THE SIGNIFICANCE OF DIFFERENTIAL RECORD LINKAGE FOR UNDERSTANDING BLACK-WHITE MORTALITY DIFFERENTIALS*

Joseph T. Lariscy, Ph.D.

Duke Population Research Institute

and Department of Sociology

Duke University

* Acknowledgements: This work was supported by the Doug Forbes Fund from the University of Texas at Austin Population Research Center and a proposal development grant from the Texas Census Research Data Center. Patricia Barnes, Donna Miller, and Jennifer Parker of the National Center for Health Statistics assisted in acquiring a special request file of the 1986-2006 National Health Interview Survey Linked Mortality File data. Analyses for this study were conducted in the Texas Census Research Data Center (College Station, Texas) and the Triangle Census Research Data Center (Durham, North Carolina). Correspondence: Joseph T. Lariscy, 271 Soc-Psyc Bldg, Campus Box 90088, Duke University, Durham, North Carolina 27708. Email: joseph.lariscy@duke.edu.

Abstract

Mortality rates among black adults exceed those of white adults throughout much of the life course. The differential is widest in young adulthood, then rates converge with increasing age until a crossover occurs at older ages. Data quality issues in survey-linked mortality studies may hinder accurate estimation of this disparity, particularly if the linkage of surveys to death records during mortality follow-up is less accurate for black adults. This study assesses black-white differences in the linkage of the 1986-2004 National Health Interview Survey to the National Death Index through 2006. Match class and match score (indicators of linkage quality) differ by race, with blacks exhibiting less certain matches than whites, particularly at older ages. Estimates of black-white mortality differentials are sensitive to alternative linkage criteria, with tightened linkage criteria resulting in a more favorable mortality risk among blacks relative to whites at older ages and an earlier crossover age.

Keywords: mortality; race/ethnicity; black-white mortality crossover; differential record linkage

Introduction

The black-white gap in U.S. mortality rates is wide and enduring throughout much of the life course as a result of lower socioeconomic status, residential segregation, political underrepresentation, and institutional- and individual-level discrimination experienced by African Americans (Elo and Preston 1997; Geruso 2012; Hummer and Chinn 2011; Rogers 1992; Williams and Sternthal 2010). In 2011 life expectancy at birth of non-Hispanic blacks was four years less than that of non-Hispanic whites (74.8 versus 78.8 years; Hoyert and Xu 2012). The differential is widest in young adulthood (with black young adults exhibiting more than twice the mortality risk of white young adults), then rates converge with increasing age and a crossover occurs at older ages, after which African Americans exhibit a lower mortality rate. The two leading explanations for the black-white mortality convergence and crossover are heterogeneity and data artifacts. The heterogeneity hypothesis suggests that the higher mortality among blacks in early life removes frailer individuals, leaving a particularly robust black population at older ages. When the mortality experience of older blacks is compared to that of older whites, who have more frail individuals surviving to older ages, older blacks will appear to have lower mortality rates than whites due to the selective survival of a particularly robust subset of black older adults (Manton and Stallard 1981; Otten et al. 1990).

The data artifact hypothesis posits that the quality of the data used to estimate health and mortality disparities is poorer among blacks than among whites, thus biasing estimates of black-white mortality differentials. Much of this work has examined data quality issues in vital statistics data. Estimates of mortality risk using vital statistics data may be particularly problematic for U.S. minority populations given that racial and ethnic identity is self-reported on the Census (the denominator of death rate calculations) but reported by a funeral director, coroner, or other official on the death certificate (the numerator of death rate calculations). Some adults who self-identify as African American are recorded as white on their death certificate and vice versa (Rogers, Carrigan and Kovar 1997). Researchers have also identified age misreporting on the death certificate among older African Americans as a source of bias in mortality differential estimates. That is, older African Americans born in the early twentieth century, before birth registration was mandated in all states, may report (or have reported for them) an age that is higher than their true age. Preston et al. (1996) matched a sample of death certificates for older African Americans to their U.S. censuses in 1900, 1910, and 1920 to show that the ages at death reported on death certificates are often too low. After adjusting for age misstatement, Preston and colleagues observed higher mortality rates among African Americans such that the "black-white mortality crossover" was no longer observed. Rosenberg and colleagues (1999) found that, without adjustment, official death rates for African Americans are biased due to age misstatement and race misclassification, as well as Census under-coverage. Regarding the Census-derived population estimates that constitute the denominator of mortality rates, African Americans have historically been undercounted in U.S. Censuses (Anderson and Fienberg 1999; Robinson, West and Adlakha 2002) including in the 2010 Census (Mule 2012), thus biasing downward the denominator in the calculation of mortality rates for black adults.

The mortality crossover is also found when using survey-linked mortality data, such as the National Health Interview Survey Linked Mortality Files (NHIS-LMF) and National Longitudinal Mortality Study (NLMS), which avoid the issues of racial/ethnic misclassification and age misreporting found in vital statistics data. Survey-linked mortality data consisting of social surveys linked to death records maintained by the National Death Index (NDI) do not suffer from this numerator-denominator discordance issue since the race self-reported or reported by a co-resident on the survey is used to identify the race of the individual during mortality follow-up. Additionally, age is self-reported on the survey then carried forward to the time of death rather than relying on the age at death reported on the death certificate. Given the strengths of survey-linked mortality data sources, they are a popular tool for assessing racial disparities in mortality risk (Eberstein, Nam and Heyman 2008; Hummer, Benjamins and Rogers 2004; Masters 2012; Preston et al. 1996; Rogers, Hummer and Nam 2000; Stewart 2008). They are particularly helpful in the study of racial health disparities since high-quality measures of socioeconomic status and health behaviors, possible mechanisms linking race/ethnicity to health, are included, whereas they are absent from vital statistics data.

Despite the strengths of linked-survey mortality datasets, they also have an important limitation: differential rates of linkage by subpopulation, particularly racial minority groups and older adults. Yet, the degree to which record linkage differs by race, age, and gender and the impact of such differences on mortality estimates are uncertain. The overall NHIS-LMF data have been determined to be highly accurate in distinguishing true death (and survivor) matches and false death (and survivor) matches. A calibration study estimated that 98.5% of respondents were correctly classified as alive or dead at the end of the follow-up period (NCHS Office of Analysis and Epidemiology 2009). However, few studies have assessed whether record linkage differs by race, and they suggest that the magnitude and even the direction of racial/ethnic mortality differences vary when alternative match criteria are used. For instance, Liao et al. (1998) used an early release of the NHIS-NDI dataset to examine the impact of using more liberal or conservative matching standards relative to the NCHS-recommended criteria on observed death rates and rate ratios by race/ethnicity. They found that mortality rates of non-Hispanic blacks and Hispanics relative to non-Hispanic whites vary when alternative matching criteria are used. In a recent study using the 1989-2000 NHIS linked to NDI death records through 2002, Lariscy (2011) showed that linkage among Hispanic decedents (particularly those who are foreign-born) is less certain than among U.S.-born non-Hispanic whites and that the hazard ratio of foreign-born Hispanics relative to non-Hispanic whites are sensitive to alternative matching criteria at ages 25-64 years but robust at older adult ages.

Differential record linkage among black and white adults could occur for a number of reasons. First, African Americans are more likely than whites to misreport their age on social surveys. Older African Americans born in the early twentieth century, many of whom were born in the rural Southeast, may not have had a birth certificate filed at the time of birth that accurately reports date of birth. Age misstatement generally biases mortality estimates among older African Americans downward relative to whites (Preston, Elo and Stewart 1999). Second, race may be misreported on either record (most likely on the death certificate). On social surveys race is self-reported or reported by a coresident proxy whereas on death certificates race is reported by a funeral director, coroner, or other official who may not record the same race with which the respondent self-identified. Since race is one of the items used to link the NHIS and the NDI, racial discordance on the two records could lead to false identification of a decedent as surviving. Other researchers have shown that race occasionally does not match between surveys and death records (Rogers et al. 1997; Sorlie, Rogot and Johnson 1992). Third, racial differences in refusal or inability to correctly report social security number (SSN) could reduce linkage quality since SSN is the most unique of the matching items and is best able to distinguish true matches from false matches. Among female NHIS respondents, SSN was missing for only 15% of the 1986 sample but increased to 67% of respondents by 2004, the last year of the current NHIS-NDI linkage. The decline in SSN reporting over time is comparable among males. If SSN is missing for a greater proportion of African Americans than whites, the linkage quality may be poorer among African Americans than among whites (Curb et al. 1985).

Research Questions

Given the data quality issues of linked-survey mortality data raised by previous research, this study assesses black-white differences in the linkage of the 1986-2004 National Health Interview Survey (NHIS) to 1986-2006 NDI death records as well as whether estimates of black-white mortality differentials are sensitive to such linkage differences. Analyses are guided by the following research questions:

1. Do record linkage indicators (match class and match score) differ by race?
2. Do race differences in match score differ by age (in 20-year groups) among decedents?
3. Is the black-white mortality differential sensitive to modification of class-specific match score cut-points?
4. Does the age at which black and white mortality rates cross over vary when alternative matching criteria are used?

Addressing these research questions is vital for estimating accurate black-white mortality differentials. First, the demographic and public health research communities would benefit greatly from gaining a better understanding of the strengths and limitations of the NHIS-LMF, one of the most commonly used data sources for studying social determinants of U.S. population health and health disparities. Second, by examining the NHIS-NDI matching process, I assess the sensitivity of the linkage process when alternative match criteria are applied. This type of data quality evaluation is important since refusal to report personally identifiable information (particularly SSN) by NHIS respondents has increased across years of data collection. Finally, if black-white mortality differentials are found to be relatively sensitive to alternative match criteria for certain race, age, and gender subgroups, this will inform NHIS-LMF data users to exercise caution when interpreting results for particular subgroups.

Methods

Data

This study uses the 1986-2006 NHIS-LMF. The NHIS is a stratified, probabilistic survey of the U.S. non-institutionalized population. It has been conducted annually since 1957, allowing for multiple cross-sections to be merged to monitor health trends over time and to compile data with large samples of specific subpopulations, such as racial/ethnic minority groups. For years 1986 forward, NCHS has linked the NHIS to NDI records to allow researchers to prospectively follow-up on the vital status of respondents until 2006. NHIS records are probabilistically linked to NDI death records based on correspondence between twelve items listed in both data sources: SSN, first name, middle initial, last name, birth month, birth day, birth year, state of birth, state of residence, sex, race, and marital status (see NCHS Office of Analysis and Epidemiology 2010 for expanded explanation of linkage methodology). NHIS records must meet one of three combinations of personal identifiers to be eligible for linkage. The NDI first identifies potential matches based on seven criteria involving combinations of SSN, first and last name, middle initial, and date of birth. Then, an algorithm assigns match scores to each potential match to distinguish true matches from false matches. Match scores are the sum of weights assigned to each of the items on which records are matched. If the items agree for the potential match, the weight is positive; disagreement yields a negative weight. A higher match score indicates more items matching between the survey and the death record. Potential matches are then placed into one of five mutually exclusive classes, based on the items on which they agree. Respondents placed into Class 1 are considered dead and respondents placed into Class 5 are considered surviving. For Classes 2, 3, and 4, different match score cut-points are used to ascertain vital status. The match score cut-points set by NCHS are 47 for Class 2, 45 for Class 3, and 40 for Class 4; respondents with a score greater than or equal to their class's cut-point are considered deceased (National Center for Health Statistics, 2005).These match score cut-points were chosen during the NHANES I Epidemiologic Follow-Up Study (NHEFS) to maximize correct identification of true matches while simultaneously minimizing false matches (NCHS Office of Analysis and Epidemiology 2009). However, such cut-points may not be most suitable among subpopulations within the data set. Ideally, all true survivors would have low match score values and be placed into class 5 and all true decedents would have high match score values and be placed into class 1. However, all five classes and the entire score distribution are populated with cases having varying degrees of certainty.

Measures

Race is measured as non-Hispanic black and non-Hispanic white. Respondents who identify as Hispanic or as a race other than black or white are excluded from the study. Although mortality estimates of racial/ethnic minority groups other than blacks, such as Asians/Pacific Islanders, Hispanics, and American Indians/Alaska Natives, are also affected by data quality issues (Arias et al. 2008; Lariscy 2011; Sorlie et al. 1992), the number of deaths in the NHIS-LMF for some of these groups is too small for reliable mortality estimates. Additionally, black-white mortality inequality is a critical U.S. population phenomenon that warrants specific attention.

Females experience a lower risk of mortality relative to males throughout the life course, and the female advantage in life expectancy at birth is wider among blacks relative to whites (Miniño et al. 2011). Additionally, Curb and colleagues (1985) found that deaths records among females were less likely to be located in the NDI than among males. Thus, all analyses are stratified by sex. Examination of match quality by age (in 20-year age groups) reveals if record linkage is better at particular ages of the life course. The black-white mortality gap has been shown to be particularly wide in early adulthood, converge throughout middle-age, and cross-over among the oldest-old (generally shown to occur at about age 85 or 90; Miniño et al. 2011). If differential record linkage by race is particularly problematic at select ages, it could bias estimates of black-white mortality differentials.

Analytic Approach

Descriptive analyses involve calculating match class distribution, mean match class, and mean match score for non-Hispanic black and white females and males, presented separately for NCHS-identified decedents and survivors. I then examine mean score among decedents for black and white females and males within 20-year age groups (25-44, 45-64, 65-84, 85+). I use survey procedures SURVEYPROC FREQ and SURVEYPROC MEANS in SAS 9.3 to estimate Taylor linearized standard errors that account for the complex sampling design used by the NHIS. Next, I fit Poisson regression models with a log link function to the data to show the rate ratios of mortality risk for non-Hispanic blacks relative to non-Hispanic whites using NCHS-recommended (based on the NHEFS calibration study), relaxed (class-specific score cut-points are decreased by 5 points), and tightened (class-specific score cut-points are increased by 5 points) match criteria for the same 20-year age groups described above in order to demonstrate if the black-white mortality differential is robust to changes in matching criteria throughout the life course. Poisson models allow examination of whether individuals have survived or died, as well as the timing of death. The quarter and year of the survey, the quarter and year of death (if applicable), and the end point of follow-up are all known, so that the model can accurately account for the duration of exposure until death or right censoring (i.e., the end of the follow-up period). A 5-point shift in class-specific score cut-points is more subtle than the shifts by Liao et al. (1998) and is comparable to the 4-point band used by NCHS staff in a sensitivity demonstration using the entire NHIS-LMF sample (National Center for Health Statistics, 2005). Tightening and relaxing can be considered conservative and liberal standards, respectively, by which vital status is ascertained. Vital status of Class 1 and Class 5 respondents does not change in the sensitivity analyses as their classes do not have cut-points; all Class 1 matches are considered deaths whereas all Class 5 matches are considered survivors.

In the final analytic step, I calculate log mortality rates using single year of age to determine whether the age of black-white mortality crossover for males and females varies when the class-specific match score cut-points are relaxed and tightened. Unlike the public-use NHIS-LMF data which truncate age at 85+ for select years, the special request file used for this study allows observation of mortality among the oldest old, at the ages where black and white mortality rates purportedly cross over.

All analyses are weighted using the NHIS-LMF weights, which adjust for ineligible respondents, to represent the non-institutionalized U.S. population. Respondents who are ineligible for linkage are excluded from analyses. Figure 1 indicates that linkage eligibility has decreased over time and that a greater proportion of black respondents than white respondents are ineligible for mortality follow-up after year 1997. NHIS-LMF users should note this black-white difference in eligibility as an additional level of differential data quality since a greater proportion of ineligible black adults are excluded from vital status follow-up. Analyses were conducted in Census Research Data Centers because the variables *match class* and *match score* are restricted-use variables of the NHIS-LMF.

Results

Table 1 shows class distribution, mean class, and mean score for non-Hispanic black and white females and males, presented separately for NCHS-identified deaths and survivors. The top panel describes racial differences in class and score among respondents identified as having died during follow-up. Recall that among deaths, a high score and placement into class 1 indicate better matches. For both male and female decedents, whites have a higher mean score, but the difference is only significant among males. For class, a greater proportion of white deaths than black deaths are placed into class 1 and a greater proportion of black deaths than white deaths are placed into classes 2-4, which are characterized as less certain death matches.

The bottom panel of Table 1 examines mean scores and class distribution among respondents identified as having survived the follow-up period. Among survivors, the best non-matches have a low mean score and are placed into class 5. Mean score among survivors is somewhat challenging to interpret since score is truncated at 0 and about 70% of survivors have a score of 0. But it's informative for comparison, and black survivors have higher scores than their white counterparts and are also less likely to be placed into class 5, showing that, as with deaths, identification of black adults as surviving the follow-up period is generally less certain than white adults.

After establishing that linkages are more certain among black adults than among white adults, I then examine the age patterns of black-white differential record linkage. Table 2 examines mean score among decedents for black and white females and males within 20-year age groups (25-44, 45-64, 65-84, 85+). I conduct significance tests (with 95% confidence intervals) to determine within which age groups the average match score of non-Hispanic black adults is statistically different from the average score of non-Hispanic whites. I only examine match score and not match class here given that the two linkage indicators are highly correlated among decedents (r = -.96). I find that mean score among black decedents is significantly lower than the mean score among white decedents for all sex and 20-year age groups except for females 25-44. Note also that mean score decreases with age for all groups, but this decrease is steeper among blacks than among whites such that the black-white gap in score among deaths increases after age 45. Note also that the black-white gap in mean match score among decedents is wider for males than for females for each age group and that the largest black-white gap is among young males.

Since record linkage is more certain among white adults than among black adults, and many matches for both race groups have score values concentrated near the score cut-points, I want to see if black-white mortality differentials are sensitive to modification of the score cut-points. Table 3 shows the rate ratios of black mortality risk relative to white mortality risk using NCHS-recommended cut-points. Then, for respondents whose matches are assigned to classes 2, 3, and 4, the class-specific cut-points are tightened (increased by 5 points) and relaxed (decreased by 5 points) to see whether the hazard ratios increase, decrease, or remain constant. Matches in class 1 remain deaths and matches in class 5 remain survivors, but some matches in classes 2-4 will change vital status. Relaxing represents a more lenient criterion for determining a match and increases the total number of death since fewer items have to match between the survey and death record for a respondent to be considered as dying during follow-up. Tightening represents a more stringent criterion for determining a match and reduces the total number of deaths since matches now have to match on more items to be considered a death. I find that relative risk ratios of black mortality risk relative to white mortality risk are not sensitive to relaxing the cut-points; they are roughly equal to the relative risk ratios when NCHS-recommended cut-points are used. Tightening, however, leads to significantly lower relative risk ratios than when NCHS cut-points are used for females ages 65+ and for males 65-84. This finding fits with other research that suggests black-white mortality differences in later life may be influenced by lower data quality among older African Americans relative to older white adults.

Finally, in Table 4 I investigate whether the age at black-white mortality crossover is sensitive to relaxing and tightening the score cut-points. Recall that the black-white mortality crossover involves black adults experiencing a greater mortality rate than whites in younger adult ages, but the rates converge across the life course, and at a certain advanced age, the black and white mortality rates cross over such that from that age forward, blacks have a lower mortality rate relative to whites. I find that the age at crossover is 84 for females and 87 for males when the NCHS-recommended cut-points are used. I find that relaxing does not change the crossover age at all. But when I tighten cut-points the crossover occurs at an *earlier* age: 82 for females and 85 for males, two years earlier than when the NCHS cut-points are used.

Discussion

Research on racial disparities in adult mortality have clearly established greater mortality risk among African Americans relative to whites throughout much of the life course. Yet, the accuracy of such estimates, particularly at the oldest ages, is compromised by data quality issues. While biases in race-specific mortality estimates are well-documented in official death rates composed of death certificate counts in the numerator and Census estimates in the denominator, the issues of differential record linkage by race in survey-linked mortality data sources have received less attention to date. This study addresses whether record linkage is poorer among African Americans relative to whites as well as whether estimates of mortality differentials vary when alternative matching criteria are used.

To address my research questions, I found that record linkage differs by race. Black adults have lower linkage quality than white adults among both females and males. Black decedents have lower mean match scores and are less likely to be classified in class 1 (i.e., near exact match) relative to whites, indicating that record linkage is less certain among black decedents relative to their white counterparts. Conversely, Black survivors have higher match scores and are less likely to be classified in class 5 relative to whites, indicating that record linkage is less certain among black survivors relative to white survivors. The black-white gap in mean match score among decedents increases with age from middle adulthood on, although young men are also characterized by the widest gap in score among decedents of any sex and age group. It is worth noting that while data quality among whites is generally more reliable than among blacks (Curb et al. 1985; Hill, Preston and Rosenwaike 2000), there is still a large proportion of white respondents in the match score range and classes characterized as uncertain and the match score among non-Hispanic white decedents decreases with age, indicating a decline in linkage quality. Thus, strategies should be implemented that improve linkage quality for all NHIS-LMF respondents, but with a particular objective of improving linkage among minority respondents.

Next, I assessed whether black-white mortality differentials are sensitive to relaxing and tightening of score cut-points. Results provide mixed evidence regarding sensitivity to alternative linkage criteria. Relaxing cut-points among black adults did not affect mortality rate ratios or age at black-white mortality crossover. Tightening cut-points on the other hand results in a lower crossover age (of about 2 years) and significantly lower relative risk among black women relative white women at ages 65+ and among black men relative to white men ages 65-84.

Most studies concerned with data quality issues when estimating mortality risk among African Americans have focused on issues at the oldest ages, particularly age misreporting. However, my analyses indicate that differential record linkage is not just a problem among older adults, but also occurs among younger adults. Young adulthood is characterized by few deaths relative to older adult ages, the widest black-white mortality gap throughout the life course (on the order of 2-to-1), reasonably good overall record linkage, a narrow black-white gap in mean match score among female decedents but a particularly wide gap among male decedents, and rate ratios robust to use of alternative linkage criteria (i.e., relaxing and tightening of class-specific score cut-points). Older adulthood is the stage of the life course where most deaths occur, the black-white mortality gap converges then crosses over, overall record linkage is poor, the gap in black-white mean match score among decedents is widest, and black-white relative risk ratios are sensitive to tightening (but not relaxing) of class-specific score cut-points. These findings regarding sensitivity of death rate ratios to tightening only among older adults contrasts with those of Lariscy (2011), who found that hazard ratios of foreign-born Hispanics relative to whites were sensitive to both relaxing and tightening at ages 25-64 (including an erasure of the Hispanic mortality advantage when criteria were relaxed among adults 45-64 years), but robust to alternative criteria at ages 65+.

These results provide evidence that black-white mortality convergence and crossover is not a data artifact as has been suggested by others, most notably Preston and colleagues (1996), who suggested that adjusting for poorer data quality among black older adults relative to white older adults eliminated the crossover. Lynch, Brown, and Harmsen (2003) found that after adjusting for data quality issues, the crossover continued but occurred at a later age than found using unadjusted data. My sensitivity analyses show that the age at which the black-white mortality crossover occurs does not change when match score cut-points are relaxed (liberal criteria) and decreases by two years for both males and females when cut-points are tightened (conservative criteria), relative to the crossover age when NCHS-recommended criteria are used. My finding that adjusting the data actually decreases the crossover age is similar to a finding by Masters (2012), in which NHIS-LMF respondents with characteristics associated with poorer linkage were excluded. In my analysis, I keep those respondents but reclassify the vital status of some with score values near to the class-specific cut-point. Note that relaxing and tightening do not represent adjustment per se, but rather are sensitivity analyses to determine whether mortality rate ratios vary when the NCHS-recommended criteria are relaxed (a more lenient criteria) and tightened (a more stringent criteria).

My results using the NHIS linked to the NDI has implications for other survey-linked mortality data sources. Because the Health and Retirement Survey (HRS) is a longitudinal study, it performs both passive linkage and active follow-up (Tracker File) to determine vital status of respondents, so even if items are inaccurate or missing on both records and probabilistic linkage is poor, the HRS staff could still accurately ascertain vital status by contacting the respondent or a next of kin. The General Social Survey has recently been linked to the NDI and potentially could be an important asset to mortality researchers given that it contains many socioeconomic, behavioral, and social stress and support variables that influence absolute and relative mortality risk. However, the GSS does not record SSN, which is the only completely unique item used to match records. Other items such as date of birth and name are not entirely unique, that is, multiple survey respondents can share the same name and birth date. Thus, the quality of linkages in the GSS-NDI data is likely lower than in the NHIS-LMF and other survey-linked data since SSN is the gold standard of unique identifiers.

Limitations

There are a few important limitations to this study. First, I only examine black and white adults, but differential linkage is a problem for other groups. For instance, Lariscy (2011) found that relaxing and tightening cut-points dramatically changed hazard ratios of foreign-born Hispanics relative to non-Hispanic whites. Mortality risk among foreign-born Hispanics is not significantly different from that of whites under the NCHS-recommended cut-points, but Hispanic immigrants are significantly disadvantaged under the relaxed criteria and significantly advantaged under the tightened criteria. So mortality estimates of some other racial/ethnic groups are much more sensitive to relaxing and tightening than among black adults. Researchers must exercise caution when interpreting mortality estimates for some racial/ethnic minority groups calculated from survey-linked mortality data since the limited evidence available suggests that their data quality is lower relative to non-Hispanic whites. Also, while I find that surveys and death records match on fewer items among blacks than among whites, I don’t know which items are responsible. This special request file of the NHIS-LMF includes match score and match class but not the personal identifiers reported on NHIS surveys and death records to maximize data access while protecting the confidentiality of NHIS respondents (Lochner et al. 2008). Therefore, I do not examine the exact items responsible for yielding differential match score and match class distributions. Ineligibility and fewer items and less unique items for linkage have become very serious issues. NHIS participants' refusal to report SSN is likely bears responsibility for reduced match quality in the NHIS-LMF. One solution recently implemented by NHIS data collectors is to request fewer digits of respondents' SSN (i.e., the last four digits rather than all nine; Sayer and Cox 2003). Another strategy to improve record linkage between the NHIS and NDI among subpopulations could involve active follow-up of the potential matches with scores closest to their class's cut-point (i.e., recontact the respondent or contact the next of kin) rather than relying solely on passive follow-up through NDI record linkage. While active follow-up of the entire NHIS-LMF sample would be prohibitively difficult given its size, active follow-up of the small subset of cases clustered nearest to the class-specific cut-points may be reasonable. Another strategy could be another calibration study similar to the original NHEFS I, but with an emphasis on minority respondents and other vulnerable populations characterized by both poorer data quality and worse health outcomes.

Conclusions

Survey-linked mortality data offer unique opportunities for studying black-white mortality differentials, given their large number of black and white respondents who die during follow-up, self-reports of race and ethnicity, detailed measurement of other sociodemographic characteristics that confound racial health disparities, and ongoing data collection. However, differential record linkage may bias mortality estimates in ways that are not yet well documented and understood. Thus, researchers must acknowledge both the strengths and weaknesses of this form of data, exercise caution when interpreting mortality estimates for smaller racial/ethnic minority groups characterized by data quality concerns, and pursue additional research that expands on this study's findings to further document whether racial/ethnic groups experience reduced data quality issues and how these issues impact estimates of racial/ethnic survival inequalities.

References

Anderson, M.J.and S.E. Fienberg. 1999. *Who Counts? The Politics of Census-Taking in Contemporary America*. New York: Russell Sage Foundation.

Arias, E., W.S. Schauman, K. Eschbach, P.D. Sorlie, and E.L. Backlund. 2008. "The validity of race and Hispanic origin reporting on death certificates in the United States." *Vital and Health Statistics* 2(148):1-23.

Curb, J.D., C.E. Ford, S. Pressel, M. Palmer, C. Babcock, and C.M. Hawkins. 1985. "Ascertainment of vital status through the National Death Index and the Social Security Administration." *American Journal of Epidemiology* 121(1):754-766.

Eberstein, I.W., C.B. Nam, and K.M. Heyman. 2008. "Causes of death and mortality crossovers by race." *Biodemography & Social Biology* 54(2):214-228.

Elo, I.T.and S.H. Preston. 1997. "Racial and ethnic differences in mortality at older ages." in *Racial and Ethnic Differences in the Health of Older Americans,* edited by L.G. Martin and B.J. Soldo. Washington, DC: National Academy Press.

Geruso, M. 2012. "Black-white disparities in life expectancy: How much can the standard SES variables explain?" *Demography* 49(2):553-574.

Hill, M.E., S.H. Preston, and I. Rosenwaike. 2000. "Age reporting among white Americans aged 85+: Results of a record linkage study." *Demography* 37(2):175-186.

Hoyert, D.L.and J. Xu. 2012. "Deaths: Preliminary data for 2011." *National Vital Statistics Reports* 61(6).

Hummer, R.A., M.R. Benjamins, and R.G. Rogers. 2004. "Racial and ethnic disparities in health and mortality among the U.S. elderly population." in *Critical Perspectives on Racial and Ethnic Differences in Health in Later Life*, edited by N.B. Anderson, R.A. Bulatao, and B. Cohen. Washington, DC: National Academies Press.

Hummer, R.A.and J.J. Chinn. 2011. "Race/ethnicity and U.S. adult mortality: Progress, prospects, and new analyses." *Du Bois Review* 8(1):5-24.

Lariscy, J.T. 2011. "Differential record linkage by Hispanic ethnicity and age in linked mortality studies: Implications for the epidemiologic paradox." *Journal of Aging and Health* 23(8):1263-1284.

Liao, Y., R.S. Cooper, G. Cao, R. Durazo-Arvizu, J.S. Kaufman, A. Luke, and D.L. McGee. 1998. "Mortality patterns among adult Hispanics: Findings from the NHIS, 1986 to 1990." *American Journal of Public Health* 88(2):227-232.

Lochner, K.A., R.A. Hummer, S. Bartee, G. Wheatcroft, and C. Cox. 2008. "The public-use National Health Interview Survey Linked Mortality Files: Methods of reidentification risk avoidance and comparative analysis." *American Journal of Epidemiology* 168(3):336-344.

Lynch, S.M., J.S. Brown, and K.G. Harmsen. 2003. "Black-white differences in mortality compression and deceleration and the mortality crossover reconsidered." *Research on Aging* 25(5):456-483.

Manton, K.G.and E. Stallard. 1981. "Methods for evaluating the heterogeneity of aging processes in human populations using vital statistics data: Explaining the black/white mortality crossover by a model of mortality selection." *Human Biology* 53(1):47-67.

Masters, R.K. 2012. "Uncrossing the U.S. black-white mortality crossover: The role of cohort forces in life course mortality risk." *Demography* 49(3):773-796.

Miniño, A.M., S.L. Murphy, J. Xu, and K.D. Kochanek. 2011. "Deaths: Final data for 2008." *National Vital Statistics Reports* 59(10).

Mule, T. 2012. "Census coverage measurement estimation report: Summary of estimates of coverage for persons in the United States." Washington, DC: U.S. Department of Commerce Economics and Statistics Administration, U.S. Census Bureau.

NCHS Office of Analysis and Epidemiology. 2009. "NHANES I Epidemiologic Follow-up Survey (NHEFS) calibration sample for NDI matching methodology." Hyattsville, MD: National Center for Health Statistics.

—. 2010. "The National Health Interview Survey (1986-2004) Linked Mortality Files: Analytic guidelines." Hyattsville, MD: National Center for Health Statistics.

Otten, M.W., S.M. Teutsch, D.F. Williamson, and J.S. Marks. 1990. "The effect of known risk factors on the excess mortality of black adults in the United States." *Journal of the American Medical Association* 263(6):845-850.

Preston, S.H., I.T. Elo, M. Rosenwaike, and M. Hill. 1996. "African-American mortality at older ages: Results of a matching study." *Demography* 33(2):193-209.

Preston, S.H., I.T. Elo, and Q. Stewart. 1999. "Effects of age misreporting on mortality estimates at older ages." *Population Studies* 53(2):165-177.

Robinson, J.G., K.K. West, and A. Adlakha. 2002. "Coverage of the population in Census 2000: Results from demographic analysis." *Population Research and Policy Review* 21(1/2):19-38.

Rogers, R.G. 1992. "Living and dying in the U.S.A.: Sociodemographic determinants of death among blacks and whites." *Demography* 29(2):287-303.

Rogers, R.G., J.A. Carrigan, and M.G. Kovar. 1997. "Comparing mortality estimates based on different administrative records." *Population Research and Policy Review* 16(3):213-224.

Rogers, R.G., R.A. Hummer, and C.B. Nam. 2000. *Living and Dying in the USA: Behavioral, Health, and Social Differentials of Adult Mortality*. San Diego, CA: Academic Press.

Rosenberg, H.M., J.D. Maurer, P.D. Sorlie, N.J. Johnson, M.F. MacDorman, D.L. Hoyert, J.F. Spitler, and C. Scott. 1999. "Quality of death rates by race and Hispanic origin: A summary of current research, 1999." *Vital and Health Statistics* 2(128).

Sayer, B.and C.S. Cox. 2003. "How many digits in a handshake? National Death Index matching with less than nine digits of the social security number." *Joint Statistical Meetings: Section on Survey Research Methods*:3666-3672.

Sorlie, P.D., E. Rogot, and N.J. Johnson. 1992. "Validity of demographic characteristics on the death certificate." *Epidemiology* 3(2):181-184.

Stewart, Q.T. 2008. "The shape of inequality: Racial disparities in age-specific mortality." *Biodemography & Social Biology* 54(2):152-182.

Williams, D.R.and M. Sternthal. 2010. "Understanding racial-ethnic disparities in health: Sociological contributions." *Journal of Health and Social Behavior* 51(Supplement):S15-S27.

Table 1. Match class and match score distributions by race and sex

	Female		Male	
	Black	White	Black	White
NCHS-identified deaths	13,254	68,992	12,040	68,266
Class (%)				
1	55.65 (54.52-56.79)	64.19 (63.57-64.80)	59.48 (58.13-60.82)	71.40 (70.77-72.04)
2	17.52 (16.61-18.43)	13.41 (13.02-13.79)	12.89 (12.24-13.53)	8.00 (7.77-8.23)
3	22.79 (21.76-23.82)	20.17 (19.60-20.74)	23.19 (22.04-24.33)	18.49 (17.92-19.05)
4	4.04 (3.66-4.42)	2.24 (2.11-2.37)	4.45 (4.01-4.90)	2.11 (1.97-2.25)
Mean class	1.75 (1.73-1.78)	1.60 (1.59-1.62)	1.73 (1.70-1.75)	1.51 (1.50-1.53)
Mean score	79.24 (78.82-79.65)	79.63 (79.39-79.88)	79.19 (78.68-79.71)	81.73 (81.50-81.97)
NCHS-identified survivors	72,609	368,884	48,089	322,377
Class (%)				
2	0.06 (0.04-0.07)	0.05 (0.04-0.06)	0.11 (0.07-0.15)	0.06(0.05-0.06)
3	0.22 (0.19-0.26)	0.20 (0.19-0.22)	0.56 (0.49-0.64)	0.31 (0.29-0.33)
4	19.19 (18.75-19.64)	11.75 (11.55-11.95)	23.12 (22.56-23.68)	13.76 (13.52-13.99)
5	80.53 (80.08-80.97)	88.00 (87.79-88.20)	76.21 (75.64-76.77)	85.88 (85.64-86.12)
Mean class	4.80 (4.80-4.81)	4.87 (4.87-4.88)	4.75 (4.75-4.76)	4.85 (4.85-4.86)
Mean score	2.91 (2.84-2.99)	1.72 (1.68-1.75)	3.86 (3.75-3.97)	2.14 (2.09-2.18)

Source: 1986-2006 National Health Interview Survey Linked Mortality Files
Note: NCHS = National Center for Health Statistics. Means and percentages are weighted and counts are unweighted. 95% confidence intervals are listed with means and percentages.

Table 2. Black-white differences in mean match score among decedents

Age	Females			Males		
	Black	White	white mean – black mean	Black	White	white mean – black mean
25-44	84.21	85.65	1.44	80.08	83.48	3.40*
	(83.25-85.17)	(85.05-86.25)		(79.02-81.14)	(82.98-83.97)	
45-64	81.9	83.32	1.42*	80.27	82.57	2.30*
	(81.24-82.55)	(82.98-83.67)		(79.50-81.04)	(82.23-82.91)	
65-84	77.15	78.73	1.58*	78.98	81.43	2.45*
	(76.66-77.63)	(78.47-79.00)		(78.46-79.50)	(81.20-81.66)	
85+	72.51	74.42	1.91*	76.26	79.60	3.34*
	(71.42-73.61)	(74.00-74.84)		(74.73-77.78)	(79.08-80.11)	

Source: 1986-2006 National Health Interview Survey Linked Mortality Files

Note: * indicates a significant black-white difference in mean match score at $p < .05$. Age is determined by age at death rather than age at interview. 95% confidence intervals are listed below mean scores.

Table 3. Relative risk ratios for the association between race and mortality using three linkage criteria

	Females			Males		
Age	Relaxed	NCHS cut-points	Tightened	Relaxed	NCHS cut-points	Tightened
25-44	2.01	1.96	1.87	2.04	2.00	1.88
	(1.89-2.14)	(1.84-2.09)	(1.76-2.00)	(1.93-2.15)	(1.90-2.11)	(1.78-1.99)
45-64	1.52	1.51	1.45	1.56	1.56	1.48
	(1.46-1.58)	(1.45-1.57)	(1.40-1.51)	(1.51-1.62)	(1.50-1.62)	(1.43-1.54)
65-84	1.09	1.10	1.00	1.15	1.15	1.06
	(1.06-1.13)	(1.06-1.13)	(0.97-1.03)	(1.11-1.19)	(1.12-1.19)	(1.02-1.09)
85+	0.83	0.84	0.67	0.88	0.87	0.71
	(0.77-0.90)	(0.77-0.90)	(0.61-0.72)	(0.79-0.99)	(0.77-0.98)	(0.63-0.80)
Deaths	82,314	82,246	81,588	80,352	80,306	79,717
Person-years	7,040,357	7,040,865	7,045,883	6,006,190	6,006,538	6,011,027

Source: 1986-2006 National Health Interview Survey Linked Mortality Files

Note: NCHS = National Center for Health Statistics, "Relaxed" indicates class-specific score cut-points are decreased by 5 points, "Tightened" indicates class-specific score cut-points are increased by 5 points. Non-Hispanic whites are the reference group in the age-specific relative risk ratios. 95% confidence intervals are listed below relative risk ratios.

Table 4. Age at crossover using three linkage criteria

Linkage criteria	Females	Males
Relaxed	84	87
NCHS cut-points	84	87
Tightened	82	85

Source: 1986-2006 National Health Interview Survey Linked Mortality Files
Note: NCHS = National Center for Health Statistics, “Relaxed” indicates class-specific score cut-points are decreased by 5 points, “Tightened” indicates class-specific score cut-points are increased by 5 points.

Figure 1. Black-white differences in linkage eligibility (sex-combined data)