AFRICAN-AMERICAN MORTALITY AT OLDER AGES: RESULTS OF A MATCHING STUDY*

SAMUEL H. PRESTON, IRMA T. ELO, IRA ROSENWAIKE, AND MARK HILL

In this paper we investigate the quality of age reporting on death certificates of elderly African-Americans. We link a sample of death certificates of persons age 65+ in 1985 to records for the same individuals in U.S. censuses of 1900, 1910, and 1920 and to records of the Social Security Administration. The ages at death reported on death certificates are too young on average. Errors are greater for women than for men. Despite systematic under-reporting of age at death, too many deaths are registered at ages 95+. This excess reflects an age distribution of deaths that declines steeply with age, so that the base for upward transfers into an age category is much larger than the base for transfers downward and out. When corrected ages at death are used to estimate age-specific death rates, African-American mortality rates increase substantially above age 85 and the racial "crossover" in mortality disappears. Uncertainty about white rates at ages 95+, however, prevents a decisive racial comparison at the very oldest ages.

Elo and Preston (1994) summarize research demonstrating serious errors and inconsistencies in the data on which national estimates of African-American mortality at older ages are based. This research includes a study that matched death certificates recorded in 1960 to records for the same individuals in the 1960 U.S. Census of Population. In that study, the ages reported on death certificates were systematically younger than those reported in the census, and the disparity increased with age. Above age 80, 29.0% more female deaths and 19.6% more male deaths were found when the census age rather than the age on the death certificate was used (National Center for Health Statistics [NCHS] 1968). Other evidence of data error includes inconsistencies between intercensal changes in cohort size and intercensal deaths (Elo and Preston 1994) and inconsistencies among sets of mortality rates for African-Americans estimated from vital statistics/census data and other sources such as Medicare (Coale and Kisker 1990), Social Security (Bayo 1972; Kestenbaum 1992), insurance records (Zelnik 1969), and extinct-generation procedures (Elo and Preston 1994).

These data problems obviously pose difficulties for establishing valid estimates of African-American mortality at older ages, and these mortality rates bear upon a major issue in mortality analysis. African-American death rates at older ages have been lower than those of whites throughout the twentieth century. The "crossover" from higher rates at younger ages to lower rates at older ages has provided empirical underpinnings for a "survival of the fittest" mechanism operating in old-age mortality (Manton, Patrick, and Johnson 1987; Manton and Stallard 1981; Manton, Stallard, and Vaupel 1981; McCord and Freeman 1990; Otten et al. 1990; Zopf 1992). Because younger African-Americans were subject to exceptionally adverse health conditions earlier in the century, it is plausible to propose that the more vulnerable members of a cohort died at high rates, leaving behind an exceptionally hardy group of survivors at older ages. The bulk of evidence from other populations, however, suggests that cohorts subject to severe health conditions in early life also experience elevated mortality in later life (Elo and Preston 1992; Mosley and Gray 1993). Coale and Kisker (1986) use indirect evidence to suggest that most instances of mortality crossovers simply reflect inaccurate data at older ages.

In this paper we report the results of an effort to establish accurate ages at death for the African-American population at advanced ages. We match a sample of death certificates for elderly African-Americans dying in 1985 or 1980 to records for the same individuals in U.S. Censuses of 1900, 1910, and 1920, when they were children or young adults. These are the latest censuses that have been released for public use under the Census Bureau's 72-year release rule. We also match the sample to records from the Death Master File of the Social Security Administration. Results of two-way and three-way matches then are used to establish corrected age distributions of deaths. We employ these corrected age distributions to estimate mortality rates for older African-Americans, and find that the corrected mortality rates for older African-Americans are much higher than uncorrected rates above age 85.

DESIGN OF THE MATCHING STUDY

Sampling Strategy

The basic sampling universe for this study consists of African-Americans born in the United States and dying in 1985

*Samuel H. Preston, Population Studies Center, University of Pennsylvania, Philadelphia, PA. 19104-6298; E-mail: spreston@pop.upenn.edu; Irma T. Elo, Ira Rosenwaike, and Mark Hill, Population Studies Center, University of Pennsylvania. This research was supported by Grant AG10168 from the National Institute of Aging. We would like to acknowledge the extraordinary assistance provided by Bert Kestenbaum of the Social Security Administration. Tim Cheney, Laura Shrestha, Julie Goldsmith, Andrew Preston, and Jeannine LaRouche provided valuable assistance in preparing or processing the data set. We would also like to thank two anonymous reviewers for useful comments. An earlier version of this paper was presented at the 1995 annual meetings of the Population Association of America, held in San Francisco.

at a reported age (i.e., age on the death certificate) of 65 or older. We first drew a sample of this group by selecting all deaths in this age range that occurred during the period January 1–January 7, 1985. The 1920 census was taken on January 1; thus anyone reported as dying at age 65+ during this period should have been eligible for inclusion in the 1920 census. Because we were concerned about small sample sizes at very advanced ages, we sampled deaths at reported ages 85+ at twice the rate for other ages. For this group, our sample includes all deaths that occurred during the period January 1–January 14, 1985.

We also oversampled decedents born in Maryland. In the first two decades of the twentieth century, Maryland was the only state with an appreciable number of African-Americans where a sizable proportion of births was registered (Shapiro 1950; U.S. Bureau of the Census 1913). We oversampled Maryland-born persons to permit a check of the quality of age reporting among children in early censuses. Our sample includes deaths to persons born in Maryland who died at ages 65+ during the period January 1–May 31, 1985.

If a person who reportedly died at 65–69 in 1985 actually died at age 60–64, there would be no chance of detecting such age overstatement by using the 1920 or earlier censuses because that person would not have been born at the time of the censuses. To ascertain the importance of this pattern of age overstatement, we selected an additional sample consisting of all African-Americans who died at a reported age of 60–69 in the period January 1–January 7, 1980. This sample also permits some inferences about the age-reporting patterns of those reported as dying at ages 60–64.

Our sample was drawn in collaboration with the National Center for Health Statistics (NCHS). NCHS obtained an agreement to participate in the study from the individual states and from New York City and Washington, DC, which maintain separate registration areas. All jurisdictions agreed to release death certificates for the study. We specified the sample features described above to NCHS, which supplied us with information on the state of death and the death certificate number of all deaths falling within our sampling domain. We requested and received copies of 5,283 death certificates from the pertinent registration areas; 45 areas contributed one or more sample deaths. Table 1 shows the number of deaths included in the final sample and its various components.[1]

TABLE 1. NUMBER OF DEATH CERTIFICATES INCLUDED IN THE MATCHING STUDY

Sampling Frame	Number of Deaths
1985 Deaths	
January 1–January 7, ages 65+ (National Sample)	2,714
January 8–January 14, ages 85+ (85+ Oversample)	536
January 8–May 31, Maryland-born 65+ (Maryland Oversample)[a]	1,046
1980 Deaths	
January 1–January 7, ages 60–69	966
Total	5,262

[a]Excludes seven deaths of Maryland-born persons age 85+ at death who died January 8–14. These persons were included in the 85+ oversample.

Linkage of Death Certificates to Censuses of 1900, 1910, and 1920

Rosenwaike and Logue (1983) linked a sample of deaths in Pennsylvania and New Jersey at ages 85+ to records from the 1900 census. The present study represents an elaboration of their basic study design. We searched soundex records from the 1900, 1910, and 1920 censuses to identify a record for each decedent. The Soundex system applies to surnames a phonetic coding system, the Russell Soundex system, to facilitate locating individuals whose surnames have several potential spellings. Soundex records cover the entire country for 1900 and 1920; for 1910, they cover states where 92% of the African-American population lived (U.S. Bureau of the Census 1913). The records are organized by state and, within states, alphabetically by surname of the family head (or individual, if a person is living in a nonfamily situation). Each member of the family is to be listed on the family card, with full name and information on his or her relation to household head, age, sex, state of birth, and month and year of birth. The two latter items are available for 1900 only.

Items on the death certificate that were critical in establishing a match were the individual's name, father's name, mother's name, and state of birth. When death certificate information was incomplete, a staff member of the Social Security Administration (SSA) provided information on parental names from SSA databases. Other useful information on the death certificate included city or county of birth, which was available on certificates from selected states; month of birth, available for matching only to the 1900 census; and sex. We excluded age and year of birth as matching criteria because the focus of the study is the quality of age reporting. The age reported on the death certificate, however, determined in which of the three censuses the search was begun: the census closest to the time when the individual should have been age 10 if the age on the death certificate was accurate. This choice permits age understatement as great as 10 years relative to the decedent's putative age at death. We searched first in the state of birth, second in the state of death (if different), and third in the state where the decedent's Social Security number was issued (if different); this state was known from the first three digits of the Social Security num-

1. We excluded 24 death certificates from the final sample, of which 14 were coded incorrectly as black in NCHS records. Another reason for exclusion was an error in age or state of birth in NCHS records that placed the certificate outside the sampling frame. One death occurring in Hawaii was omitted inadvertently. Discrepancies involved only a tiny fraction of cases. Three deaths that should have been included in the NCHS list were brought to our attention in records of the Division of Vital Records, Maryland. We added these to the sample.

ber reported on the death certificate. Thus we conducted up to nine searches per person (three censuses times three states). In some instances we conducted additional searches under the mother's maiden name and the father's surname if the latter differed from a male decedent's last name.

Linkage was aided by a numerical estimate of the expected number of black children in the state of birth, of death, or of Social Security card application who had the characteristics listed on the death certificate or Social Security record. (For information on linkage to Social Security records, see below.) We obtained the relative frequency of particular first names and last names from unpublished tabulations supplied by the Health Care Financing Administration. These tabulations were based on a 10% sample of names of African-Americans born before 1920 and included in Medicare enrollee files as of 1990. Frequencies were provided for all names held by 30 or more males or females. The estimated number of persons with the observed characteristics is

$$V = .24N_{1912} \times R \times D \times F \times M \qquad (1)$$

where N_{1910} is the state's black population in the 1910 census, R is the proportion of African-Americans with the subject's surname, D is the proportion of African-Americans of the subject's sex with the subject's first name, F is the proportion of African-American males with the subject's father's first name, and M is the proportion of African-American females with the subject's mother's first name. The multiplier of .24 converted the total African-American population of a state in 1910 into an estimated number of African-Americans of a particular sex below age 20.

The quality of a potential match was assessed initially by staff members working in the Philadelphia branch of the National Archives. Analysts were urged to be very conservative in accepting matches—that is, to take great pains to avoid false matches. The subjective scoring system for matches was "very confident," "fairly confident," "somewhat confident," and "not sure. Matches in the last category were dropped from further analysis. A second staff member also reviewed all potential matches. Matches that two analysts classified as "very confident" were accepted. This category contained 2,874 matches. Matches in the "fairly confident" and "somewhat confident" range then were subjected to a reapplication of eq. (1), in which information was added on month of birth, county of birth, and similarity of names when names did not match exactly. If names showed loose agreement (e.g., Willis and William), we assumed that 40% of the state's residents would show loose agreement with the name field on the death certificate. We accepted the match if the final V score was less than .01, indicating less than a 1-in-100 chance that another person in the state would match the characteristics on the death certificate even with what might have been a liberal definition of a "match." By this criterion, 99 of 181 "fairly confident" and 18 of 88 "somewhat confident" matches were elevated to a match. (Additional details on matching procedures are available from the authors on request.)

TABLE 2. MATCH RATE BY AGE, FULL SAMPLE

Age on Death Certificate	Number of Certificates	Percentage of Certificates Matched to an Early Census Record
60–64	409	45.97
65–69	1,345	52.64
70–74	812	54.80
75–79	716	56.84
80–84	724	57.73
85–89	665	64.66
90–94	378	68.78
95–99	161	65.22
100+	52	57.69
Total	5,262	56.84

Altogether 2,991 of 5,262 death certificates, or 56.8%, were judged to have been matched successfully to an early census. In one of the matched cases no age was reported on the census, so the analysis is based on 2,990 cases. We linked 19.9% of the matches to the 1900 census, 18.4% to the 1910 census, 61.7% to the 1920 census, and one decedent to the 1880 census. Table 2 presents the match rates by age. Presumably the reason for greater success in matching persons age 85+ at death is that their records might be found in any of the three early censuses, whereas persons who were actually age 65–74 at death could be matched only to the 1920 census.

Linkage of Death Certificates to Social Security Administration Records

We also attempted to link each of the death certificates to records from the publicly available Death Master File (DMF) of the Social Security Administration. This file contains records of age which are based mostly on evidence submitted when a claim for benefits was made and which are largely independent of the age of death reported on the death certificate.[2] The principal field used for linkage to the DMF was the decedent's Social Security number (SSN). Other linkage criteria were first and last name, month and day of birth, month and year of death, and state of last residence. We linked death certificates to the DMF in two steps.[3]

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2. The SSA generates two versions of the DMF from its NUMIDENT database, the principal repository of the SSA death notices collected from various sources including the Master Beneficiary Record (MBR), the Supplemental Security Record (SSR), the Black Lung File, Health Care Financing Administration files, and the Beneficiary and Earnings Data (BENDEX) files. The publicly available version of the DMF excludes some death data received from state bureaus of vital statistics under agreements with the SSA (Aziz and Buckler 1992:264–65). The copy of the DMF used here was obtained in 1992.

3. To minimize the possibility of spurious matches, we chose a subset of the DMF records for the linkage; this subset included all individuals whose month and year of death was recorded as either December 1979, January 1980, December 1984, or January through June 1985.

First we selected DMF records that showed an exact match with the individual's SSN reported on the death certificate. Because of the possibility that the SSN on the death certificate is not the decedent's own number (Kestenbaum 1992), we treated as a match only those cases which showed name agreement between the sources, with allowance for minor spelling differences. We did not use age at death in any way to establish a match, thereby avoiding one potential bias in a study of age misreporting.

A second step in the match to the DMF involved records for which no SSN match was made. Here we selected records for which the first or middle name and the last name, state of residence at the time of death, and month and year of death agreed exactly, and for which there was only a one- or two-digit variation on the reported SSN. We made no attempt to match 130 death certificates without SSNs.[4] (Further details on linkage procedures are available from the authors on request.)

Using these criteria, we were able to match 88.1% of death certificates to the DMF. We matched the smallest proportion of records in the age interval 60–64 (82.4%); at ages 65 and above, the proportions matched varied from a low of 86.3% at ages 85–89 to a high of 90.4% at ages 100+. Altogether we were able to match 94.4% of the entire sample to either the DMF or an early census record. We accomplished three-way linkage for 2,657 records, or 50.5% of the entire sample of death certificates.

Ascertaining Age at Death from Different Sources

This study focuses on the age at death reported on the death certificate. We could have concentrated instead on the age at death implied by death certificate information on month/day/year of birth and month/day/year of death, but the reported age at death (a separate field on the death certificate) is the principal basis of NCHS tabulations and of national mortality estimates.

To assign an age at death that is consistent with the decedent's age reported at an early census, one must introduce additional information on the decedent's birthday (i.e., month and day of birth). We required this information in order to ascertain whether a birthday would have occurred between the date in the calendar year when the decedent was enumerated in an early census and the date of death reported on the death certificate. When a subject was matched to the 1910 or 1920 censuses, we took his or her birthday from the day and month of birth reported on the death certificate. When a subject was matched to the 1900 census, we inferred his or her age at death from the "year of birth" and "month of birth" fields directly available in the 1900 census. Day of birth (i.e., day in the month) for these subjects was taken from the death certificate.

We inferred age at death in the DMF by comparing month/day/year of birth with month/day/year of death on the DMF. When information on date of death was partially missing on the DMF (a frequent occurrence for day of death), we substituted equivalent information from the death certificate.[5]

RESULTS

Age Reporting on Death Certificates Relative to Early Censuses

Table 3 presents the joint distribution of ages reported on the death certificate and the ages at death inferred from early census records for the 2,990 cases matched to an early census. In this Table, we have not yet applied a weighting system to the matched cases to reflect varying probabilities of selection and success in linkage. At age intervals beginning with 65–69 and above, 73.7% of female deaths and 80.0% of male deaths are reported to be in the same five-year age interval on both the death certificate and the early census record. Greater consistency of reporting for males is observed throughout this study and also was found in the 1960 death certificate/census matching study (NCHS 1968).

At death certificate ages 65+, 20.2% of female and 13.2% of male deaths would have been in a higher age bracket according to the age at death based on early census records than on death certificates. Only 6.1% of female and 6.8% of male deaths would have been in a lower age bracket. Thus ages at death appear, on average, to be understated on death certificates. This understatement is confined to death certificate ages below 90; at death certificate ages 90+, ages on death certificates are more likely to be overstated than understated relative to the census-based ages for both men and women.

This pattern of age inconsistencies is also evident in Table 4, which presents the degree of agreement between the ages at death from the two sources by single years of age. Only 44.6% of female and 50.7% of male matched cases showed the age at death on the death certificate that would be expected from the early census record. The probability of exact agreement did not vary substantially with ages up to 95+ for females and 90+ for males, except that the age range 80–84 showed unusually poor agreement for both sexes. This result could be attributable in part to the reporting of 1900 as the birth year for persons born around the turn of the century.

Relative to the early census age, 40.4% of women had a death certificate age that was too young, including 8.7% in which it was too young by at least five years; among males,

4. On about 9% of the death certificates no SSN was reported. Because the SSN is a key variable in matching to the DMF, attempted to obtain SSNs for these cases from an alternative source. As a part of this effort, we also attempted to verify the SSNs for records that we were initially unable to match to the DMF. Here we were assisted by Bert Kestenbaum of the SSA, who searched through various internal SSA files (other than the DMF) accessible only to SSA personnel, for potential matches to the death certificates. When agreement between the death certificate and an internal SSA record was found for the decedent's first and/or middle and last name, sex, month of birth and death, year of death, and state of last residence at the time of death, we accepted the SSN and included it in the match to the DMF. By these procedures we were able to obtain SSNs for all but about 3% of the death certificates.

5. An alternative procedure would have been to use the date of death from the death certificate in calculating age at death from the DMF. This procedure would not have altered the results presented below.

TABLE 3. JOINT DISTRIBUTION OF DEATHS BY AGE AT DEATH ON THE DEATH CERTIFICATE AND AGE IMPLIED BY AN EARLY CENSUS RECORD

	Calculated Age at Death (Census)										
Age on Death Certificate	60–64	65–69	70–74	75–79	80–84	85–89	90–94	95–99	100–104	105–109	Total
					Females						
60–64	56	14	3	4							77
65–69	3	216	60	13	3						295
70–74		6	147	36	9	2	1				201
75–79			9	142	38	7	1				197
80–84				8	150	47	9	3			217
85–89				1	9	198	39	4			251
90–94			1		2	15	133	11			162
95–99						6	13	48	2		69
100–104					1		3	6	5		15
105–109									1	1	2
110+								1	1		2
Total	59	236	220	204	212	275	199	73	9	1	1,488
					Males						
60–64	90	17	1	3							111
65–69	8	337	62	3	3						413
70–74		7	198	31	6	1					243
75–79		2	12	172	19	3	2				210
80–84		2	2	13	159	23	2				201
85–89				2	8	148	16	4	1		179
90–94						19	73	6			98
95–99						5	10	21			36
100–104							2		4	1	7
105–109									1	1	2
110+								1	1		2
Total	98	365	275	224	195	199	105	32	7	2	1,502

32.4% had an age at death that was too young. Age at death was overstated on the death certificate for 15.1% of the women and 16.9% of the men. Once again, a net understatement of age at death on death certificates is implied, at least at death certificate ages below 90.

Age Reporting on Death Certificates Relative to the Death Master File of the Social Security Administration

Table 5 presents information equivalent to that in Table 4 but pertaining to death certificates that were linked to Social Security records. A similar pattern of discrepancies in death certificate ages is revealed. For both sexes combined, 23.6% of death certificates had an age at death that was lower than that implied by the Death Master File. Only 10.7% of death certificates had a higher age at death, whereas 65.7% showed age agreement in the two sources. In a majority of instances in which age is understated on the death certificate relative to the Social Security record, the discrepancy was 2+ years, whereas age overstatement on the death certificate was concentrated more heavily at a discrepancy of one year. As in the case of the match to an early census, age discrepancies were more common among women than among men.

Although Kestenbaum (1992) found a higher overall level of agreement between death certificate and Social Security ages at death, his analysis of 1987 death certificates from Massachusetts and Texas revealed similar patterns: ages at death for blacks reported on the death certificate were more frequently understated than overstated in relation to ages on social security records. Our results are also consistent with the findings from the 1960 death certificate and census matching study, which revealed systematic underreporting of age

TABLE 4. PERCENTAGE DISTRIBUTION OF DISCREPANCIES BETWEEN AGE AT DEATH REPORTED ON THE DEATH CERTIFICATE AND AGE IMPLIED BY EARLY CENSUS RECORDS

	Census Based Age minus Death Certificate Age								
Age on Death Certificate	–5 and below	–4 to –2	–1	0	1	2 to 4	5+	Total	Number of Deaths
				Females					
60–64		1.30	1.30	45.45	22.08	15.58	14.29	100.0	77
65–65	0.34	1.69	3.05	48.47	18.98	17.63	9.83	100.0	295
70–74	1.49	1.49	6.47	44.28	20.90	14.43	10.95	100.0	201
75–79	1.02	4.06	7.11	45.18	16.75	15.74	10.15	100.0	197
80–84	1.38	2.30	7.37	40.09	18.89	17.51	12.44	100.0	217
85–89	1.20	4.78	10.36	46.61	17.13	13.55	6.37	100.0	251
90–94	4.94	6.17	19.75	47.53	9.26	11.11	1.23	100.0	162
95–99	17.39	10.14	23.19	31.88	14.49		2.90	100.0	69
100–104	26.67	40.00	6.67	20.00		6.67		100.0	15
105–109		50.00		50.00				100.0	2
110+	100.00							100.0	2
Total	2.55	3.90	8.60	44.56	17.27	14.45	8.67	100.0	1,488
				Males					
60–64			7.21	52.25	24.32	10.81	5.41	100.0	111
65–69		2.66	7.51	57.38	18.16	8.23	6.05	100.0	413
70–74		4.53	8.64	55.97	17.28	8.23	5.35	100.0	243
75–79	0.95	5.24	9.52	46.19	24.76	7.62	5.71	100.0	210
80–84	3.48	5.47	13.43	40.30	24.38	10.45	2.49	100.0	201
85–89	2.23	4.47	10.61	51.40	15.08	11.17	5.03	100.0	179
90–94	3.06	13.27	22.45	43.88	7.14	9.18	1.02	100.0	98
95–99	25.00	19.44	2.78	41.67	8.33	2.78		100.0	36
100–104	28.57	14.29	14.29	28.57			14.29	100.0	7
105–109	50.00		50.00					100.0	2
110+	100.00							100.0	2
Total	2.00	4.86	10.05	50.67	18.77	8.85	4.79	100.0	1,502

on the death certificate relative to the age on the matching 1960 census record at older ages (NCHS 1968).

The widespread misreporting of age and the net understatement of age on death certificates are undoubtedly due to many factors. First, most African-Americans born before 1920 were born in the south, where birth registration was inadequate or nonexistent. We have shown elsewhere that availability of birth records is associated significantly with consistency in age reporting between the death certificate and an early census (Hill et al. 1995). Second, the concept of chronological age is said to lack salience among elderly African-Americans, and the attainment of advanced age may not confer the same esteem as it does in many other groups (Peterson 1990). Reasons for net understatement of age may include deliberate concealment of age by the decedent in order to appear younger than she or he was. Interviews that we have conducted with elderly African-Americans in Philadelphia suggest that a vanity motive for age understatement may be widespread, especially among women (Clarke, Hill, and Riddley 1995). Such a sex difference would be consistent with a greater stigmatization of aging among women (Harris 1994) and with our evidence that age misreporting, especially age understatement, is greater among female than male decedents. Finally, the understatement of age on the death certificate may simply reflect the informant's failure to advance the decedent's age at each birthday. Age accuracy requires periodic updating; errors of omission lead to understatement of age.

Non-Match Bias

Direct tests of nonmatch bias are possible because we have three sources of information on age at death. The first test

TABLE 5. PERCENTAGE DISTRIBUTION OF DISCREPANCIES BETWEEN AGE AT DEATH REPORTED ON THE DEATH CERTIFICATE AND ON THE SOCIAL SECURITY RECORD

	Social Security Age minus Death Certificate Age								
Age on Death Certificate	−5 and below	−4 to −2	−1	0	1	2 to 4	5+	Total	Number of Deaths
				Females					
60–64	0.80	1.60	0.80	72.00	6.40	7.20	11.20	100.0	125
65–65	0.64	1.06	2.55	67.45	10.21	10.85	7.23	100.0	470
70–74	0.31	2.15	5.21	63.50	9.51	10.12	9.20	100.0	326
75–79	0.32	1.60	3.85	60.58	11.54	11.22	10.90	100.0	312
80–84	0.86	3.72	5.16	55.87	12.89	13.47	8.02	100.0	349
85–89	1.72	2.87	7.76	63.22	10.06	8.33	6.03	100.0	348
90–94	4.19	6.05	8.84	67.91	7.44	5.12	0.47	100.0	215
95–99	10.99	15.38	12.09	51.65	7.69	1.10	1.10	100.0	91
100–104	18.52	18.52	7.41	40.74	7.41	7.41		100.0	27
105–109	25.00	25.00		50.00				100.0	4
110+	100.00							100.0	3
Total	1.89	3.30	5.24	62.73	10.04	9.60	7.18	100.0	2,270
				Males					
60–64	0.47	0.94	4.25	71.23	10.85	5.66	6.60	100.0	212
65–69	0.14	1.38	6.22	71.27	9.81	6.35	4.83	100.0	724
70–74	0.49	4.18	7.13	66.58	11.06	6.39	4.18	100.0	407
75–79	1.23	1.85	6.79	70.37	10.19	5.25	4.32	100.0	324
80–84	1.69	4.07	7.80	64.41	12.20	6.44	3.39	100.0	295
85–89	0.88	3.98	6.19	67.70	10.62	7.96	2.65	100.0	226
90–94	0.89	9.82	8.93	69.64	6.25	3.57	0.89	100.0	112
95–99	17.31	11.54	3.85	55.77	5.77	3.85	1.92	100.0	52
100–104	20.00	30.00	10.00	30.00	10.00			100.0	10
105–109	100.00							100.0	1
110+	100.00							100.0	2
Total	1.27	3.21	6.55	68.46	10.27	6.09	4.14	100.0	2,365

examines the possibility of nonmatch biases in age reporting for the death certificate-census link. This test uses all deaths for which a link was established between the Social Security and the death certificate records. Then we compare the distribution of differences between "Social Security" age and "death certificate" age for two subgroups: (1) those for which an additional link was established to an early census record and (2) those for which no link to an early census was made. Results are shown in Table 6, Part A. The two distributions do not differ significantly for either males or females. In other words, given the Social Security age at death, the reporting of age at death on death certificates that we were able to match to an early census record does not differ significantly from age reporting on records that we were unable to match.

We use the same logic to examine nonmatch bias among death certificates linked to Social Security records. This test compares the distribution of differences between "census-based" age and "death certificate" age for two subgroups, each of which had a death certificate/census link: (1) those for which an additional link was established to a Social Security record and (2) those for which no link to a Social Security record was made. Again, the two distributions do not differ signficantly for either males or females (Table 6, Part B).

Thus, in the subsample of the 4,968 of the 5,262 death certificates that were linked to either of the alternative data sources, we find no evidence of sample selection bias with respect to death-certificate age reporting, the only variable of interest in this study. It is still possible that the remaining 294 certificates (5.6%) displayed age-reporting patterns that differed systematically from those 94.4% of certificates which were linked. We would need a fourth data source to

TABLE 6. TESTS OF NONMATCH BIAS IN AGE REPORTING

A. TEST OF NONMATCH BIAS FOR DEATH CERTIFICATE-CENSUS LINK[a]

	Females		Males	
Age at Death on Death Certificate minus Age at Death on DMF (in Years)	Death Certificate Matched to Early Census Record and the DMF	Death Certificate Not Matched to Early Census Record	Death Certificate Matched to Early Census Record and the DMF	Death Certificate Not Matched to Early Census Record
≤ −5	85	78	53	45
−2 to −4	120	98	75	69
−1	139	89	155	88
0	818	606	932	687
+1	66	53	89	66
+2 to +4	40	35	41	35
≥ +5	23	20	21	9
Total	1,291	979	1,366	999
Pearson Chi-Square with 6 Degrees of Freedom	4.207		8.389	
p-Value	.649		.211	

B. TEST OF NONMATCH BIAS FOR THE DEATH CERTIFICATE-SOCIAL SECURITY LINK[b]

	Females		Males	
Age at Death on Death Certificate minus Census-Based Age at Death (in Years)	Death Certificate Matched to DMF and Early Census Record	Death Certificate Not Matched to the DMF	Death Certificate Matched to the DMF and Early Census Record	Death Certificate Not Matched to the DMF
≤ −5	108	21	66	6
−2 to −4	181	34	116	17
−1	220	37	253	29
0	577	86	701	60
+1	117	11	139	12
+2 to +4	52	6	63	10
≥ +5	36	2	28	2
Total	1,291	197	1,366	136
Pearson Chi-Square with 6 Degrees of Freedom	7.552		6.417	
p-Value	.273		.378	

[a]All death certificates in Part A have been linked to Social Security records.

[b]All death certificates in Part B have been linked to early census records.

investigate this question directly. In its absence, we estimated a logistic regression model of the probability that a death certificate could not be linked to either of the alternative data sources as a function of characteristics available on the death certificate. These included age at death, whether in the 1980 sample, whether born in Maryland, whether state of death differed from state of birth, three marital status categories, the adult literacy level in the state of birth in 1920, and six occupational categories. We ran regressions separately for males and for females. The only variable that was significant at the 5% level for either sex was widowhood; widows were significantly less likely to be linked than married persons for both sexes. Elsewhere we have shown that among persons linked to an early census, age reporting among widows does not differ significantly from that among married persons (Hill et al. 1995). The absence of significance for occupation and literacy variables suggests that persons not linked to either source are not unusual in their social or economic circumstances. Therefore we believe that age-reporting patterns revealed among linked records are a reliable indication of patterns in the entire sample.

Quality of Age Information on Early Censuses: Birth Certificate Match in Maryland

We would like to be able to attribute any discrepancy between age at death on the death certificate and age at death implied by an early census record to an error in the former record. Ages reported in early censuses, however, are also subject to error, as evidenced by distortions in recorded age distributions (Coale and Rives 1973). To investigate the quality of age reporting in early censuses, we attempted to match decedents born in Maryland for whom a link to the 1920 census was established to Maryland birth registration records. The 1920 census was taken on January 1; thus an exact correspondence can be established between age in the 1920 census and implied year of birth. Because of limitations in the Maryland birth registration files, we limited the search to persons whose putative year of birth on the death certificate was between 1905 and 1919. Details of the matching procedure are provided in Rosenwaike and Hill (1995).

A total of 154 census-death certificate matches were also linked to Maryland birth registration records. All of the children matched should have been below age 15 at the time of the 1920 census. A slight majority (82) of the matched cases were born between 1915 and 1919, probably reflecting improvements in Maryland birth registration coverage during the period. Twenty-five births were registered during 1905–1909, and 47 between 1910 and 1914.

Table 7 presents the results of this matching procedure. For 77% the children, the correct age was reported in the 1920 census. For another 18.2%, the age in the 1920 census was within one year of the correct age based on birth records. Age overstatement in the census was four times as common as age understatement, reflecting a tendency to "round up" the child's age to the nearest birthday rather than reporting the age at last birthday. This tendency is confirmed by examining age reporting by month of birth as reported on the birth certificate. Of those born in January–March—that is, those who would have had a birthday within three months of the 1920 census—32.4% (12/37) were reported to be older than they actually were on January 1, 1920. Of those born April–June, 22.9% (8/35) were too old on the census. Of those born in the second half of the year (July–December), however, only 9.8% (8/82) had an overstated age on the census.

A comparison of Tables 4 and 7 suggests that most of the discrepancies between reported age at death and age at an early census are attributable to error on the death certificate. The cases in which death certificate age did not correspond to the age reported on an early census represent 52.4% of total matched cases. The corresponding proportion for the matched cases in the Maryland sample is 46.4% (not shown); the proportion of cases where early census age did not agree with birth registration records is 22.7%. Among census/death certificate matches in the national sample, a discrepancy of 2+ years is observed for 25.0%; in the Maryland sample, the corresponding figure is 17.7% (not shown). In the Maryland birth certificate-census match, however, the proportion with such a large discrepancy is only 4.5%. Therefore we conclude that most age discrepancies of 2+ years between the death certificate and an early census are attributable to error on the death certificate. Below we introduce an allowance for the tendency to round up ages reported in the census for children approaching a birthday.

TABLE 7. AGREEMENT BETWEEN THE YEAR OF BIRTH AS REPORTED ON A MARYLAND BIRTH RECORD AND THE YEAR OF BIRTH CALCULATED FROM THE MATCHING 1920 CENSUS RECORD

1920 Census Age Relative to Birth Record	Number	Percentage
Same Year of Birth	119	77.3
Younger Age on Census	7	4.6
1 year younger	6	3.9
3 years younger	1	0.7
Older Age on Census	28	18.2
1 year older	22	14.3
2 years older	4	2.6
3 years older	1	0.7
10 years older	1	0.7
Total	154	100.0

Note: Sample consists of African-Americans born in Maryland who died at ages 65–79 during January–May 1985 and who were linked to both a birth certificate and a 1920 census record.

Age Distribution of Deaths

In order to use the results of the matching study to estimate the correct distribution of ages at death, one must account for the fact that not all of the matched cases should receive equal weight in constructing a national sample. Our sampling fraction varied with age and was different for Maryland-born decedents, and the proportion of deaths that were linked to census records also varied with age. Furthermore, it is desirable to integrate the 1980 deaths with the 1985 deaths so that we can include deaths at reported ages 60–64. In the appendix we describe the weighting system that we employed to convert the linked cases into a nationally representative sample of elderly African-Americans deaths in 1985.

Table 8 presents the weighted matrix of ages at death from the death certificate and from an early census record for the linked cases. The total number of cases shown in the table equals the total number of linked cases in the sample. The actual number of links at ages 85+ is larger than the number reported in this table because of both the oversampling of deaths and the higher linkage rate in this age interval (see Table 2). Essentially the same pattern of age disagreement is evident here as in Table 3: death certificate ages below 90 appear, on average, to be understated relative to the census-based age. The columns of Table 8, however, can also be used to investigate the pattern of age reporting on death certificates, given a certain age reported on an early census. The results are surprising: at all "census" ages below

TABLE 8. WEIGHTED JOINT DISTRIBUTION OF NUMBER OF DEATHS BY AGE AT DEATH ON THE DEATH CERTIFICATE AND AGE IMPLIED BY AN EARLY CENSUS RECORD

	Calculated Age at Death (Census)										
Age on Death Certificate	60–64	65–69	70–74	75–79	80–84	85–89	90–94	95–99	100–104	105–109	Total
60–64	353.12	75.68	10.55	16.81							456.16
65–69	16.82	379.03	90.92	13.43	3.47						503.68
70–74		15.44	421.77	88.06	23.05	5.66	1.55				555.53
75–79		3.10	26.53	390.63	84.81	14.64	3.19				522.91
80–84		2.72	3.14	25.31	314.98	75.01	15.25	2.55			438.95
85–89				3.28	13.34	223.87	34.14	4.04	0.47		279.13
90–94			0.75		1.47	21.13	115.79	8.41			147.55
95–99						6.31	15.56	39.33	1.09		62.29
100–104					0.94		5.14	4.79	7.24	0.11	18.23
105–109									1.58	2.70	4.28
110+								0.63	0.63		1.27
Total	369.94	475.98	553.66	537.52	442.06	346.63	190.62	59.75	11.02	2.81	2,990.00

100 for both males and females, the death certificate age is understated more often than overstated. At ages 100+, the cases are too few to permit any conclusions.

As noted earlier, a total of 2,657 death certificates were linked both to an early census record and to the Death Master File of the Social Security Administration. For these deaths we have three independent sources of information on age at death. Table 9 shows the age distribution of these deaths in the three sources, weighted as described in the appendix. The distributions based on census age and on Social Security age are very similar to one another but quite different from the distribution based on the death certificate age. The similarity between census and Social Security age distributions provides an important confirmation that errors in death certificate ages are principally responsible for the discrepancies in the linked data.

Figure 1 shows the ratios of death certificate deaths by age to deaths in each of the other two sources (males and females combined). Relative to deaths in the other sources, too many deaths are registered at ages 65–69 and above age 95. The excess above 95 may appear surprising in light of the tendency of death certificate ages to be understated. Yet the number of deaths reported in any age interval is a function not only of the direction of net age misstatement but also of the magnitude of the misstatement relative to the underlying true distribution. When age misreporting is frequent and when the underlying death distribution declines rapidly with age, too many deaths can be reported at older ages despite a downward net direction of age misstatement. That is, more deaths can be transferred upward into a particular interval than are transferred downward and out, even though the proportion of upward transfers from the lower interval may be smaller than the proportion of downward transfers from the higher interval, where deaths are far fewer. Table 8 illustrates this phenomenon—for example, at ages 90–94 and 95–99, which are outlined a box. At both census ages, many more deaths are transferred downward than upward. Yet because deaths at 90–94 are far more numerous, a larger number of deaths are transferred upward from 90–94 to 95–99 than are transferred downward from 95–99 to 90–94.

For each of the three-way link, we assigned a "final" age at death, case-by-case. When the age at death agreed on all three records, we accepted that age (N = 1,317).[6] If a person was linked to a census before the time of birth implied by both the death certificate and the Social Security record, we accepted the census-based age at death (N = 20). Among the remaining records, if two of the three records were consistent (N = 1,067), we used that age. If all records were inconsistent with each other, we accepted the "Social Security age" if the Social Security year of birth was after 1900 (N = 122) and the "census age" if the Social Security year of birth was 1900 or earlier (N = 129). In two cases in which all three ages disagreed and the Social Security date of birth was later than the census to which the record was matched, we also accepted the census-based age at death.

We offer the following justification for the procedure we adopted when all three ages disagreed. First, as noted above,

6. Our definition of consistency included cases in which the "census" age at death was one year older than the age in another source if the person's birthday occurred in the month when the census was taken or in either of the next two months. We employed this procedure to account for the tendency, described earlier, for census ages to be rounded up to the next age when a birthday was imminent. In this situation, the "final" age at death is the age in the other source. This expansion of the census age field accounted for 7.7% (149/1,932) of either three-way or two-way agreements with census age. Similarly, we expanded the concept of agreement with the death certificate record to include agreement with the day/month/year-of-birth field on the death certificate when it was inconsistent with the age field. Again, in this situation, the "final" age used was that in the other source. This expansion of the death certificate age accounted for 1.9% (35/1,867) of three-way and two-way agreements with death certificate age.

TABLE 9. WEIGHTED MARGINAL DISTRIBUTION OF AGE AT DEATH, BY SOURCE

Age Group	Death Certificate Age	Census Age	Social Security Age	Final Age
		Females		
60–64	162.95	119.67	133.30	132.24
65–69	188.37	174.26	170.69	170.44
70–74	222.87	218.21	215.04	217.34
75–79	226.98	226.44	241.05	236.69
80–84	208.78	208.74	195.65	195.91
85–89	145.29	185.46	183.80	182.30
90–94	83.01	109.43	101.32	107.20
95–99	37.93	40.42	39.21	37.86
100+	14.82	8.37	10.94	11.00
Total	1,291.00	1,291.00	1,291.00	1,291.00
		Males		
60–64	244.04	207.86	213.24	215.23
65–69	260.62	256.14	256.25	256.60
70–74	271.61	280.99	272.90	269.66
75–79	237.63	253.92	248.91	258.24
80–84	180.36	177.96	180.83	175.85
85–89	101.57	115.64	118.84	115.28
90–94	47.18	55.84	56.24	58.59
95+	22.98	17.65	17.20	16.55
Total	1,366.00	1,366.00	1,364.41	1,366.00

Note: A male decedent, whose Social Security age was < 60 years, is dropped from this table.

comparison of the age distributions of deaths showed much greater agreement between census age and Social Security age than between death certificate age and either of the other two. For example, the mean age at death for the 2,657 three-way matches is 75.82 for census reports and 75.67 for Social Security reports, but only 75.03 for death certificates.

Second, Social Security age showed the greatest agreement with each of the other two sources, and death certificate age the least agreement. When we found age agreement between only two of the three sources, Social Security provided one of the two agreeing ages in 90.8% of cases. The census was the source of one of the two agreeing ages in 57.6% of cases, and the death certificate in 51.5%. This result implies that Social Security age may be the most reliable of the three.

This suggestion is also supported by an analysis of covariances. We calculated covariances among the differences between ages reported in each of the three sources. The covariance between (death certificate age – census age) and (death certificate age – Social Security age) is 5.59. This result implies that when the death certificate age is inconsistent with the census age in a particular case (and when both ages are measured relative to their respective means), it also tends to be inconsistent in the same direction with respect to Social Security age. The covariance between (census age – death certificate age) and (census age – Social Security age) is 2.68; the covariance between (Social Security age – death certificate age) and (Social Security age – census age) is only 0.74. Social Security age shows the smallest systematic discrepancy with ages from the other two sources.

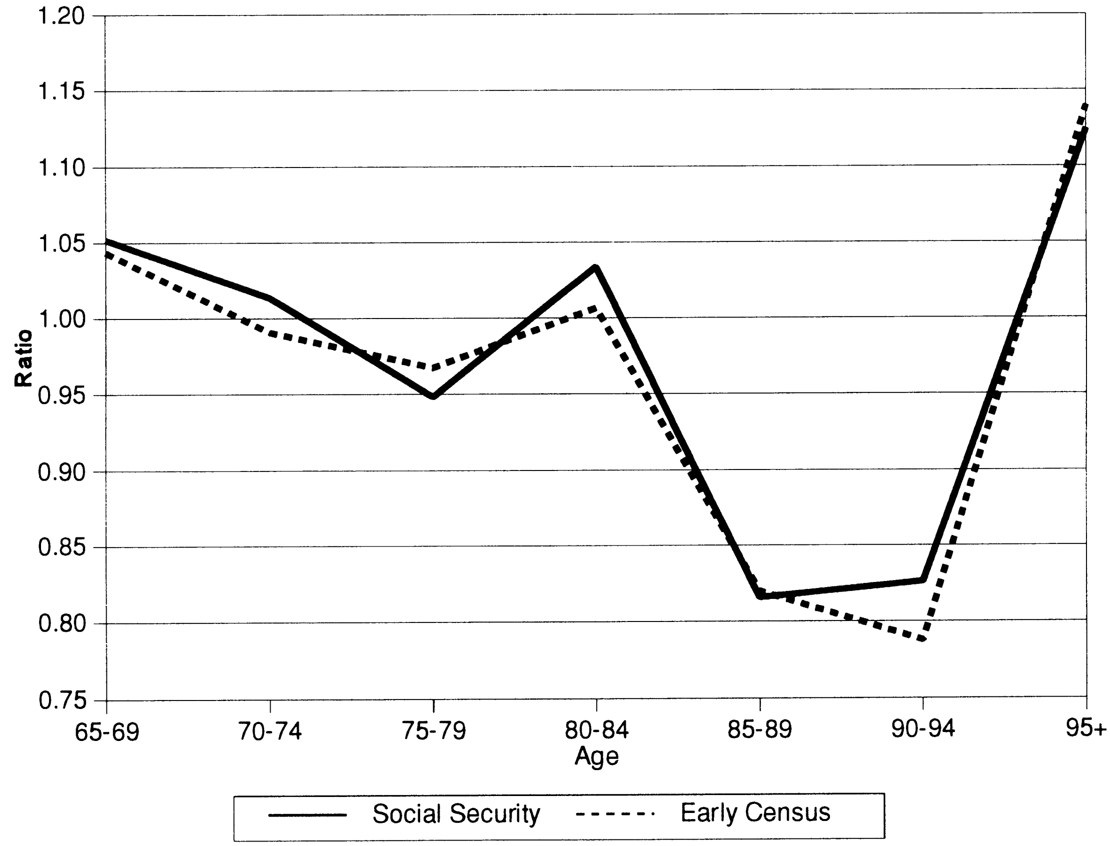
Third, age verification requirements for receipt of benefits in the Social Security system have been fairly strict since November 1965, or for persons born after approximately 1900 (Deutch 1973:1–2). In the period immediately preceding that date, however, approximately 21% of persons qualified for Social Security benefits without any proof of age (calculated from Deutch 1973:6), and the incentives to overstate age were considerable. There is no reason to expect any such bias in the ages reported for children in the 1900–1920 censuses; accordingly we accepted these ages for the oldest decedents when the three sources did not agree.

The last column of Table 9 presents the "final" age distribution of deaths. Not surprisingly, it is similar both to the census-based age distribution and to the Social Security age distribution, which are similar to one another.

Mortality

The reconstructed age distribution of African-American deaths in 1985 provides a more reliable basis for estimating mortality than the age distribution of deaths reported on death certificates. The conventional way to estimate mortality rates

FIGURE 1. RATIO OF NUMBER OF DEATHS BY AGE IN DEATH CERTIFICATES TO THOSE IN TWO OTHER SOURCES: THREE-WAY MATCHED SAMPLE



is to relate deaths in the numerator to denominators drawn from census populations. This procedure is not advisable in the present case, however, because census counts for elderly African-Americans are subject to serious error. Relative to Medicare estimates and estimates based on deaths, for example, far too many African-Americans are reported in the census at very advanced ages (Coale and Kisker 1990). There is no obvious way to correct census age distributions.

An alternative is to use a set of demographic identities developed by Preston and Coale (1982:224). They show that in a population closed to migration, the number of deaths at a particular age in the life table for that population can be inferred (to an arbitrary scalar) from the actual death distribution by means of a simple growth correction. That is,

$$\frac{d(y)}{d(x)} = \frac{D(y)}{D(x)} e^{\int_x^y r(a)da}, \tag{2}$$

where $D(y)$, $D(x)$ = number of deaths in the population at exact ages x and y respectively ($y > x$); where $d(y)$, $d(x)$ = number of deaths at ages y and x in the current life table; and where $r(a)$ = annualized growth rate of the population at exact age a. In this formula, the growth rates between ages x and y project the additional number of deaths that will be experienced by the cohort now age x when it reaches age y, given constant mortality. A closely related method of mortality estimation has been described in detail by Bennett and Horiuchi (1984).

The U.S. Census, however, is the principal source available for estimating age-specific growth rates. The advantage of using the census to estimate population growth rates rather than absolute population size is that equiproportionate errors in successive census counts at a particular age will not affect the intercensal growth rate for that age. Thus, similar patterns of age misstatement at both censuses should have relatively little effect on the recorded intercensal growth rates. Our growth rates are drawn from the U.S. Census Bureau's reconstructed population counts in five-year age intervals for July 1 of each calendar year between 1980 and 1990 (Hollman 1993). This reconstruction is based on a reconciliation of results from the 1980 and 1990 censuses and on the introduction of addi-

TABLE 10. ESTIMATED AGE-SPECIFIC DEATH RATES BY RACE: UNITED STATES, 1985 (DEATH RATES PER 1,000)

	Females			Males		
	African-Americans		Whites	African-Americans		Whites
Age Group	Death Certificate Age	Final Age		Death Certificate Age	Final Age	
65–69	26.3	22.7	16.1	46.0	44.0	30.3
70–74	38.7	35.4	25.2	65.0	62.4	47.5
75–79	54.9	52.9	40.1	87.6	91.1	71.5
80–84	83.8	70.2	67.8	123.4	114.4	109.2
85–89	118.5	128.9	115.1	160.5	168.8	162.5
90–94	153.4	198.7	188.6	199.2	272.3	238.2
95+	214.3	290.8	271.2	232.8	323.2	317.7

Notes: Death certificate age refers to death rates based on age as reported on the death certificate. Final age refers to death rates based on deaths corrected for age misstatement. White rates are based on registered deaths in 1985 and on Census Bureau's estimates of population on July 1, 1985.

tional information from Medicare population counts. We use growth rates based on intercensal population estimates between 1983 and 1987 for age intervals up to 85–89 for males and 90–94 for females. Because the Bureau's intercensal estimates are presented to the nearest thousand, which obscures detail at the highest ages and thus encourages the use of longer time intervals for the oldest ages, we use intercensal growth rates based on the Bureau's reconstructions in 1980 and 1990 for ages 90+ for males and 95+ for females.[7] We have repeated the analysis using growth rates based on actual census counts in 1980 and 1990 for all age intervals; the results were not sensitive to the source of growth rates.

Table 10 presents the death rates in five-year age intervals based on the original age on the death certificate and on the "final" age estimated from the three-way match. Although results are presented in five-year summaries, we made all calculations on single-year data.[8] The uncorrected rates are higher for both males and females through ages 80–84, except for males at ages 75–79, and are lower thereafter. At ages 90–94 and 95+, the corrected rates are 30% to 66% higher than the uncorrected rates. The age distribution of deaths in vital statistics for the African-American population appears to give too optimistic a picture of African-American mortality above age 85. The corrected black death rates are also higher above age 85, and much higher above age 90, than death rates for 1987 computed directly from Social Security data (Kestenbaum 1992).

In his 1992 study, Kestenbaum carefully examined mortality estimates based on Medicare data and investigated how the elimination of records of questionable quality would affect estimates of mortality. His final results were based on the SSA's Master Beneficiary Record and on information drawn from the NUMIDENT file for insured persons enrolled in Medicare Part B. These data exclude groups of individuals with suspiciously low mortality; also, because the data are limited to Medicare Part B participants, who must pay a monthly premium for participation, it is unlikely that many deceased individuals are included in the database used to estimate mortality. The accuracy of age reporting, however, remains suspect. As noted earlier, age verification in the Social Security system was looser for persons born in the nineteenth century than in the twentieth century.

The only age interval in which blacks have lower death rates than whites in the official abridged life tables of the

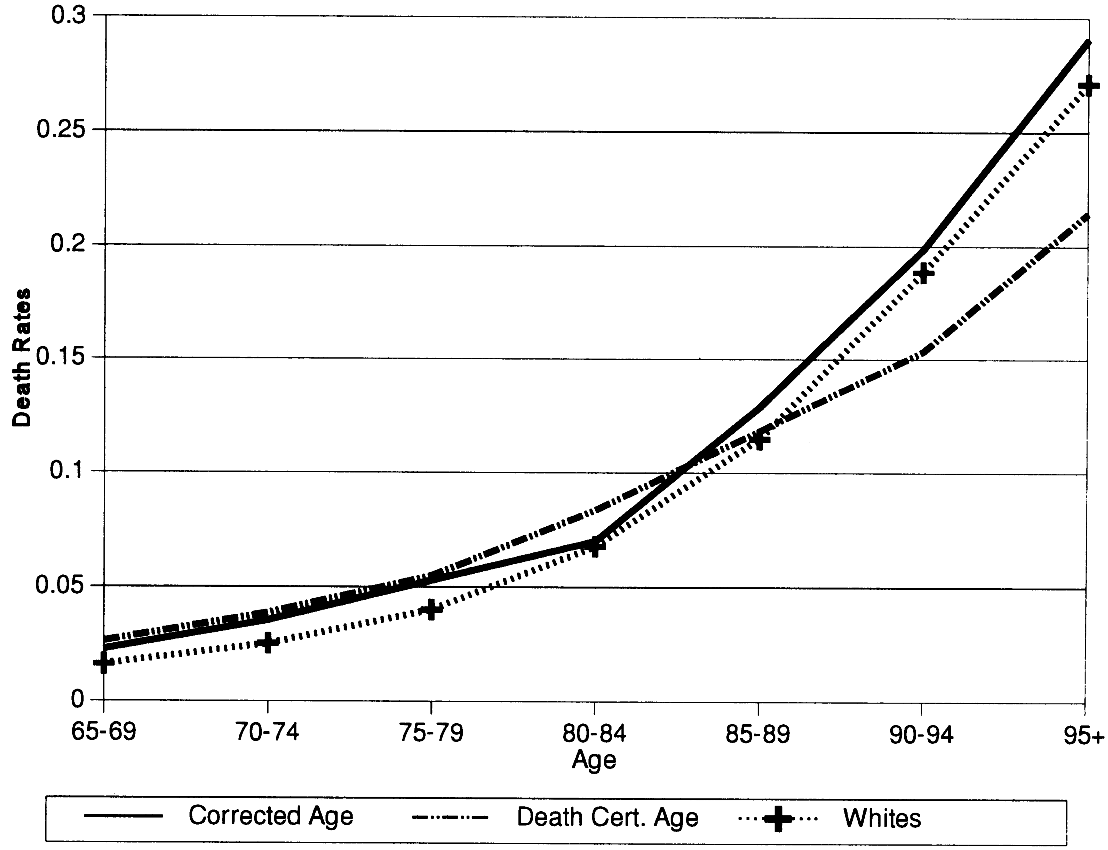
7. We used the following age-specific growth rates in the calculations:

	Growth Rate in Interval	
Age Interval	Males	Females
65–69	.00880	.01128
70–74	.00407	.01220
75–79	.01471	.02740
80–84	.02877	.04123
85–89	.01725	.03809
90–94	.02231[a]	.02175
95+	.02231[a]	.05306[a]

[a]1980–1990 growth rate; all others pertain to the period 1983–1987. Male growth rates are generally lower than female rates because male age-specific mortality rates have improved less over the lifetime of relevant cohorts.

8. The death rates presented are those of a stationary population within each five-year age interval, reconstructed by means of eq. (1) applied in single-year age categories. To estimate person-years lived in the single-year age interval, we assumed that weighted deaths at age x (last birthday) occurred, on average, at exact age $(x + 0.5)$. The growth rates in a five-year age category, presented in note 5, are assumed to apply to each single-year age group within that category. We use no arbitrary procedure to "close out" the life table at the highest ages; instead we follow the above procedure until the last death is observed. The last death based on uncorrected data is observed at age 116 for females and 119 for males. The last death based on "final" age occurs at age 106 for females and 103 for males.

FIGURE 2. CORRECTED AND UNCORRECTED DEATH RATES: AFRICAN-AMERICAN FEMALES COMPARED WITH WHITE FEMALES



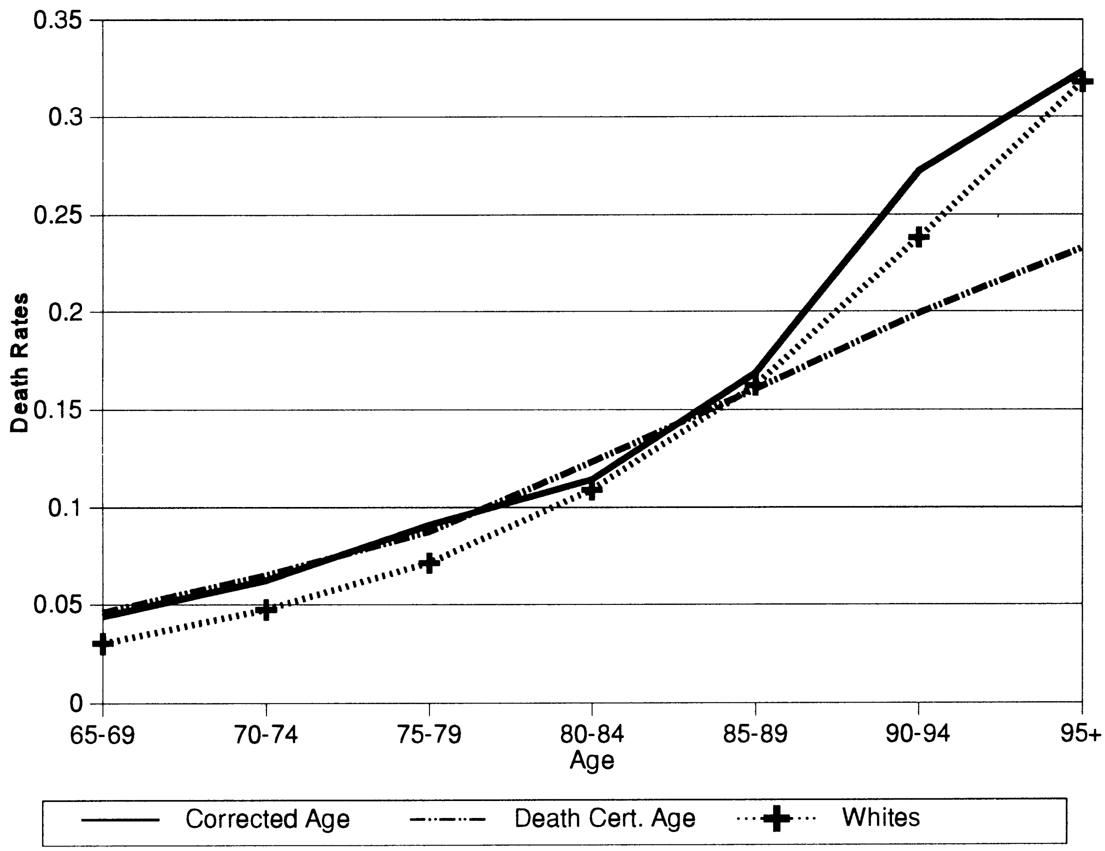
Notes: Death rate calculations for African-Americans use wage-specific growth rates based on 1983, 1987, 1980, and 1990 population estimates (Hollman 1993). White rates are based on vital statistics data on deaths (National Center for Health Statistics 1988) and Census Bureau estimates of population (Hollman 1993), both for 1985.

United States for 1985 is age 85+, the last interval shown (NCHS 1988b).[9] It does not seem coincidental that this is also the age interval at which uncorrected black death rates cross over with the corrected rates in our analysis. To examine African-American/white differences in more detailed ages above 85 than permitted by the 1985 abridged life table, we computed white death rates for 1985 in the conventional manner, using 1985 deaths in the numerator and the Census Bureau's reconstruction of the white population on July 1, 1985 in the denominator (Hollman 1993; NCHS 1988a). As shown in Table 10 and in Figures 2 and 3, the corrected African-American rates are higher at every age than the white rates, although the differences are relatively small. When corrected ages at death are used for the African-American population, we find no evidence of a racial crossover at advanced ages.

An obvious drawback of our black-white comparison in Table 10 is that we have compared corrected black rates with uncorrected white rates. We are confident of the accuracy of white death rates below age 95 in Table 10, but much less so regarding the rate at ages 95+. The white rates shown in Table 10 are virtually identical to white rates at ages 85–94 in 1987 that are computed from Social Security data, but they are lower than Social Security rates at 95+ (computed from Kestenbaum 1992). If we used 1987 Social Security rates at 95+, we would reinstate the crossover at this age. Coale and Kisker (1990) also found that in 1980, white rates up to age 94 based on vital statistics/census data were very similar to

9. In the more detailed tables available for 1979–1981, the crossover occurs at age 84 for males and 85 for females (NCHS 1985). The age at crossover has risen rapidly since 1959–1961, when it was 75 for men and 77 for women in a white/nonwhite comparison (Kestenbaum 1992). We believe that this increase reflects, in part, improved age reporting.

FIGURE 3. CORRECTED AND UNCORRECTED DEATH RATES: AFRICAN-AMERICAN MALES COMPARED WITH WHITE MALES



Notes: Death rate calculations for African-Americans use wage-specific growth rates based on 1983, 1987, 1980, and 1990 population estimates (Hollman 1993). White rates are based on vital statistics data on deaths (National Center for Health Statistics 1988) and Census Bureau estimates of population (Hollman 1993), both for 1985.

those based on Social Security/Medicare data but diverged thereafter. They identified data weaknesses for whites in both data sources above age 95. In direct relation to data used in Table 10, Shrestha and Preston (1995) showed a very high degree of consistency between death registration and census counts by age for whites during the 1980–1990 decade up to age 94, but increasing inconsistencies thereafter.

Therefore we believe that the white rates shown in Table 10 are quite accurate up to age 95 and provide solid evidence against a racial crossover in death rates below that age. Uncertainty about white rates at ages 95+ is compounded by a recent estimate using extinct-generation methods for the cohort reaching age 95 during 1985–1990 (Manton and Vaupel 1995). Estimated mortality at ages 95–100 for this cohort is much lower than that for the same interval in Kestenbaum's Social Security data for 1987 (Manton and Vaupel 1995, Table 1).

Whether or not a racial crossover exists above age 95, we have shown that African-American death rates computed from conventional death registration are seriously understated at the very advanced ages. Ironically, this result is produced by a pattern of net understatement of ages at death. Yet despite this net direction of age misreporting, too many deaths are reported at advanced ages because the steeply declining age pattern of deaths gives a much larger base for upward transfers into an age category than for downward transfers out of it. This complex pattern of age errors could not have been detected by indirect estimation techniques, and demonstrates the value of matching studies in demographic analysis. In the present instance, the conclusions rest on a firmer basis because we were able to match individuals in three different sources, two of which showed very similar patterns of age reporting on death certificates.

APPENDIX. WEIGHTING LINKED DEATHS TO ACHIEVE NATIONAL COVERAGE

The focus of investigation is African-American deaths in 1985. For reasons described in the text, we oversampled deaths of persons whose death certificate age at death was 85+ and persons born in Maryland. We took an additional sample of deaths at ages 60–69 in 1980, so that additional age-reporting patterns could be studied.

We created two linked samples:

S1: Death certificates linked to an early census ($N = 2{,}990$);

S2: A subset of S1 consisting of death certificates linked both to an early census and to a record in the Death Master File ($N = 2{,}657$).

To obtain from these samples national estimates of the age distribution of deaths in 1985, it is necessary to adjust for the different sampling proportions we have used for different ages and for Maryland-born decedents, to integrate the 1980 sample, and to adjust for variations in linkage rates by age on the death certificate. Stage 1 of the weighting procedure deals with the first two of these concerns, in a way that is identical for Samples S1 and S2. The Stage 1 weights for linked deaths are inversely proportional to the number of days in 1985 in which deaths falling into a particular age/state of birth category were accepted into the sample. For example, deaths at ages 80–84 were given a weight of 1.000 and deaths at 85+ a weight of .500, reflecting the twice-as-heavy sampling of deaths in the latter category. Deaths of Maryland-born persons at all ages received a weight of .04636, reflecting the fact that a 1985 decedent born in Maryland in any of 151 days is included in the sample, compared with seven days for persons under age 85 born outside Maryland.

As reflected in Appendix Table A1, 1980 deaths at ages 60–69 were integrated into the sample in the following way. We made an assumption that the pattern of age reporting in 1980 was the same as in 1985. Because virtually the same number of African-American deaths were recorded at ages 65–69 in 1980 as in 1985 (the ratio of deaths at 65–69 in 1985 to that in 1980 was 1.000 for females and 0.996 for males), deaths at ages 65–69 in 1985 and 1980 received equal weights of .500. This weighting reflected the fact that deaths at this age were double-sampled when the 1980 and 1985 deaths were combined, relative to ages 70–84. We made an exception for deaths in this age group that had a "census" age of 60–64 at death. This identification could be made only in 1980 because people younger than 65 in 1985 could not have been enumerated in the 1920 or earlier censuses. Thus the 1980 deaths at reported age 65–69 and census-implied age 60–64 received a weight of 1.000 rather than 0.500.

Finally, we gave deaths at ages 60–64 in 1980 a weight of 1.081 for females and 1.066 for males. These are the ratios of deaths in this age interval in 1985 to deaths in this age interval in 1980 for each sex. They exceed 1.000 because more deaths in this age interval would have been expected had we sampled from 1985 rather than 1980 deaths. Stage 1 weights are presented in Appendix Table A1.

APPENDIX TABLE A1. STAGE 1 WEIGHTS APPLIED TO THE LINKED SAMPLES, S1 AND S2

	1985 Deaths		1980 Deaths	
Age Interval	Not Born in Maryland	Born in Maryland	Females	Males
60–64	—	—	1.081	1.066
65–69	0.500	0.04636	0.500[a]	0.500[a]
70–84	1.000	0.04636	—	—
85+	0.500	0.04636	—	—

[a]If "census" age at death was 60–64, the weight is 1.000.

A Stage 1 distribution of reported ages at death would be identical (except for sampling error) to the U.S. distribution in 1985 if linkage rates did not vary by age. The rates vary, however. For example, the proportion linked to an early census at ages 85+ was 65.7%, compared with 54.1% at ages below 85. To adjust for variations in linkage rates (and sampling error), in Stage 2 we developed an additional set of weights representing the ratio of 1985 U.S. deaths for males and for females by single years of age to the number of Stage 1 deaths in each age-sex category. Stage 2 weights differ for Samples S1 and S2. The final weight applied to each linked case is the product of its Stage 1 and Stage 2 weights. The number of weighted deaths is then scaled down so that the totals by sex equal the numbers of linked deaths by sex in Samples S1 and S2.

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