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Consistency of Age Reporting By Cause of Death Among Elderly African-American Decedents

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PARC Working Paper Series

WPS 96-04

" The authors acknowledge the support of the National Institutes of Health - National Institute on Aging, Grant number P30 AG12836, B.J. Soldo, P.I."

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Population Aging Research Center, University of Pennsylvania
Working Paper Series No. 96-04

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July 18, 1996

This research was supported by grants from the National Institute on Aging, AG00177-07 and AG10168. We would like to thank Samuel H. Preston for his helpful advice. We are also grateful to Mark Hill and Ira Rosenwaike for their assistance in the construction of the data files, to Tim Cheney for programming assistance, and to the National Center for Health Statistics and state health departments for giving us their cooperation.

Because age is associated with many biological and social phenomena, accurate age data are critical for researchers exploring the societal impact of population aging and for policy makers deciding how to best allocate resources to this burgeoning group. Of particular importance is the quality of age data for the rapidly expanding elderly population. Past research has shown the quality of these data to be questionable for the U.S. elderly population, particularly for African-Americans (Hambright 1969; Kestenbaum 1992; National Center for Health Statistics [NCHS] 1968; Rosenwaike 1979; Rosenwaike and Logue 1983). A recent study comparing 1987 death certificates from Massachusetts and Texas with matched Social Security/Medicare files, for example, found exact age agreement in the two data sources for 94.6% of non-Hispanic whites aged 65 and over but only for 72.6% of African Americans (Kestenbaum 1992: Table 4). Age agreement deteriorated more rapidly with advancing age among blacks than among whites; for those aged 85 and over, exact age agreement was found for 91.7% of non-Hispanic whites compared with only 63.2% of African Americans.

The quality of age data for elderly African-Americans plays a prominent role in a key debate within the mortality literature: the African-American/white mortality "crossover" at advanced ages. Throughout the twentieth century this mortality crossover, from higher African American than white mortality to lower African American mortality, has typically taken place at ages in the mid- to late-seventies or early eighties and has been documented using both cause-specific and all-cause mortality data. The age at which the white/black mortality crossover occurs has increased over time and varies by cause of death (Bayo 1972; NCHS 1985; U.S. Bureau of the Census 1946; Zelnik 1969; Manton 1980; 1982; Manton and Poss 1977; Manton, Poss and Wing 1979).

Two main explanations for the "crossover" are given. According to the first view, the crossover results from heterogeneity in survival potential (Manton 1980; Manton, Poss, and Wing 1979; Manton and Stallard 1981). Proponents of the second view maintain that the mortality crossover is largely an artifact of age misreporting and other data errors that are more pronounced for African Americans than for whites (Coale and Kisker 1986; Elo and Preston 1994; Preston et al. 1996).

In addition to age and race, several prior studies have shown age inconsistencies across matched records to vary by the decedent's sex (Elo et al. 1996; Hill et al. 1996; Kestenbaum 1992; NCHS 1968), by birth record availability (Elo et al. 1996; Hill et al. 1996), by the level of literacy in the decedent's state of birth (Elo et al. 1996), and by marital status (Elo et al. 1996; Kestenbaum 1992). In contrast, the relationship between cause of death and quality of age data has been examined in only one prior investigation. As part of the Matched Records Study of 1960 census and death certificate records, age consistency within four cause-of-death categories -- cardiovascular, cancer, external, and all other causes -- was examined (NCHS, 1968). At ages 65 and above, the results indicate relatively small differences in age agreement by cause of death.[1] Among nonwhite females aged 65 and older, externally caused deaths exhibited the highest age agreement (66.9%) while the lowest agreement was found for deaths from all other causes (62.3%) and cardiovascular diseases (62.4%).[2] Among nonwhite males aged 65 and older, the highest age agreement was found for those dying from cancer (70.9%) and the lowest agreement was associated with deaths from external causes (64.4%). For all causes combined, the female age-standardized agreement rate at ages 65 and above was 62.6% and the male rate was 70.2%.

The present study updates and extends the Matched Records Study in several important ways. First, we examine age agreement in a more recent nationally representative sample of deaths among elderly African-Americans, drawn from deaths that occurred in 1980 and 1985. Second, rather than examining

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[1] We standardized the 1960 results to the 1985 U.S. resident population for persons aged 65 and older (U.S. Bureau of the Census 1993: Table 1). The 1960 cause-specific agreement rates were presented for three age groups: 65-74, 75-84, and 85+ (NCHS 1968: Table 4). We calculated the proportion of the 1985 U.S. resident population aged 65 and older falling into each of these three age groups and used those proportions to weight the 1960 agreement rates.

[2] In the 1960 Census, 92% of the total nonwhite population was African-American (Elo and Preston, 1994: footnote 1).

consistency of age data in census records and on death certificates from the same year, we utilize Social Security Administration data and early-life census records collected when the decedents were children or young adults to establish a "true" age at death for our sample decedents. Following Rosenwaike and Logue (1983), we reason that age information on early-life census records is more accurate than that found on later-life records. Social Security age data are also thought to be more accurate than death certificate data. Unlike the death registration system, the Social Security Administration now requires verification of alleged age as a condition for entitlement to program benefits and enrollment in Medicare. Third, we examine age agreement for eleven cause-of-death categories. Most significantly, our coding scheme allows us to examine the quality of age reporting for cardiovascular deaths in greater detail than the Matched Records Study. Prior research suggests that cardiovascular deaths, in particular, are implicated in mortality crossovers (Manton and Poss 1977; Nam, Weatherby, and Ockay 1978).

The following analysis is organized around three questions. First, what is the pattern of age agreement by major causes of death? Second, can we account for the pattern of age agreement by cause of death by controlling for the decedent’s age, sex, differential mortality by educational attainment, educational background, and suddenness of death? Third, how are cause-specific death rates for elderly African-Americans affected by using corrected age data? We expect to find less age agreement among causes associated with an older mean age at death, with a steeper educational mortality gradient, for individuals born in a state with relatively low educational attainment, and among deaths that occur more suddenly.

The quality of age reporting on death certificates, for example, is known to deteriorate as age advances (e.g., Kestenbaum 1992; Elo et al. 1996). Relative to younger decedents, older decedents may be less likely to have records which officially document their age due to lower lifetime involvement with age-linked institutions (Hill et al. 1996) and the greater likelihood that the decedent's birth was never registered (Shapiro 1950). An older age at death may also be associated with a greater likelihood that decedents and/or potential death certificate informants, most commonly family members, lose track of the decedent's true age, e.g., a failure to advance the age forward at each successive birthday (Clarke, Hill, and Riddley 1995).

Literacy has also long been considered an important characteristic in determining the quality of age reporting (Wolfenden 1954). Thus, we expect to find a negative relationship between our proxy measure of literacy and age agreement. Using the same sample as employed in this paper but focusing on all-cause mortality, Elo et al. (1996) found a strong relationship between the level of literacy in the decedent's state of birth early this century and age agreement. Because educational attainment is associated with income and occupational status as well as cognitive skills, we also expect to find a positive association between cause-specific educational gradients in mortality and age agreement, i.e., the steeper the cause-specific educational mortality gradient the worse the age reporting on death certificates. For causes of death with a steeper educational gradient in mortality a larger proportion of deaths are likely to have occurred to individuals with lower levels of schooling than for causes for which the educational gradient is more gradual. Educational attainment of the decedent may also be positively associated with educational attainment of the death certificate informant.

Finally, we predict a negative association between the suddenness of death and age agreement. In cases of prolonged illness, both the decedent and potential death certificate informants may be more likely to come in contact with official documentation of the decedent's age (e.g. for purposes of filing medical insurance claims, handling the decedent's personal affairs). Serious and prolonged illnesses may also lead to increased contact between the decedent and potential informants, thus raising the likelihood that a well-informed survivor will be present to provide accurate age information at the time of death. To the extent that the chronically or terminally ill and their significant others engage in the process of putting their affairs "in order," we would expect these activities to reduce age misreporting. In contrast, in the case of a sudden death, death certificate informants may have nothing more than their memory to draw on when answering questions about the decedent's age for the purpose of filling out the death certificate.

Data and Methods

This study utilizes a unique three-way linked data set created for a larger project on the quality of age reporting among elderly African-Americans. A sample of 5,262 death certificates of elderly African-Americans from 1980 and 1985 were matched to early-life census records from 1900, 1910, and 1920 and to the Social Security Administration (SSA) records. Based on the three-way linkages a correct age distribution at death was then established.

In collaboration with the National Center for Health Statistics (NCHS), death certificates were obtained for all African-Americans with reported age at death of 65+ who died on January 1-7, 1985 (N=2,714). To increase sample size at the oldest ages deaths at ages 85+ were oversampled, i.e., all deaths at reported ages 85 and older from January 1-14, 1985 were included (N=536). Death certificates of all Maryland-born African-Americans who died at reported ages 65+ between January 8 and May 31, 1985 were also added to the sample (N=1,046). This Maryland oversample was obtained in order to examine the quality of age reporting among children in early-life census records. Maryland is the only state with a sizeable African-American population where a substantial proportion of births were registered in early decades of this century (Shapiro 1950). Finally, all African-American decedents with reported ages at death of 60-69 who died on January 1-7, 1980 were included in the sample (N=966). This 1980 sample was drawn to examine age overstatement on the death certificates for decedents whose "true" age at death was 60-64. If a person aged 60-64 at death in 1985 had a recorded age of 65-69 on the death certificate there would be no possibility of that person being included in the 1920 or earlier censuses since they had not yet been born.

Linkage to Census and Social Security Administration Records

An attempt was made to link all 5,262 death certificates to their corresponding Soundex records from the 1900, 1910, or 1920 Censuses of Population. The key pieces of information on death certificates used to establish a match were the decedent's name, sex, father's name, mother's name, and state of birth. Other useful information included city or county of birth and month of birth in matching to the 1900 census only. Because the focus of the larger project for which the sample was obtained is quality of age reporting, age and year of birth were excluded as matching criteria. Fully 2,991 or 56.8% of the death certificates were matched to an early census record. Matching was more successful for older decedents than for younger decedents, presumably in large part because there was a possibility of locating a match in more than one census (for further details on the matching procedure, see Preston et al. 1996).

As noted above, an attempt was also made to link death certificates to the Social Security Administration's (SSA) records. The SSA records used for the match come from the SSA's publicly available variant of the Death Master File (DMF). The age information on the DMF is primarily based on information submitted in conjunction with a benefit claim and is therefore largely independent of the age at death reported on the death certificate. The decedent's social security number was the primary piece of information used in the linkage. Other relevant information included first and last name, month and day of birth, month and year of death, and state of last residence. Again, in order to avoid potential bias, age at death was not used as a matching criterion. Further, recognizing the possibility that the SSN on the death certificate is not the decedent's own number (i.e. decedent was an auxiliary beneficiary), only those cases with name agreement, excepting minor spelling differences, were accepted as matches. Altogether, we matched 4,635 (88.1%) of our death certificate sample to the DMF. An examination of matched cases by age-group suggests that inclusion of deaths in the DMF may be more complete for persons who have reached retirement age prior to death (for further details, see Elo et al. 1996).

Linkage among all three sources, death certificate, the DMF and early census records, was obtained for 2,657 cases or 50.5% of all death certificates. In this paper, all analyses are based on records for which a three-way linkage was established. Cause of death is missing for three cases and they are excluded from all subsequent analyses. Thus, the sample size for these analyses consists of 2,654 deaths. We have shown elsewhere that age misreporting patterns in this sample of matched cases is not significantly different from the patterns present among unmatched death certificates (see Preston et al. 1996). Since the purpose of this paper is to investigate age agreement by cause of death, we have further examined whether the probability of achieving a three-way match varied by cause of death. To do so, we estimated a logistic regression model where the dependent variable was coded 1 if a three-way linkage was achieved and 0 otherwise. In this model, cause of death was entered as a set of dummy variables along with death certificate age at death, and dummy variables for whether the case belonged to the Maryland oversample and for the year of death. The results (not shown) indicate that the probability of obtaining a three-way linkage did not vary by cause of death. None of the parameter estimates for the cause of death variables were significant at the .05 level.

Age Agreement

To examine age agreement by cause of death, we compare the reported age on the death certificate to a "corrected" or "final" age at death. This final age represents our best estimate of a "true" age at death based on all age information available to us. It was assigned on a case-by-case basis for all records with three-way linkages as follows. When age at death agreed on all three records, that age was accepted as the final age (N=1,317). If a person were linked to a census before the time of birth implied by both the death certificate *and* the social security record, the census-based age at death was accepted as the final age (N=20). Among the remaining cases, if two of the three records were consistent, that age was accepted as the final age (N=1,067). 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). Finally, in two cases for which all three ages disagreed and the social security date of birth was after the census to which the record was matched, we also accepted the census-based age at death (for a justification of these procedures, see Preston et al. 1996). [3]

The dependent measure in our analyses, age agreement, was constructed by subtracting the decedent's death certificate age from his or her final age. Age "agreement" was defined as a difference equal to 0; all non-zero results were defined as age misreporting.

Cause of Death Categories

Prior research and sample size considerations influenced our choice of how to group causes of death. The cause of death refers to the underlying cause coded from death certificate information by NCHS. For most analyses we group causes of death into eleven categories listed below with their associated ICD-9 three-digit codes (World Health Organization 1977) : (1) infectious diseases; pneumonia and influenza (001-139; 480-487); (2) malignant neoplasms of digestive organs and peritoneum (150-159); (3) malignant neoplasms of respiratory and intrathoracic organs (160-165); (4) other malignant neoplasms (140-149; 170-208); (5) ischemic heart disease (410-414); (6) cerebrovascular diseases (430-438); (7) other cardiovascular diseases (390-405; 415-429; 440-448); (8) diabetes mellitus (250); (9) chronic obstructive pulmonary diseases and allied conditions (490-496); (10) external causes (E800- E999); and (11) all other causes of death.

Sample size limitations necessitate collapsing the eleven cause-of-death categories into five for

[3] The Social Security age at death is calculated from the date-of-birth and date-of-death information available on the DMF. Because the specific day of death is missing for most cases on the DMF, the death-certificate day of death was substituted in calculating the SSA age at death. The decedent's census-based age at death was computed from the age in years reported on the census record and the decedent's birthday (i.e., month and day) reported on the death certificate. The latter information was required in order to determine whether a birthday would have occurred between the date in the calendar year when the decedent was enumerated in the early census and the date when the death occurred. When the 1900 census was used, the decedent's census-based age at death was calculated from the month and year of birth fields from the census record and the day of birth and date of death fields from the death certificate.

the purpose of estimating uncorrected and corrected age and sex-specific death rates. The five category cause of death groupings are listed below with their associated ICD-9 three-digit codes (World Health Organization 1977): (1) malignant neoplasms (140-208); (2) ischemic heart disease (410-414); (3) cerebrovascular disease (430-438); (4) other cardiovascular diseases (390-404, 415-429, 440-448); and (5) all other causes. In 1985, the first four causes accounted for approximately 70% of all African-American and all U.S. deaths at ages 65+ (NCHS 1987a, Table 7; NCHS 1988, Table 1-31).

Educational Attainment in State of Birth

Although we do not have a direct measure on the educational attainment of our decedents we were able to construct two educational measures by utilizing other data sources. The first measure is the proportion of African-Americans in the decedent's state of birth with 0-4 years of schooling based on the 1990 Census of Population. These proportions are calculated by each five-year birth cohort and sex from the 1990 Census 5% PUMS file. They are then linked to the larger African-American Mortality data file by state of birth, sex, and final (i.e. corrected) age. [4]

Educational Inequality in Mortality by Cause of Death

To assess whether age agreement by cause of death is associated with educational gradient in cause-specific mortality, we constructed a relative index of inequality (RII) for each of the twenty-two cause of death by sex categories. The RII is equivalent to the slope of the log of death rates when plotted on the cumulative educational distribution scale. It indicates the mean proportionate decline in mortality when levels of schooling advance from the lowest to the highest levels of educational attainment (Preston and Elo 1995). Because educational attainment is not included on death certificates, we used the National Longitudinal Mortality Study Public Use File, Release 2 (NLMS2) to

[4] Among the 2567 sample individuals for whom final age was determined, the education variables are missing for 12 cases: for 11 decedents state of birth was missing from the death certificate and 1 decedent was born in Maine, a state for which the sample size was too small to calculate the schooling variables.

construct the RII for each of the 11 cause-of-death categories discussed above. The NLMS2 sample links Current Population Surveys (CPS) from 1979-81 to the National Death Index through 1989. Release 2 of the NLMS contains 637,162 individual records including 42,919 deaths occurring within the nine-year follow-up period (National Institutes of Health 1995). The NLMS2 is considered the best data source for examining educational differentials in U.S. mortality (Preston and Elo 1995).

To construct the RII for 1979-1989, we first estimate a slope index of inequality (SSI) for each sex-education-cause of death group. Four educational attainment levels are considered in these analyses, 0-8 years, 9-11 years, 12 years, and 13+ years of schooling. To obtain the SII, we first compute age-specific death rates by five-year age groups, educational attainment, sex and cause-of-death category for individuals aged 45 and above. These death rates are then age-standardized using the estimated 1985 U.S. resident population (U.S. Bureau of the Census, 1993). We then determine for each sex the proportion of the population in each education category in 1985 (U.S. Bureau of the Census, 1987: Table 1) and calculate the cumulative proportionate distribution of the population from the lowest to the highest level of schooling and estimate the midpoint of each group's range. The SII is then obtained by weighted least squares regression where the dependent variable is the age-standardized death rate and the independent variable is the midpoint of each group's range in the cumulative proportionate education distribution. Separate models are estimated for each sex and cause of death category. As weights, we use the proportions in each education group in 1985. The SII for each cause of death is then divided by its associated age standardized death rate for all educational groups combined to yield the RII.

Suddenness of Death

To assess our hypothesis that the quality of age reporting on death certificates is associated with suddenness of death, we have constructed a "suddenness of death" measure by cause of death from the 1986 National Mortality Followback Survey (NMFS) Public Use Data Tape (U.S. Department of

Health and Human Services 1992). The NMFS links information from death certificate informants and health care facilities used by the decedents in their last year of life to a nationally representative sample of 1986 U.S. death certificates. For our measure, we utilize a count of the total nights spent in all health care facilities (including hospitals, nursing homes, hospices, mental hospitals, and drug and alcohol treatment facilities) during the last year of life. “Sudden” deaths are defined (most conservatively) as those occurring to persons having spent 0 nights in any health care facility in the year prior to death. For each of our 11 cause of death categories, we then determine the percentage of decedents who spent zero nights in health care facilities in the year prior to death.

RESULTS

Age Agreement by Cause of Death

Age agreement varies by cause of death, particularly among females. The percentage of deaths with age agreement, broken down by cause and sex, is presented in Table 1. These estimates are based on weighted number of cases. We have constructed a set of weights to obtain a national estimate of age distribution of deaths in 1985. The weights take account of the different sampling proportions by age and of Maryland-born decedents and also adjust for variation in linkage rates by age on the death certificate (see Preston et al., 1996, Appendix). For the total sample death certificate age agrees with the final (corrected) age in 67% of the cases. As in the 1960 Matched Records Study (NCHS 1968: Table 4), age agreement is lower for female deaths than for male deaths. For all causes of death combined, age agreement is found in 63.8% of female deaths and 70.3% of male deaths. Comparing female and male cause-specific agreement rates we see that for 8 of the 11 causes listed, the female rate is lower than the corresponding male rate. Moreover, there is greater variation in age agreement across causes of death for females than for males. Among males, the highest age agreement is found for deaths from diabetes (88.2%) and the lowest agreement is found for deaths from infections, pneumonia, and influenza (59.7%). Among females, the best age agreement is found for deaths from chronic obstructive pulmonary diseases (88.2%) and the lowest agreement occurs for deaths from external causes (28.0%). Finally, the relatively high agreement rate for male external deaths (79.7%), which we would expect to be very sudden, was not expected.

Accounting for Variations in Age Agreement by Cause of Death

We know from past studies that age, sex, education, and suddenness of death are related to cause of death. Of particular interest in the present study, then, is the extent to which differences in age agreement by cause of death are explained by these factors.

Beginning with descriptive findings, we first turn to the relationship between educational attainment and cause of death. In Table 2 we present, for each cause of death, the mean proportion of African-Americans in the decedent's state of birth with 0-4 years of education. A general observation for both female and male deaths is the lack of dramatic variation in educational attainment by cause of death. It is interesting to note that for both female and male deaths, respiratory cancer is the cause associated with the highest educational attainment (i.e., it has the lowest proportion with low education).

Our second education measure, the relative index of inequality (RII), indicates the mean proportionate decline in mortality by cause of death when educational levels move from the lowest to the highest (Preston and Elo 1995). In other words, the smaller (more negative) the RII, the greater the decline in mortality as educational attainment increases. The RII values for each cause of death are reported in Table 3. Interestingly, among female deaths, the largest educational inequality is found for deaths from diabetes mellitus whereas among males, there is virtually no educational inequality associated with this cause. Sex differences in the etiology of this disease or in how likely it is to be recorded as the underlying cause of death could explain this anomalous finding. Among male deaths, it is also worth noting that the largest educational inequality is associated with smoking-related diseases: respiratory cancer and chronic obstructive pulmonary disease (COPD). Among female deaths, following diabetes, ischemic heart disease and infections and pneumonia show the next steepest gradients in mortality by level of schooling. Except for diabetes and ischemic heart disease, educational differentials in mortality for the all other causes of death are greater for males than for females.

Descriptive results on the suddenness of death by cause and sex are presented in Table 4. The ranking of causes, from most sudden to least, are quite similar for females and males. Not surprisingly, externally-caused deaths are the most sudden for both sexes, followed by deaths from ischemic heart disease. The least sudden deaths, for both females and males, are those from cancer and infections.

To test our hypotheses about the effects of cause of death, age at death, educational attainment, and suddenness of death on age agreement we estimate a series of logistic regression models. The dependent variable is the log odds of age agreement, and the samples are pooled with a dummy variable indicating whether the decedent died in 1980 or was a part of the Maryland oversample. Cause of death is coded as a series of dummy variables with "all other causes" as the reference category. Our measure of the suddenness of death is included as a linear variable indicating the percentage of decedents who spent zero nights in health care facilities in the year prior to death; as noted above, this measure is specific to each cause of death. The measure of educational attainment included in the multivariate analyses, and entered as a linear variable, is the proportion of African-Americans in the decedent's state of birth who had attained 0-4 years of schooling by sex and birth cohort.

The results from five logistic regression models, estimated separately for females and males, are presented in tables 5 and 6. All five models control for three sample characteristics: age at death, year of death, and state of birth. Models 1-3 focus, respectively, on the effects of cause of death, suddenness of death, and educational attainment on age agreement. Model 4 includes both the suddenness and educational attainment measures while Model 5 includes the cause of death and educational attainment measures.

As expected, cause of death, suddenness of death, and educational attainment are significantly related to age agreement. Females who die from digestive and "other" cancers are significantly more likely to have age agreement (Table 5, Model 1). Moreover, this finding is not due to age or educational differences in cause of death as the cause of death coefficients remain significant when these factors are adjusted for (Table 5, Model 5). For male deaths, adjusting for educational attainment affects which cause of death coefficient is associated with better age reporting. When education is not adjusted for, deaths from respiratory cancer are associated with better age agreement (Table 6, Model 1). When education is adjusted for, deaths from digestive cancer are associated with significantly better age agreement (Table 6, Model 5).

Model 2 in Tables 5 and 6 examines the relationship between suddenness of death and age agreement. Among women, suddenness of death remains a significant predictor of age agreement controlling for age and sample selection variables; the more sudden the death the less likely are ages to agree. This effect remains significant after controlling for educational attainment (Table 5, Model 4). For males, the size of the coefficient for suddenness of death is only about half of that for females and is not statistically significant (Table 6). Unfortunately, due to collinearity with our cause of death measure, we cannot determine the extent to which cause-specific differentials in age agreement are due to suddenness of death. [5]

Model 3 shows that the proportion of African-Americans with 0-4 years in the decedent's state of birth has a strong negative relationship with age agreement. The strong education effect is not altered by adjusting for either suddenness of death (Model 4) or cause of death (Model 5). These results are consistent with our view that age agreement is tied to educational attainment of the decedent and possibly the death certificate informant.

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[5] Due to the way in which we constructed the suddenness measure (i.e. assigning a suddenness value, derived from the NMFS, to each sex by cause category), if we know the sex and cause of death of a decedent we also know their suddenness value.

The final step in our multivariate analysis is to assess which model best fits the data. To assess model fit we use the Bayesian Information Criterion (BIC) (Raftery 1995). BIC adjusts for the fact that the null hypothesis will always be rejected with a large sample and also favors parsimonious models over all-inclusive ones. BIC also facilitates comparisons between non-nested models, making it possible to choose between all possible models (as opposed to the null and alternative nested models considered in classical hypothesis testing) (Raftery 1995). The smaller (more negative) the BIC value, the better the fit; positive BIC values suggest that the intercept only model fits the data better than a model containing covariates. When comparing models, a BIC difference of 10 or greater provides very strong evidence that the model with the smaller (more negative) BIC value provides the best fit (Raftery 1995).

Model 3--the educational attainment model--is the best fitting model for both sexes according to the BIC criterion. For females, Model 4--with education and suddenness of death parameters--fits the data nearly as well as Model 3. Model 1, for both females and males, and Model 5 for males actually have positive BIC values, indicating that an intercept only model fits the data better than these models. According to the conventional -2 log likelihood chi-square statistics, by contrast, Models 1 and 5 are significant at the .001 level. This demonstrates how conventional tests can be misleading when assessing model fit.

Cause-Specific Death Rates

The final issue examined in this paper is to see how cause-specific death rates for elderly African-Americans are affected when corrected age data are used. It has been previously shown that age-specific death rates from all-cause mortality are biased downward at ages 85 and above when uncorrected data are used (Preston et al. 1996). As noted above, in these analyses deaths are grouped into the following five categories: cancer, ischemic heart disease, cerebrovascular diseases, all other cardiovascular diseases, and all other causes combined. The final open-ended age interval for these analyses is 90+ due to the relatively small number of deaths by cause at higher ages. Manton (1982) and Manton and Poss (1977) have documented racial crossovers in mortality by cause of death for cancer, cerebrovascular diseases, heart disease, generalized atherosclerosis, and respiratory diseases based on vital statistics and census data.

The uncorrected and corrected age-specific death rates by cause of death for males and females are shown in Table 7. Due to large errors in the census counts of elderly African-Americans, it would be problematic to use census estimates in the denominator in the calculation of age-specific death rates. Consequently, we employ an alternative approach, which uses the actual death distribution and annualized intercensal growth rates to infer the number of deaths at a given age in the life table. Although the age-specific growth rates are based on census estimates, if we can assume similar patterns of age misreporting in both censuses, this should have little effect on the intercensal growth rates. The same approach was employed in estimates of all-cause mortality by Preston et al. (1996).

We were able to produce our age and cause-specific death rates by taking advantage of the fact that these rates sum to the all-cause death rate. Specifically, we used our knowledge of the uncorrected and corrected cause of death distributions to allocate Preston et al.'s (1996) estimates of total age-specific deaths to the five specific causes. We compare our estimates of cause-specific death rates for African Americans to those of whites. We have estimated cause-specific death rates for whites in the conventional manner, using 1985 deaths in the numerator and the Census Bureau's estimates of the white population on July 1, 1985 in the denominator (U.S. Bureau of the Census, 1993). The deaths by cause were obtained from the NCHS Mortality Detail Files for 1985 (National Center for Health Statistics 1987b).

Table 7 indicates that for most causes of death examined the corrected and uncorrected rates are quite similar up to about age 85, after which the two rates begin to diverge. By age 90, the corrected cause-specific rates are (in all cases) higher than the uncorrected rates. This pattern is essentially the same as that documented for mortality from all causes combined (Preston et al. 1996).

The comparison of corrected African-American death rates by cause of death to those of whites show that the mortality crossover is eliminated for some--but not all--causes of death (Table 7). The use of corrected age data clearly eliminates the crossover for male cancer and cerebrovascular deaths. The use of corrected data does not, however, eliminate the crossover for female and male deaths from ischemic heart disease.

DISCUSSION

This study updates and extends the 1960 Matched Records Study--the only previous study to examine age agreement by cause of death. Consistent with the Matched Records Study (MRS), we find that for all causes combined, age agreement is somewhat higher for male deaths (70.3%) than for female deaths (63.8%). Turning to cause-specific rates, we find that for all cardiovascular deaths the agreement rates in the Matched Records Study are very similar to those in the our sample. By contrast, age agreement rates for all cancer deaths are higher in our sample than in the MRS. For male cancer deaths, the MRS agreement rate is 70.9% compared to 76.2% in our sample. For female cancer deaths, the MRS agreement rate is 63.9% compared to 75.3% in the our sample. These differences are likely to reflect improvements in age reporting over time.

As expected, age agreement varies by cause of death, particularly among females. Few of the differences are, however, statistically significant. The two notable exceptions are female deaths from digestive and "other" (e.g., skin, breast, genitourinary organs) cancers, which have significantly better age agreement than deaths from other causes. Among male deaths there is less variation in age agreement by cause and only deaths from digestive cancers have significantly better age agreement once we control for sample characteristics.

While the results suggest that age agreement is not strongly tied to cause of death, they highlight the importance of education and the suddenness of death in predicting age agreement. As expected, suddenness of death is negatively associated with age agreement, and remains significant for females when other characteristics are controlled. The strong influence of educational background on age agreement for both females and males is the most significant finding and is consistent with previous analyses of all cause mortality. We interpret this finding as evidence that literacy and general cognitive functioning are strongly related to the quality of data on the age at death. Finally, we show that cause-specific death rates for African-Americans estimated from uncorrected vital statistics data are too low at ages 85 and above.

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Table 1. Percent Agreement between Death Certificate Age and Final Age by 11 Causes of Death, Weighted African American Mortality Sample (unweighted Ns in parentheses)

Cause of Death	Female (%)	N	Male (%)	N	Both Sexes (%)
Infections/Pneumonia	56.3	(76)	59.7	(76)	58.1
Cancer: Digestive Organs	77.1	(85)	76.6	(74)	76.9
Cancer: Respiratory	65.5	(28)	77.3	(104)	74.3
Cancer: Other	77.6	(105)	75.1	(152)	76.2
Ischemic Heart Disease	62.8	(265)	68.0	(284)	65.6
Cerebrovascular Disease	64.0	(157)	71.2	(121)	67.0
Other Cardiovascular Diseases	62.7	(292)	63.7	(273)	63.2
Diabetes Mellitus	58.8	(63)	88.2	(18)	65.4
COPD	88.2	(10)	76.7	(44)	78.5
External Causes	28.0	(27)	79.7	(44)	65.3
All Other Causes	60.4	(181)	70.3	(175)	65.1
All Causes Combined	63.8	(1289)	70.3	(1365)	67.1

Table 2. Mean Proportion of African-Americans with 0-4 Years of Education (in State of Birth) by Cause of Death (% age agreement in parentheses)

Cause of Death	Females	(% Agree)	Males	(% Agree)
Infections/Pneumonia	.25	(56.3)	.31	(59.7)
Cancer: Digestive Organs	.21	(77.1)	.29	(76.6)
Cancer: Respiratory	.16	(65.5)	.24	(77.3)
Cancer: Other	.19	(77.6)	.29	(75.1)
Ischemic Heart Disease	.24	(62.8)	.32	(68.0)
Cerebrovascular Disease	.26	(64.0)	.32	(71.2)
Other Cardiovascular Dis.	.24	(62.7)	.31	(63.7)
Diabetes Mellitus	.22	(58.8)	.29	(88.2)
COPD	.21	(88.2)	.31	(76.7)
External Causes	.23	(28.0)	.31	(79.7)
All Other	.24	(60.4)	.32	(70.3)

Table 3. Relative Index of Educational Inequality (RII) by Cause of Death (% age agreement in parentheses)

Cause of Death	Females	(% Agree)	Males	(% Agree)
Infections/Pneumonia	-.46	(56.3)	-.55	(59.7)
Cancer: Digestive Organs	-.32	(77.1)	-.38	(76.6)
Cancer: Respiratory	-.17	(65.5)	-.80	(77.3)
Cancer: Other	.01	(77.6)	-.13	(75.1)
Ischemic Heart Disease	-.57	(62.8)	-.37	(68.0)
Cerebrovascular Disease	-.35	(64.0)	-.48	(71.2)
Other Cardiovascular Dis.	-.43	(62.7)	-.49	(63.7)
Diabetes Mellitus	-1.30	(58.8)	-.02	(88.2)
COPD	-.27	(88.2)	-.76	(76.7)
External Causes	-.17	(28.0)	-.48	(79.7)
All Other	-.32	(60.4)	-.49	(70.3)

Note: Age Standardized; per 1000 deaths

Table 4. Suddenness of Death: Percent Spending 0 Nights in Health Care Facility in Year Prior to Death (% Age Agreement in Parentheses).

Cause of Death	Females	(% Agree)	Males	(% Agree)
Infections/Pneumonia	0.8	(56.3)	12.4	(59.7)
Cancer: Digestive Organs	4.4	(77.1)	7.1	(76.6)
Cancer: Respiratory	5.1	(65.5)	4.3	(77.3)
Cancer: Other	5.9	(77.6)	3.2	(75.1)
Ischemic Heart Disease	37.4	(62.8)	42.5	(68.0)
Cerebrovascular Disease	21.5	(64.0)	23.8	(71.2)
Other Cardiovascular Dis.	29.3	(62.7)	35.5	(63.7)
Diabetes Mellitus	18.3	(58.8)	26.1	(88.2)
COPD	10.2	(88.2)	25.0	(76.7)
External Causes	56.5	(28.0)	62.9	(79.7)
All Other Causes	16.3	(60.4)	19.2	(70.3)

Note: Health care facilities include hospitals, nursing homes, hospices, mental hospitals, and drug and alcohol treatment centers
Note: Percentages are age standardized.
Note: Data are from the 1986 National Mortality Followback Survey Public Use Data Tape

Table 5. Coefficients of Equations Predicting the Log Odds of Age Agreement for Female Deaths

Characteristic	Model 1	Model 2	Model 3	Model 4	Model 5
Cause of Death					
Infections	-0.0238				0.0546
Cancer: Digestive	0.7888*				0.8747**
Cancer: Respiratory	0.0884				-0.0047
Cancer: Other	0.8609**				0.8847**
Ischemic Heart Dis	0.1297				0.1368
Cerebrovascular Dis	0.1539				0.3087
Other Cardiovascular	0.0743				0.1279
Diabetes Mellitus	0.1932				0.2377
COPD	0.1024				0.1343
External Causes	-0.6379				-0.5827
All Other Causes	---				---
Suddenness of Death		-0.0114*		-0.0119*	
Propor. Low Education			-6.6719***	-6.7005***	-6.7689***
Death Certif. Age	-0.0130	-0.0146*	0.0413***	0.0426***	0.0446***
Maryland Birth					
No	---	---	---	---	---
Yes	0.5667***	0.5543***	0.2734	0.2492	0.2605
1980 Sample					
No	---	---	---	---	---
Yes	-0.2977	-0.2730	-0.1233	-0.1118	-0.1280
Constant	1.4457*	1.9985***	-1.0504	-0.8728	-1.4960*
-2 Log-Likelihood					
Intercept Only	1652.2	1652.2	1648.9	1648.9	1648.9
Intercept and Covars.	1607.5	1622.8	1555.4	1549.2	1533.8
Chi-Square	44.8***	29.4***	93.5***	99.7***	115.1***
Sample Size	1289	1289	1285	1285	1285
BIC	48.35	-0.78	-64.89	-63.94	-14.89

--- reference category; *** p-value ≤ .001; ** p-value ≤.01; * p-value ≤ .05

Table 6. Coefficients of Equations Predicting the Log Odds of Age Agreement for Male Deaths

Characteristic	Model 1	Model 2	Model 3	Model 4	Model 5
Cause of Death					
Infections	-0.0060				-0.0510
Cancer: Digestive	0.6112				0.6962*
Cancer: Respiratory	0.6069*				0.5761
Cancer: Other	0.3614				0.3853
Ischemic Heart Dis	0.1138				0.1687
Cerebrovascular Dis	0.1822				0.2486
Other Cardiovascular	0.0450				0.0604
Diabetes Mellitus	1.3365				1.3833
COPD	0.2799				0.3897
External Causes	0.3462				0.4533
All Other Causes	---				---
Suddenness of Death		-0.0056		-0.0044	
Propor. Low Education			-4.2803***	-4.2501***	-4.3690***
Death Certif. Age	-0.0223**	-0.0260***	0.0075	0.0081	0.0128
Maryland Birth					
No	---	---	---	---	---
Yes	0.4425**	0.4420**	0.1972	0.1902	0.1842
1980 Sample					
No	---	---	---	---	---
Yes	-0.5893**	-0.5937**	-0.5042**	-0.4872*	-0.4782*
Constant	2.4712***	3.0840***	1.7815**	1.8414**	1.1795
-2 Log-Likelihood					
Intercept Only	1624.0	1624.0	1616.8	1616.8	1616.8
Intercept and Covars.	1582.8	1593.1	1547.6	1546.3	1534.2
Chi-Square	41.2***	31.0***	69.3***	70.5***	82.6***
Sample Size	1365	1365	1357	1357	1357
BIC	52.60	-2.08	-40.41	-34.45	18.35

--- reference category; *** p-value ≤ .001; ** p-value ≤.01; * p-value ≤ .05

Table 7. Estimated Age-Specific Death Rates by Cause of Death and Race: United States, 1985 (death rates per 1,000)

Cause: Cancer

	Females			Males		
	African-Americans		Whites	African-Americans		Whites
Age Group	Death Certificate Age	Final Age		Death Certificate Age	Final Age	
65-69	5.4	5.4	5.7	13.7	13.6	9.2
70-74	7.1	5.8	7.3	16.1	15.5	12.9
75-79	8.0	7.8	8.6	21.0	21.3	16.8
80-84	13.4	12.0	10.5	27.3	24.2	20.7
85-89	16.1	15.8	12.5	19.0	23.4	24.0
90+	10.8	14.9	13.6	18.5	34.3	25.7

Cause: Ischemic Heart Disease

	Females			Males		
	African-Americans		Whites	African-Americans		Whites
Age Group	Death Certificate Age	Final Age		Death Certificate Age	Final Age	
65-69	5.9	5.3	3.7	9.3	8.2	9.2
70-74	8.3	7.6	6.6	13.6	14.0	14.5
75-79	10.0	12.0	11.8	17.3	17.6	21.8
80-84	16.2	10.6	21.0	34.7	33.6	33.9
85-89	27.4	30.9	37.1	46.3	50.0	50.6
90+	43.1	53.6	69.5	42.2	53.1	81.2

Table 7. (continued)

Cause: Cerebrovascular Disease

	Females			Males		
	African-Americans		Whites	African-Americans		Whites
Age Group	Death Certificate Age	Final Age		Death Certificate Age	Final Age	
65-69	3.1	2.7	0.9	3.5	3.3	1.3
70-74	3.6	3.2	1.9	7.1	5.7	2.6
75-79	5.7	5.5	3.9	8.2	8.3	5.0
80-84	14.5	12.5	8.0	10.2	11.4	9.2
85-89	15.9	16.6	15.3	18.2	16.1	15.1
90+	27.4	36.6	27.1	20.4	27.6	23.6

Cause: Other Cardiovascular Diseases

	Females			Males		
	African-Americans		Whites	African-Americans		Whites
Age Group	Death Certificate Age	Final Age		Death Certificate Age	Final Age	
65-69	4.4	3.6	1.8	9.5	9.3	3.7
70-74	9.3	8.7	3.2	11.6	10.7	6.0
75-79	15.4	13.6	5.9	18.4	22.3	9.5
80-84	15.7	15.7	11.4	22.3	18.0	15.9
85-89	33.0	35.9	21.6	36.3	34.8	26.3
90+	40.5	45.3	45.8	44.6	64.1	47.9

Table 7. (continued)

	Cause: All Other Causes					
	Females			Males		
	African-Americans		Whites	African-Americans		Whites
Age Group	Death Certificate Age	Final Age		Death Certificate Age	Final Age	
65-69	7.5	5.5	3.9	10.0	9.5	6.9
70-74	10.3	10.1	6.1	16.6	16.5	11.4
75-79	15.8	14.0	9.9	22.7	21.5	18.4
80-84	24.0	19.4	16.8	28.9	27.1	29.5
85-89	26.1	29.8	28.5	40.8	44.5	46.4
90+	54.6	74.3	51.6	84.5	104.1	75.1