrate that the effect of out-migration on the age composition of Puerto Rico is relatively minor above age 50. Figures 12 through 14 plot the age distribution of islanders from age 60 and above for the years 1950, 1960 and 1970, and Table 5 presents the results of an age ratio analysis of this data.

The age accuracy indices suggest considerable misreporting above age 50. In 1950 age ratios indicate over-reporting in the intervals 50-54, 60-64, and 80-84 among men; and these same age groups plus the interval 90-94 among women. There seems to be a general pattern of age heaping out of the later years of a decade (e.g., the late 50s) and into the early years of the next decade (e.g., the early 60s ·). In addition, both men and women seem to under-report all ages in the 70s leading to large ratios in the age group 80-84. Women also tend to over-report ages in the early 90s, , while men show a small deficit in this interval. However, the very low age ratio in the age interval 95-99 suggests age heaping out of the late 90s to the 100s.

This interpretation is strengthened by age ratios computed for the group 95-99 from 1960 data. Recalling that in 1960, the wording of the age question changed from one on age at last birthday to one giving the year of birth, people who wanted to present themselves as 100 years old in 1960 might list 1860 as their year of birth. When this information is converted to age at last birthday, if they were born May through December, they would be reported as 99 years old. If there was a widespread

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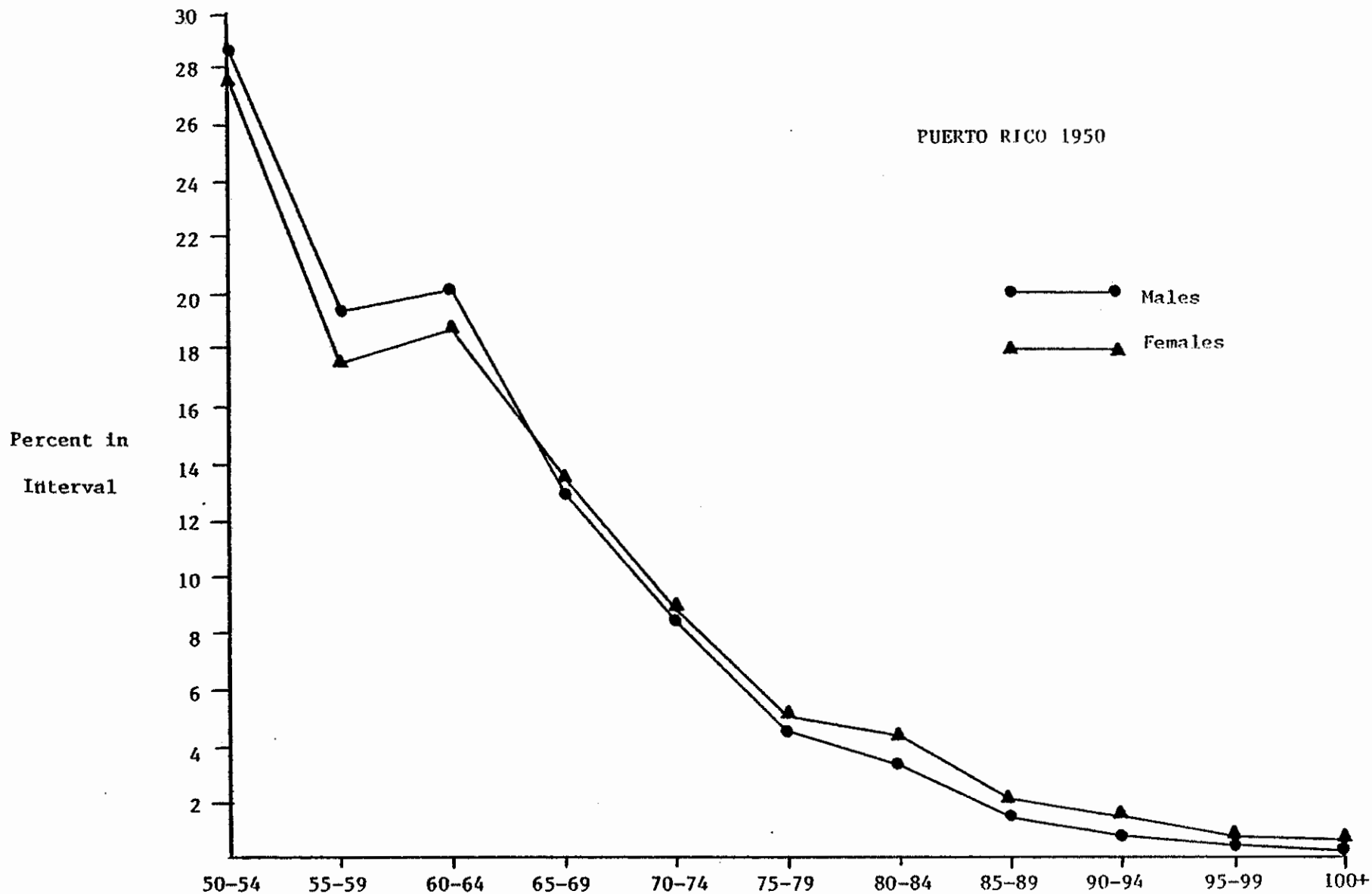
Figure 12. Age composition of the population aged 60 and above: Puerto Rico, 1950.
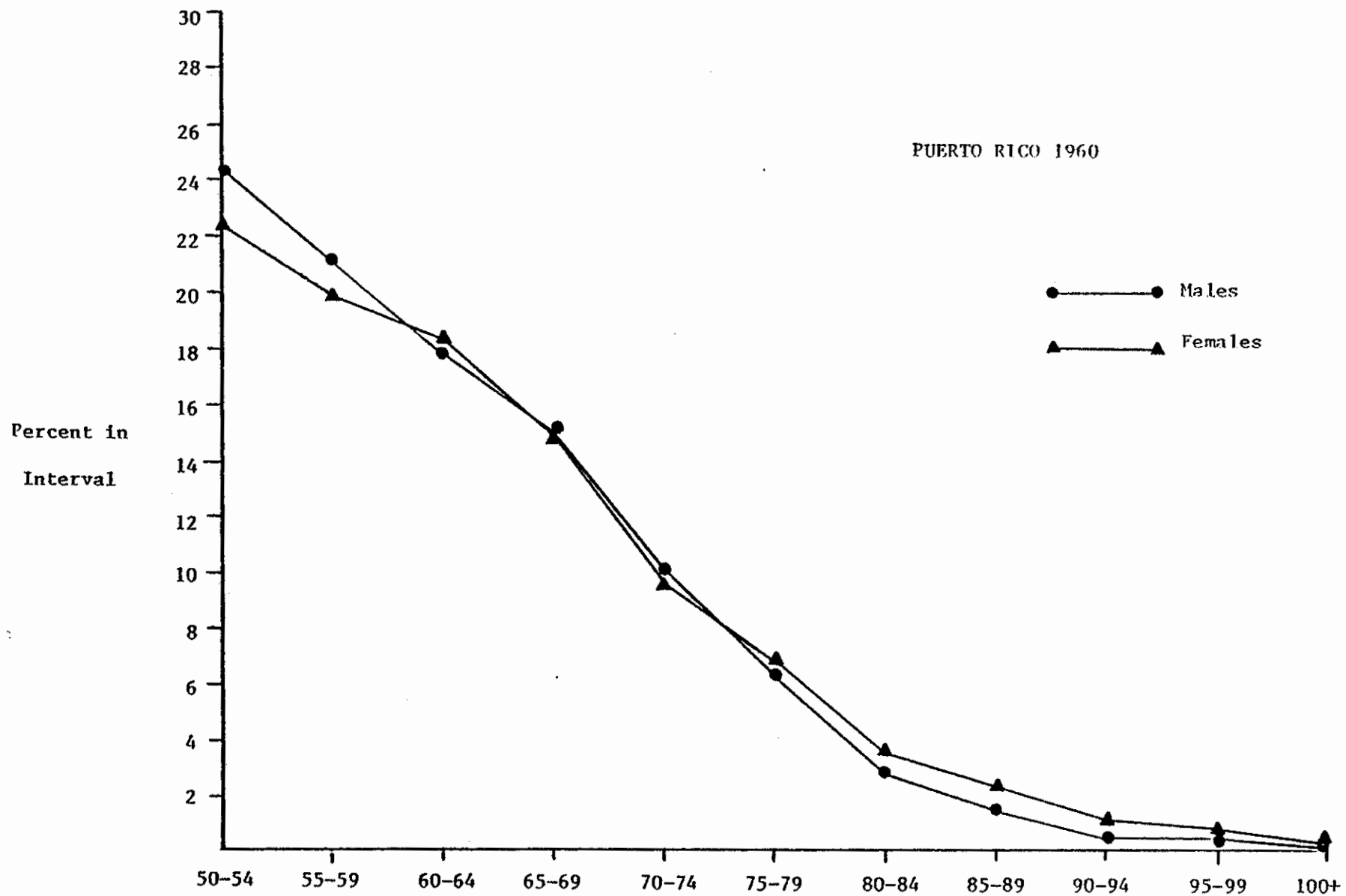
Figure 13. Age composition of the population aged 60 and above: Puerto Rico, 1960.
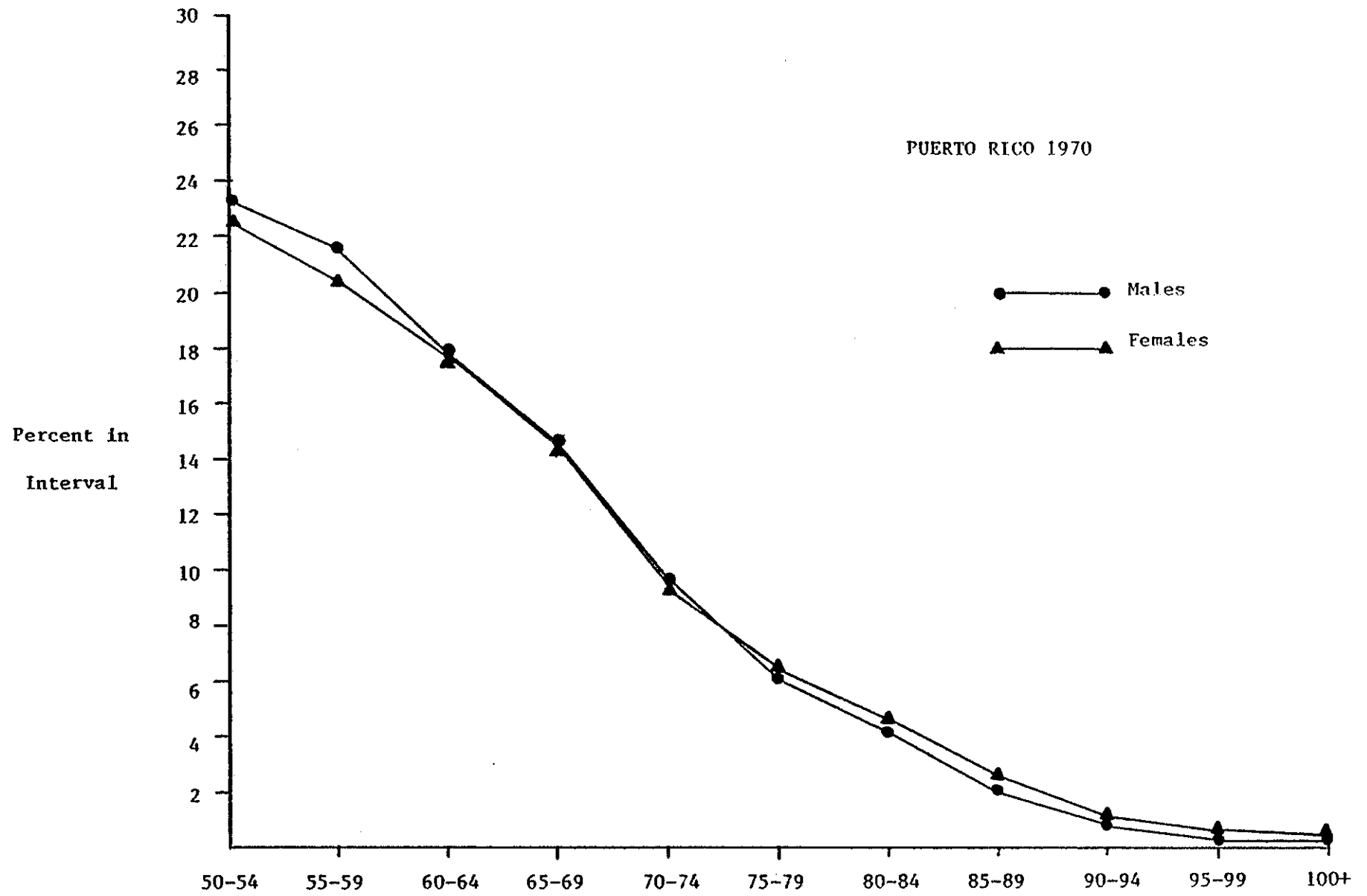
Figure 14. Age composition of the population aged 60 and above: Puerto Rico, 1970.

TABLE 5: Age-accuracy Indices for Population Aged 50 and Over: Puerto Rico, 1950, 1960, and 1970.

| | 1950 | | | 1960 | | | 1970 | | |
	M	F	T	M	F	T	M	F	T
50-54	108.4	112.8	110.5	93.3	89.5	91.5	98.4	97.1	97.8
55-59	85.3	81.8	83.6	99.9	98.5	99.2	103.2	100.8	102.0
60-64	115.5	113.5	114.5	99.2	103.5	101.3	99.4	100.9	100.1
65-69	92.8	98.0	95.3	105.1	104.5	104.8	103.5	104.7	104.1
70-74	98.2	96.7	97.5	96.0	91.4	93.7	95.5	93.0	94.3
79-79	82.9	81.8	82.3	98.5	104.1	101.3	92.3	93.1	92.7
80-84	107.5	116.9	112.6	80.2	81.2	80.7	100.7	102.3	101.5
85-89	76.5	76.8	76.7	91.9	104.4	99.2	87.5	94.5	91.4
90-94	97.8	107.6	103.8	65.3	74.4	71.0	76.9	79.2	78.2
95-99	71.7	73.3	72.7	124.4	120.0	121.5	69.1	78.8	75.0
Age Accuracy Index	12.6	14.3	13.3	10.5	10.2	9.4	8.8	7.3	7.8

tendency to report age as 100 in 1960, we would expect the category 95-99 to be inflated. This is exactly what we find. Age ratios for males and females are 124 and 120, respectively, higher than within any other age interval (Table 5). The very high ratio for males 95-99 and the very low ratio for males 90-94 suggests that the tendency to over-report one's age as 100 may be more widespread among men than among women.

In 1970, the self-enumeration of the age question caused the pattern of age heaping to switch back to a preference for ages ending in 0 and 5, as in 1950. The high age ratios in the interval 95-99 are therefore replaced by very low ratios. Low age ratios throughout the 90s again point to significant heaping at age 100. In general, over-reporting by males is found in the age intervals 55-59, 65-69, and presumably at age 100 or above, with under-reporting concentrated in the age groups 50-54, 70-74, 75-79, 85-89, 90-94, and 95-99. There is evidence among males of general heaping out of the 70s and 90s to other, presumably higher, age intervals. Women display age ratios significantly higher than expected only in two cases: the age groups 65-69 and 80-84, the former possibly reflecting over-statement of ages to qualify for social security benefits. There are apparent deficits within the age groups 50-54, 70-74, 75-79, 85-89, 90-94, 95-99. For women there is also evidence of systematic heaping out of the 70s and 90s, although the phenomenon generally appears to be less pronounced than for men.

Detailed examinations of both single-year and five-year age distributions are consistent in suggesting a history of systematic age misreporting in the Puerto Rican population. Results indicate that even in

1970 there was a tendency for older Puerto Ricans to avoid reporting ages in the 70s, late 80s, and 90s. Age is given great status in traditional Puerto Rican society, and it seems likely that this could result in a prevalence of systematic over-reporting of age in the 70s, late 80s, and 90s. Moreover, given the patriarchal structure of authority within Puerto Rican culture, it makes sense that this over-reporting might be more pronounced among men than among women, in contrast to the situation at younger ages. If the hypothesized pattern of age misreporting is correct, measures of old age survival based on unadjusted age data could be biased substantially upwards. Men who reported living ages over age 100 may in fact be living them within ages as low as the 70s, thus inflating the denominator of mortality rates. Because the oldest age groups contain small numbers of people, gross overstatements of age by a few persons could substantially alter measures of old age life expectancy.

C. Age-Accuracy in Five-Year Intervals: Sex Ratio Analysis

Up to this point, we have considered the accuracy of age reporting among males and females separately. It is also possible to assess the relative degree of age accuracy by combining the data to form age-specific sex ratios. Because females tend to have lower mortality at every age than males, age-specific sex ratios should start somewhere between 100 and 105 in the interval 0-4 years and fall steadily thereafter, barring sudden changes in sex-specific mortality (for example, those occurring in times of war). The extent of departure from a smooth progression of sex ratios by age can be used to measure the overall level of age accuracy in the population. Such a measure should be especially sensitive

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to differences in patterns of over- and under-reporting between the sexes.

The United Nations (1952) has proposed an age-sex accuracy index which takes advantage of the expected regularity of the change in sex ratios from age to age. The index combines the sum of (1) the mean deviation of male age ratios from 100, (2) the mean deviation of female age ratios from 100, and (3) three times the mean of age-to-age differences in reported sex ratios (Shryock and Siegel, 1973). Using this procedure to assess the age-sex accuracy of the U.S. census in 1960, one obtains a value of 12.2. According to the United Nations, values under 20 indicate that an age-sex distribution is "accurate." Values from 20 to 40 indicate a distribution that is "inaccurate," and those over 40 reflect age-sex data that are "highly inaccurate."

Migration is highly sex-specific and can seriously disrupt the sex composition of a small insular population like Puerto Rico. Therefore a closed population was constructed by combining mainland and island populations of Puerto Rican birth. Figures 15 through 17 show age-specific sex ratios for this composite population in 1950, 1960, and 1970, respectively. The irregularities in the sex ratios by age in 1950 and 1960, indicate substantial age-sex inaccuracy in these years. The ratios start high and climb in the age groups from 0 to 15, then fall through the interval 20-24, rise from 25-29 to 55-59, and fall thereafter. The progression of sex ratios is much less erratic in 1970, but they still do not show the expected monotonic decline with age. There is little change in age groups between 0 and 15, followed by a sharp drop through the
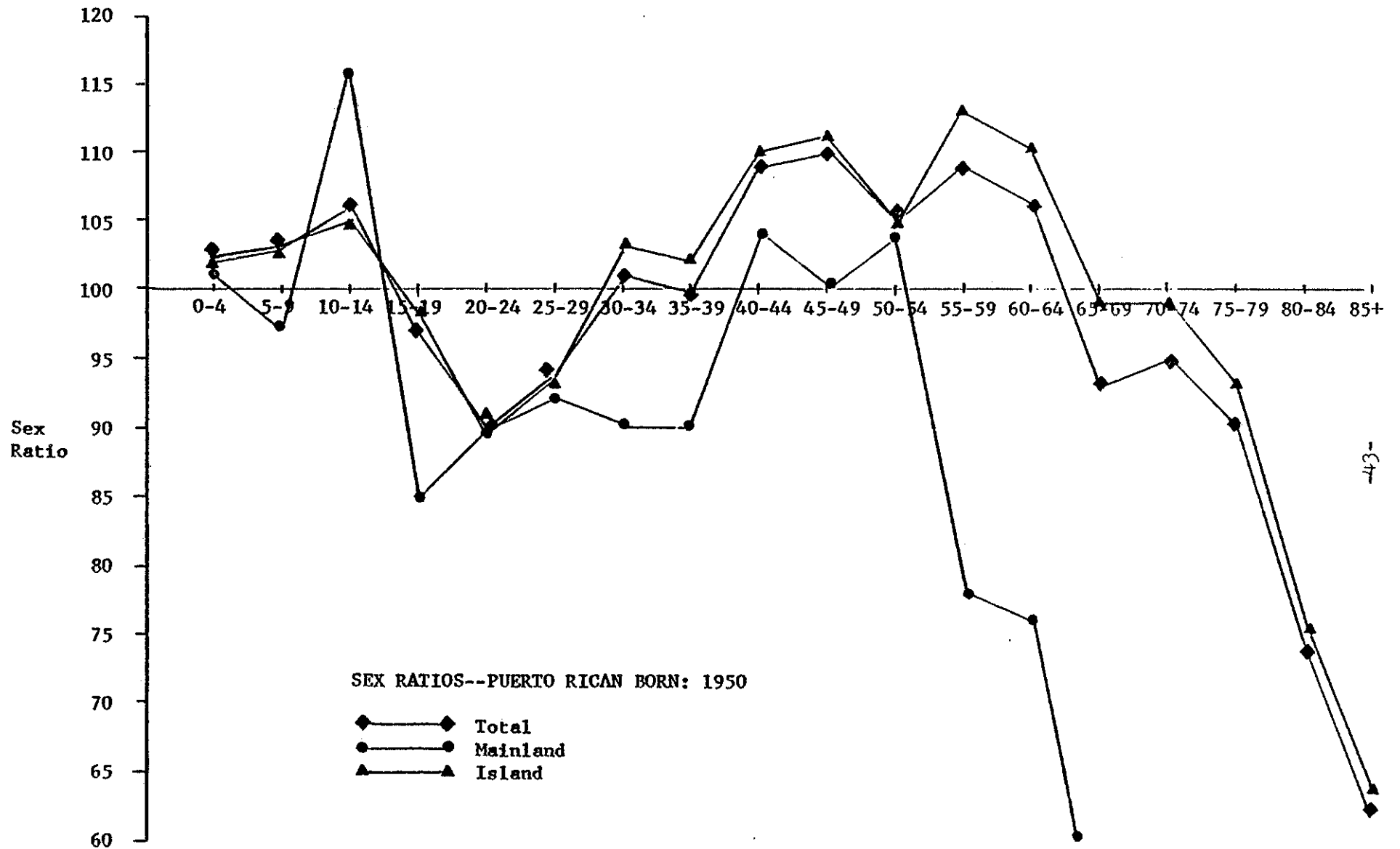
Figure 15. Sex ratios by age for the population of Puerto Rican birth: 1950.
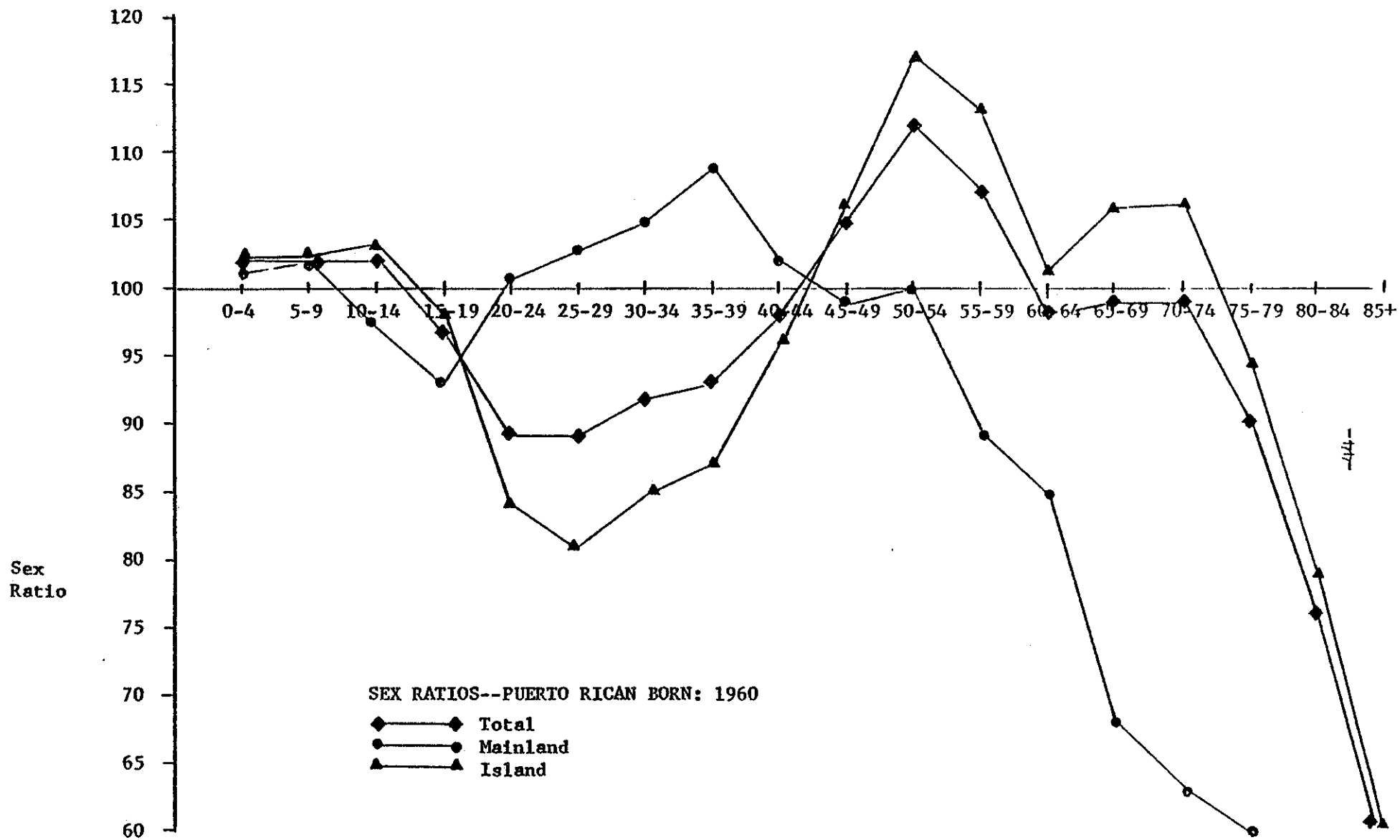
Figure 16. Sex ratios by age for the population of Puerto Rican birth: 1960.
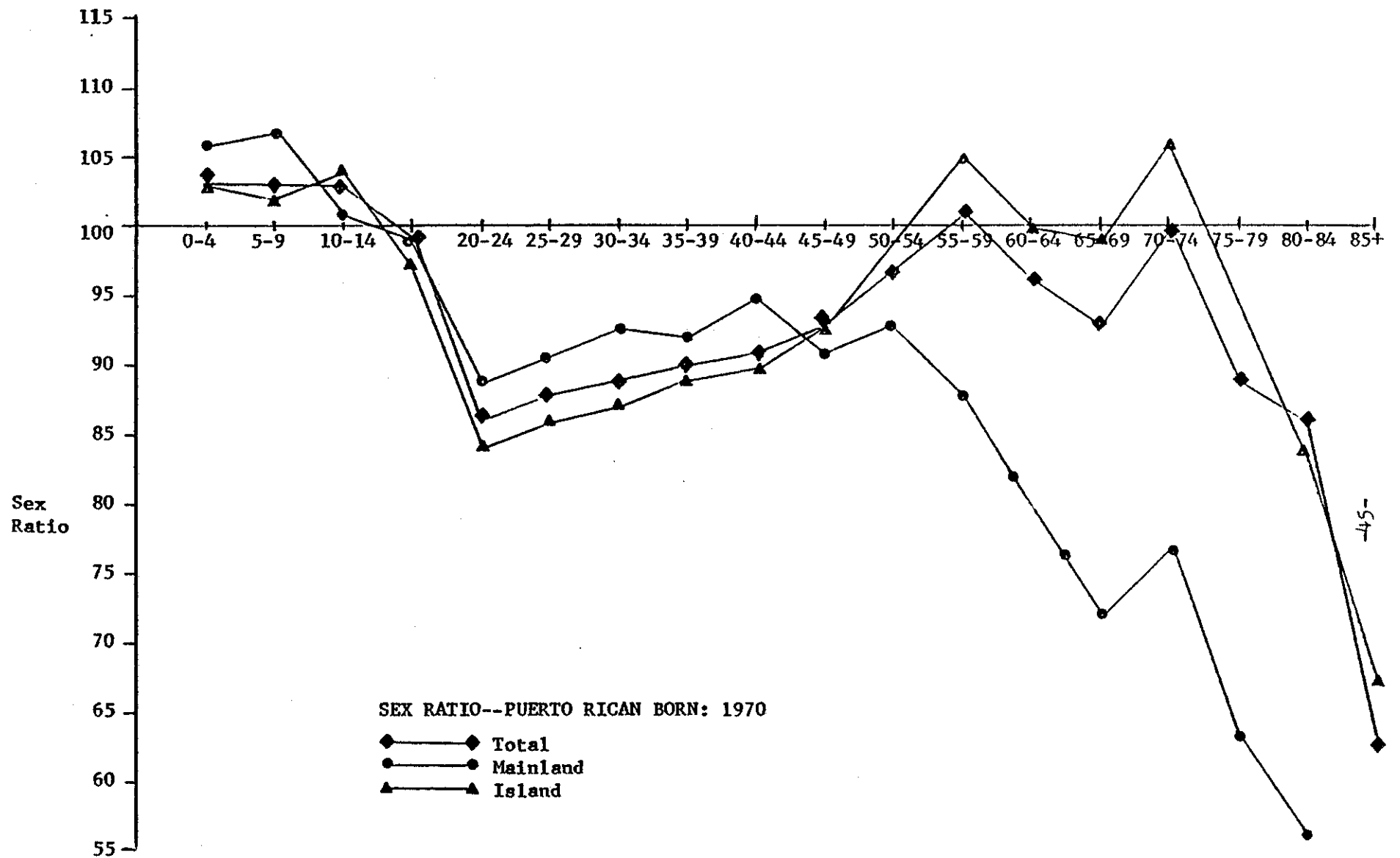
Figure 17. Sex ratios by age for the population of Puerto Rican birth: 1970.

interval 15-19 to 20-24. From ages 25-29 there is a slow rise in the
sex ratio through the age group 55-59, then a sharp drop through 65-69,
a rise in 70-74, followed by a sharp drop after those years. Such a
pattern suggests substantial differences between the sexes either in
patterns of age misreporting or in patterns of net under-enumeration by
age. In either case, the result is a relatively high degree of age-sex
inaccuracy.

Table 6 shows sex ratios by age, age-to-age differences among sex
ratios, and age-sex accuracy indices for the composite population of
Puerto Rican birth in 1950, 1960, and 1970. Although there has been an
improvement from 1950 to 1970, according to U.N. criteria all three age-
sex distributions would be described as "inaccurate," especially above
age 40. In 1950, age-to-age fluctuations in sex ratios and the frequent
deviation of age ratios from 100 (see Table 4) combine to give an index
for those aged 40 and above that the U.N. would consider to be "highly
inaccurate." Even in 1970 the index of age-sex accuracy above age 40 is
clearly within the "inaccurate" range.

Table 7 provides a detailed look at sex ratios above age 60. In
the older ages, there seems to be considerable age-sex inaccuracy. Sex-
ratios stay at or near 100 until the age group 70-74, and fall quite
rapidly after this age group. A pattern of more gradual decline in the
earlier age groups would be expected in an accurately reported age-sex
distribution. Declines in the sex-ratio are particularly pronounced in
the age groups 85-89 and 95-99, a pattern that would be expected if there
were more heaping by men than by women out of these age intervals. Even

TABLE 6. Age-Sex Accuracy Indices for the Total Population of Puerto Rican
          Birth (Island + Mainland): 1950, 1960, and 1970

	1950		1960		1970	
	Sex Ratio	Difference	Sex Ratio	Difference	Sex Ratio	Difference
0-4	102.04	-	102.10	-	103.32	-
5-9	102.64	-0.60	102.50	0.05	102.66	0.66
10-14	105.62	-2.98	101.86	-0.19	103.35	-0.68
15-19	96.71	-8.91	97.33	4.53	97.82	5.52
20-24	89.69	7.03	89.22	8.11	85.90	11.92
25-29	93.55	-3.86	88.70	0.52	87.66	-1.76
30-34	100.60	-7.06	92.14	-3.44	89.34	-1.68
35-39	100.21	0.40	93.10	-0.96	90.26	-0.93
40-44	108.82	-8.62	97.78	-4.68	91.48	-1.22
45-49	109.54	-0.77	104.49	-6.71	92.53	-1.05
50-54	105.25	4.33	112.51	-8.02	97.34	-4.82
55-59	109.22	-3.96	107.19	5.32	101.08	-3.73
60-64	106.49	2.73	97.94	9.25	95.90	5.18
65-69	93.11	13.38	99.32	1.39	93.35	2.55
70-74	94.68	-1.58	98.58	0.74	100.33	-6.98
75-79	90.46	4.23	90.00	8.58	89.02	11.32
80-84	73.67	16.78	76.26	13.74	80.06	8.39

| Index of Age-Sex Accuracy Ages 5-84 | 37.02 | | 26.20 | | 19.56 | |

| Index of Age-Sex Accuracy Ages 40+ | 46.15 | | 31.9 | | 24.58 | |

TABLE 7.   Age-sex Accuracy Indices for Population Aged 50 and Over:
Puerto Rico, 1950, 1960, and 1970

	1950		1960		1970	
	Sex Ratio	Difference	Sex Ratio	Difference	Sex Ratio	Difference
50-54	105.40	5.92	112.60	-8.79	100.94	5.88
55-59	113.65	-8.25	109.33	3.27	103.93	-2.99
60-64	110.17	3.48	100.41	8.92	99.42	4.31
65-69	98.65	11.52	104.01	-3.01	98.34	1.08
70-74	99.39	-0.74	108.17	-4.15	101.30	-2.96
75-79	93.18	6.20	93.74	14.43	95.40	5.90
80-84	75.84	17.34	84.48	9.27	87.14	8.26
85-89	71.02	4.82	63.50	20.97	74.62	12.52
90-94	58.10	12.93	51.76	11.74	68.69	5.93
95.99	54.81	3.29	55.15	-3.39	56.18	12.50

	1950	1960	1970
Age-Sex Accuracy Index	59.91	54.75	41.07

in 1970, the age-sex accuracy index computed for groups aged 60 or more
is about 41, which is within the "inaccurate" range.

D. Census Survival Ratios

In Tables 8 and 9 census survival ratios, computed for the 1950 to
1960 decade and the 1960 to 1970 decade are shown comparing all Puerto
Rican-born persons with U.S. whites, male and female. Census survival
ratios reflects coverage and age-reporting errors in combination. In the
absence of coverage or age-reporting errors, the census survival ratios
would represent mortality only and would "exhibit a characteristic pattern
similar to that shown by life table survival rates; i.e., all rates
would fall below 1.00, the rates would show a smooth decline with in-
creasing age, and the male-female ratios of the rates would be less than
1.00 and shift downward generally with increasing age" (Siegel and Passel,
1979.) In comparing the Puerto Rican males in Table 9 with U.S. white
males, 1960 to 1970, the pattern for the Puerto Rican males is uneven
while the ratio for the U.S. white males is a relatively even pattern.

The census survival ratios for Puerto Rican males at ages 20-24 and
25-29 in 1970 are extremely low, suggesting serious under-enumeration;
the ratio is higher for ages 30-34, continuing upward until at ages 35-39
it exceeds 1.00. This is higher than any ratio for U.S. white males.
At ages 60-64 in 1970 the ratio for Puerto Rican males is again higher
than that of U.S. white males and remains substantially higher to ages 75
and over.

In comparing the 1950-1960 and 1960-1970 census survival ratios the
loss of Puerto Rican males at ages 20-24 is striking. One possibility
is some were in the Armed Forces overseas. The males reappear both in
1950-60 and 1960-70, reaching a peak at 35-39, in 1960-70 over 1.0. In
1950-60 there is an increase to close to 1.0 at ages 65-69 after a

TABLE 8.   Census Survival Ratios for the Combined Population of
            Puerto Rican Birth (Island and Mainland), by Sex:
            1950 to 1960 and Comparative Data for U.S. Whites

Age in 1950	Age in 1960	Combined Puerto Rican Population	U.S. Whites
MALES			
0-4	10-14	1.021	1.014
5-9	15-19	.916	.984
10-14	20-24	.787	.958
15-19	25-29	.852	.982
20-24	30-34	.887	.998
25-29	35-39	.987	.991
30-34	40-44	.946	.985
35-39	45-49	.904	.954
40-44	50-54	.913	.922
45-49	55-59	.910	.903
50-54	60-64	.820	.823
55-59	65-69	.988	.797
60-64	70-74	.640	.710
65+	75+	.475	.411
FEMALES			
0-4	10-14	1.022	1.020
5-9	15-19	.966	.998
10-14	20-24	.931	.987
15-19	25-29	.927	1.004
20-24	30-34	.860	1.006
25-29	35-39	.991	.998
30-35	40-44	.972	.989
35-39	45-49	.865	.956
40-44	50-54	.880	.941
45-59	55-59	.928	.942
50-54	60-64	.878	.898
55-59	65-69	1.080	.909
60-64	70-74	.688	.836
65+	75+	.534	.492

Source: Computed from data in U.S. Bureau of the Census (1963a, 1963b.)
          Data for U. S. whites from U.S. Bureau of the Census (1965.)

TABLE 9. Census Survival Ratios for the Combined Population of
Puerto Rican Birth (Island and Mainland), by Sex:
1960 to 1970 and Comparative Data for U.S. Whites

Age in 1960	Age in 1970	Combined Puerto Rican Population	U.S. Whites
		MALES	
0-4	10-14	.986	1.002
5-9	15-19	.954	1.005
10-14	20-24	.788	.987
15-19	25-29	.841	.973
20-24	30-34	.980	.984
25-29	35-39	1.026	.980
30-34	40-44	.933	.972
35-39	45-49	.884	.948
40-44	50-54	.932	.933
45-49	55-59	.859	.885
50-54	60-64	.948	.845
55-59	65-69	.877	.750
60-64	70-74	.751	.675
65+	75+	.531	.389
		FEMALES	
0-4	10-14	.974	.997
5-9	15-19	.995	1.007
10-14	20-24	.934	.998
15-19	25-29	.934	.989
20-24	30-34	.979	.996
25-29	35-39	1.008	.994
30-34	40-44	.940	.989
35-39	45-49	.890	.968
40-44	50-54	.936	.964
45-49	55-59	.888	.939
50-54	60-64	1.112	.936
55-59	65-69	1.007	.891
60-64	70-74	.733	.837
65+	75+	.611	.509

Source: Computed from data in U.S. Bureau of the Census (1963a, 1963b,
1973a, 1973b.) Data for U.S. whites from Siegel and Passel
(1979.)

gradual progression downward from ages 35-39. In 1960-70 the sharp

increase occurs at 60-64, which could be caused by heaping at age 60.

Comparing the Puerto Rican females with males, the females show

higher survival ratios at most age groups, both in 1950-60 and 1960-70.

At ages 35-39, 60-64 and 65-69 in 1970 the Puerto Rican women show a

slightly higher ratio (over 1.00) than the highest ratio for U. S. white

females. A high census survival ratio (in excess of 1.00) for females of

Puerto Rican birth aged 65-69 in 1960 also could indicate large coverage

errors but more likely results from a similar pattern of age misreporting

in 1960 and in 1970. This pattern of excess survival rates could be due

to a tendency to report older ages that make one eligible for Social Se-

curity.

The census survival ratios for Puerto Ricans of both sexes at ages 65-

69 and ages 75 and over in 1960 exceeded that of the U. S. white population.

At all ages over 60 for males and most ages over 60 for females in 1970

the census survival ratios for Puerto Rican were markedly in excess of

those for U. S. whites. Better coverage of Puerto Ricans in the 1970 census

than in the 1960 census is unlikely to be an explanation for more than a

small part of the difference. Mortality levels may be much lower among

elderly Puerto Ricans than among U.S. whites or, and this seems most likely,

age misstatement could play a major role in producing the patterns shown in

Tables 8 and 9.

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E. Intercensal Cohort Analysis

The results of intercensal cohort analysis of the population of Puerto Rican birth at the censuses of 1960 and 1970 appears in Table 10. As observed earlier, by considering the combined population of Puerto Rican birth resident in Puerto Rico and in the United States the problem of estimating a migration component is avoided. "In applying intercensal cohort analysis when there is no need to allow for net migration...relatively more accurate estimates of coverage and reporting errors may be derived" (Siegel and Passel, 1979.) The basic steps in deriving the expected population of Puerto Rican birth in 1970 by estimating the number of survivors of this population in 1960 have been described in Section 2.   The open ended cohorts ages 25+ and 35+ in 1960 show the expected numbers in 1970, to within 1 or 2 percent. However, there is an increasingly rapid divergence as age increases. For example, there are 9.5 percent too many men 65+ in 1970, and 14.2 percent too many women. By age 85 the numbers are far more inconceivable. There are almost as many reported intercensal deaths to the cohort aged 75+ in 1960 as there were original members of the cohort; yet nearly half the members are reported as alive at the 1970 census.

These figures give excellent evidence of massive overstatement of age at the older ages. The only alternative explanation is that deaths are over-reported, which hardly seems plausible. Age overstatement could be occurring either in death registration or the census or both. The discrepancy in the cohort 75+ in 1960 points to a problem in over-reporting age at death. It is also likely that people are over-stating ages in the 1970 census relative to age reporting in the 1960 census, gaining more than 10 years. Age overstatement seems to be producing death rates that are too low at the older ages.

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TABLE 10: INTER-COHORT COMPARISONS FOR THE PUERTO-RICAN BORN POPULATION, 1960 AND 1970

MALES

Age of cohort in 1960	Population 1960 (1)	Population 1970, 10 years older (2)	Deaths to cohort, 60-70 (3)	Expected population 1970 (4) = (1) - (3)	Ratio, actual to expected population (5) = (2)/(4)
25+	616,470	541,637	82,666	533,804	1.015
35+	423,421	352,243	75,755	347,666	1.013
45+	260,164	204,389	66,003	194,161	1.053
55+	138,815	95,626	51,512	87,303	1.095
65+	63,310	33,629	35,440	27,870	1.207
75+	19,717	8,419	18,230	1,487	5.662

FEMALES

Age of cohort in 1960	Population 1960 (1)	Population 1970, 10 years older (2)	Deaths to cohort, 60-70 (3)	Expected population 1970 (4) = (1) - (3)	Ratio, actual to expected population (5) = (2)/(4)
25+	641,211	582,122	66,735	574,476	1.013
35+	427,514	373,595	62,951	364,563	1.025
45+	255,926	217,449	57,236	198,690	1.094
55+	143,276	107,261	49,327	93,949	1.142
65+	69,878	42,728	36,800	33,078	1.292
75+	25,857	13,270	22,654	3,203	4.143

* Censuses were assumed to occur on January 1. Deaths within an age group are assumed to be evenly distributed by age. So, for example, deaths to the cohort aged 25+ in 1960 were derived as the sum,

All deaths, 35+, 1960-69
+ All deaths, 30+, 1960-64
+ $.9_5D_{30}(65) + .7_5D_{30}(66) + .5_5D_{30}(67) + .3_5D_{30}(68) + .1_5D_{30}(69)$

+ $.9_5D_{25}(60) + .7_5D_{25}(61) + .5_5D_{25}(62) + .3_5D_{25}(63) + .1_5D_{25}(64)$

F. Mortality Data

Age-specific death rates provide the means for calculating life tables. Thus it would be particularly instructive to examine the data for detailed age intervals. Age specific changes in the course of mortality in Puerto Rico in the decade between 1959-61 and 1969-71 are shown in Table 11. In this period remarkable improvement occurred in infant and childhood mortality (particularly at ages 1-4) but the rate of decrease at other ages was generally not substantial. Death rates among males increased during the decade for most age groups between 15-49 years, although rates for females showed sizable declines. At ages 50 and above changes in death rates during the decade sometimes were erratic. At ages 75-79 years death rates for both males and females showed sizable increases between 1959-61 and 1969-71 whereas very large decreases showed up for both sexes at ages 80-84. Such fluctuations probably reflect the variation in the pattern of age heaping between the 1960 and 1970 censuses discussed earlier (heaping at age 79 in 1960 and at age 80 in 1970.)

Table 12 presents mortality differentials between the population of Puerto Rico and the U.S. white population for the two time periods. Puerto Rican males and females had higher death rates than U. S. whites at ages under 45 years (with one exception.) Death rates for Puerto Rican males were lower than those for U.S. whites at every age over 45 in 1959-61 and at every age over 50 in 1969-71. Puerto Rican females had lower death rates in 1959-61 than their U.S. white counterparts at every age over 55; however their differential advantage was generally much smaller than that of Puerto Rican males. In 1969-71 Puerto Rican females in 4 of the 7 age groups 55 and older had lower death rates than U.S. white women; in the other 3 age groups the rates for Puerto Rican women were higher.

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Table 11. Average Annual Death Rates per 100,000 by Age and Sex: Puerto Rico, 1959-61 and 1969-71

Age	1959-61		1969-71	
	Male	Female	Male	Female
Under 1	4,962	3,827	3,556	2,710
1-4	298	321	94	89
5-9	90	77	49	34
10-14	76	46	58	33
15-19	113	70	135	52
20-24	196	108	219	78
25-29	245	154	230	90
30-34	279	178	257	115
35-39	354	246	352	170
40-44	486	346	499	246
45-49	586	394	730	334
50-54	1,030	700	980	540
55-59	1,334	794	1,326	789
60-64	1,928	1,305	1,977	1,228
65-69	2,858	1,996	2,866	1,893
70-74	4,478	3,436	4,318	3,342
75-79	5,538	4,163	6,131	4,465
80-84	11,389	9,548	9,338	7,688
85-89	15,696	11,983	14,621	11,659
90-94	29,470	23,471	21,460	19,940
95+	24,848	24,333	24,222	23,600

Source: Computed from death statistics of the Puerto Rico Department of Health and population data from U.S. Bureau of the Census (1963a, 1973a.)

Table 12. Age and Sex Mortality Differentials: Ratio of Rates for Puerto Rico to Rates for U.S. Whites, 1959-61 and 1969-71.

Age	1959-61			1969-71	
	Male	Female		Male	Female
Under 1	1.84	1.91		1.68	1.68
1-4	2.84	3.77		1.12	1.35
5-9	1.67	2.01		1.03	1.05
10-14	1.48	1.48		1.20	1.18
15-19	.91	1.39		.92	.89
20-24	1.18	1.78		1.10	1.19
25-29	1.61	2.16		1.36	1.23
30-34	1.61	1.83		1.38	1.18
35-39	1.40	1.67		1.35	1.13
40-44	1.17	1.46		1.19	1.06
45-49	.83	1.07		1.07	.89
50-54	.87	1.25		.89	.96
55-59	.75	.96		.75	.95
60-64	.70	.96		.73	1.00
65-69	.71	.93		.71	.98
70-74	.76	.96		.74	1.07
75-79	.64	.68		.71	.83
80-84	.84	.90		.74	.87
85+	.92	.92		.97	1.01

Source: Derived from data for Puerto Rico in Table 11 and data for the U. S. in U.S. Department of Health, Education and Welfare, 1980.

The fact that census survival rates for the Puerto Rican population at older ages tend to be considerably higher than comparable rates for the U.S. white population would seem to support the belief that under-registration of deaths is not an explanation for the relatively low mortality levels of the elderly Puerto Rican population shown in vital statistics reports. Another source of data is at hand that sheds further light on this issue. Computer tape files recording deaths of New York City residents that occurred in New York City contain a code indicating if the decedent was born in Puerto Rico. This permits a direct comparison of death rates for Puerto Ricans and non-Puerto Ricans in an area where unquestionably the registration of deaths is complete. Population and death data for Puerto Ricans and non-Puerto Rican whites were assembled from decennial census statistics and from unpublished tabulations perpared by the New York City Department of Health and combined to produce mortality rates for the 1969-71 period.

Table 13 presents the age specific death rates computed for Puerto Rican and non-Puerto Rican white males and females aged 25 years and over in New York City in 1969-71. The mortality differentials by age are shown in Table 14 which also indicates differentials by sex among the Puerto Rican born and non-Puerto Rican born whites. The first column in the table shows that Puerto Rican born males had higher death rates than other white males at ages under 55 years but lower death rates in all age groups over 55 years. The second column indicates that Puerto Rican born females had higher death rates than other white females at all ages under 75 years but lower death rates at ages 75-84 and 85+.

Table 13. Average Annual Death Rates per 100,000: Puerto Rican Born and
Non-Puerto Rican-born Whites, by Age and Sex:
New York City, 1969-71

AGE	Males		Females	
	Puerto Rican	Non-Puerto Rican whites	Puerto Rican	Non-Puerto Rican whites
25-34	421.8	152.2	124.1	85.2
35-44	643.5	335.3	218.0	209.3
45-54	1,030.8	863.2	514.7	492.7
55-64	1,922.0	2,077.0	1,122.2	1,020.4
65-74	3,573.2	4,558.6	2,787.3	2,391.0
75-84	5,973.7	9,185.9	5,564.3	6,824.3
85 and over	11,847.9	16,816.7	8,964.3	15,722.2

Source: Computed from unpublished death statistics provided by New York City Depart-
ment of Health and population data from U. S. Bureau of the Census (1973a.)

Table 14. Ratio of Death Rates for the Puerto Rican Born to Death Rates
for Whites, excluding Puerto Rican Born: New York City, 1969-71

AGE	Ratio of Male Rates	Ratio of Female Rates	Ratio of Both Sexes Rates	Male/Female Ratio	
				Puerto-Rican Born	Whites, excluding Puerto-Rican Born
25-34	2.77	1.46	2.19	3.40	1.79
35-44	1.92	1.04	1.51	2.95	1.60
45-54	1.19	1.04	1.13	2.00	1.75
55-64	.93	1.10	.99	1.71	2.04
65-74	.78	1.17	.94	1.28	1.91
75-84	.65	.82	.73	1.07	1.35
85+	.70	.57	.60	1.32	1.07

The last two columns of Table 14 present the ratio of the male
to the female age-specific death rates for the Puerto Rican born and other
white groups. However, among both population groups male mortality ex-
ceeds that of females at every age. The male disadvantage is consider-
ably greater among Puerto Ricans under 55 years than for other whites
but substantially less among Puerto Ricans at ages 55-84 years.

The low mortality exhibited among the Puerto Rican male residents of
New York City relative to other white males is in accord with the pattern
shown by comparing mortality for U.S. whites as a whole with comparable
data for the Commonwealth of Puerto Rico. Mortality rates are higher at
young ages among Puerto Ricans but lower at older ages. Similarly, among
females, rates for Puerto Ricans also are higher at young ages but they do
not become lower than those of U.S. white women until the oldest age groups.
The New York City data offer evidence that under-registration of deaths in
Puerto Rico does not play a part in creating this pattern. Other explan-
ations must be sought, and peculiarities in age reporting by the Puerto
Rican populace is one likely cause.

NOTE

As of completion date of this study (March 1982,) no 1980 census data
(either in published form or in the form of summary tape files) showing
the age distribution of the population of Puerto Rico were yet available.
Accordingly, it was not possible to consider the mortality experience
around the 1980 census period.

G. Illiteracy

One explanatory factor in the consideration of age misstatement
is literacy. Mazess and Forman (1979) observe that "age exaggeration
appears to be a common finding in the extreme elderly throughout the
world and appears associated with illiteracy and absence of actual
documentation." Elderly illiterate persons tend to exaggerate age and
are more likely to round ages on years ending in zero. Table 15 shows
the percent of residents of Puerto Rico who were literate by age group
and sex according to the 1970 census. There is a direct correlation
between age and the ability to read and write. In the age group 35-39,
92 percent of the combined male and female population can read and write.
The percent steadily declines until at ages 75 and over only 49 percent
of males and 43 percent of females are literate. The category 75 years
and over is the oldest for which published data are available. The
public use samples of the 1970 census of Puerto Rico were utilized to
extend the examination of illiteracy to higher age groups (Table 15.)
The sample data indicate that only 39 percent of those persons reported
as 90 or over were able to read and write.

Table 16, also developed from the 1970 public use samples, shows
the percent of literate and illiterate Puerto Ricans in selected ten-
year age groups reporting a particular age. Excessive numbers of il-
literate persons tend to report ages ending in 0. Literate persons are
less likely than illiterate persons to report ages 40, 50, 70,80, and 90.
Interestingly, there is no difference in the pattern of heaping at
age 60, but illiterate persons are more likely to report age 62. This
may be associated with the age of eligibility for social security.

TABLE 15. Percent of Puerto Rican Population Able to Read
           and Write, by Sex and Age, for Persons 35 Years
           and Over, 1970 Census

Age	Both Sexes	Male	Female
35-39	92.0	93.4	90.7
40-44	90.8	92.6	89.1
45-49	88.6	91.1	86.2
50-54	85.8	89.5	82.2
55-59	82.0	86.4	77.3
60-64	74.5	79.8	69.3
65-69	66.0	70.9	61.1
70-74	59.2	62.7	55.6
75 and over	46.1	49.4	43.4
75-79*	53.2	--	--
80-84*	46.1	--	--
85-89*	40.9	--	--
90 and over*	39.4	--	--

*Derived from Public Use Samples of Puerto Rico

Source: U.S. Bureau of the Census (1973a)

TABLE 16. Percent of Persons in Puerto Rico in Specified Ten-year Age Groups Reporting a Particular Age, by Literacy Status, 1970 Census

Age Group	Number of Persons		Percent Reporting Specified Age		
	Literate	Illiterate	Age	Literate	Illiterate
35-44	7,406	731	40	10.7	13.5
45-54	5,723	838	50	12.1	14.1
55-64	4,175	1,120	60	11.0	10.7
			62	8.6	13.5
65-74	2,160	1,181	70	10.5	14.1
75-84	764	752	80	10.5	14.0
85-94	206	291	90	15.5	19.9

Derived from Public Use Samples of Puerto Rico

Mazess and Forman (1979) constructed geneologies for residents of
an Ecuadorian village population renowned for its apparent extreme
longevity. Church and civil records were located as evidence of identi-
fication. None of the 23 investigated cases of reputed centenarians
had survived over 100 years; their average age based on reconstructed
genealogies was 86 years. Among 15 reputed nonagenarians (none of whom
had survived 90 years) the mean age was actually 81.5 years.

Life tables for populations such as U. S. whites indicate that at
older ages there generally is an increase of 9 or 10 percent in the
death rate with the increase in age of one year. Thus, if the average
age in a population - say the Puerto Rican population 85-89 years of age-
on census and death records is one year younger than the true age, errors
on the order of 10 percent will be introduced. An average error of two
years could result in an error of the magnitude of 20 percent. Systematic
overstatement of age could thus account for the substantial differences
in reported death rates of Puerto Ricans at advanced ages compared with
other populations.

SECTION 4

CONCLUSION

The phenomenon of Puerto Rican longevity has attracted the attention

of demographers. Official statistics indicate life expectancy at age 45

is among the highest in the world, despite the relatively low economic

status of the Puerto Ricans. Various theories have been suggested for the

longevity: a modern health and medical care system, family care of the

elderly, the effects of climate, and specific cultural factors. This

study suggests another reason for these high survival rates, age misre-

porting.

This paper has presented evidence of systematic over-reporting of

ages within certain groups in the older ages. Examination of single-year

age distributions in 1970 showed a lack of discernable heaping at ages 75,

85, and 95, in contrast to substantial heaping at younger ages ending in

5, thereby suggesting a pattern of wholesale heaping out of the mid-70s,

mid-80s, and mid-90s into the next higher age intervals. This interpre-

tation is consistent with the pattern of net reporting error implied by

age ratios computed within five-year age groups. These ratios suggest net

under-reporting of age in the intervals 50-54, 70-79, 85-89, and 90-99,

with net over-reporting in the age groups 55-59, 80-84, and 100+. The

summary age accuracy and age-sex accuracy indices corresponding to these

distributions generally question the validity of age reporting in the

Puerto Rican population, especially at the older ages.

Another approach in viewing misreporting errors is a comparison of

census survival ratios from 1950-60 and 1960-70. The ratio pattern is

uneven for Puerto Rican males when compared with U. S. white males.

In the older age groups the numbers of surviving Puerto Rican males and
females are substantially more than expected based on intercensal patterns
for U. S. whites as well as published life tables.

A comparison of changes in intercensal cohort size to intercensal
deaths further indicates the quality of age reporting. The group age 75
and over in 1960 showed almost as many reported deaths during the years
1960-70 as were in the original cohort and yet nearly half the members
are reported as alive in the 1970 census. At ages 85 and over the
numbers are extraordinarily high and seem to indicate major errors in
age reporting. Very likely extensive over-reporting of age occurred in
the 1970 census; compared to the 1960 census Puerto Ricans were gaining
more than ten years.

In general, the direction of net reporting error seems to involve a
systematic tendency to over-report age among the elderly. Such a pattern
of over-reporting is consistent with a highly illiterate population and a
culture in which age is generally accorded status and prestige. The system-
atic over-reporting of age would have the effect of generally biasing es-
timates of old age survival when mortality rates are computed using un-
adjusted age data.

This demographic investigation is an example of an approach that has
demonstrated the error in accepting the official data on Puerto Rican
longevity advantage without further documentation. The many examples of
age misreporting demonstrated in this study indicate the need for further
investigation of age validity. Unless comparison of the death record is
made with an accurate document such as a birth certificate any attempt to
correct the age statement would be highly arbitrary. The need to establish

the true picture of the Puerto Rican longevity advantage is of utmost importance in evaluating the health progress of this population and to make reliable international comparisons.

To conclude, evidence indicates that the official life tables for Puerto Rico in recent years overstate the expectation of life; the estimates for expectation of life at birth probably are only slightly overstated, but estimates of life expectancy of persons 45 years of age and over may be considerably exaggerated. As a result, values of life expectancy published for recent years need to be modified downward. There is no doubt that remarkable mortality decline has occurred in Puerto Rico since 1940. Nevertheless, the findings cited above suggest the evidence that Puerto Ricans over 45 years of age have unusually low mortality, and consequently extremely favorable life expectancy, is primarily due to age misreporting.

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