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Differential Adult Mortality by Underlying and Associated Causes of Death

Isaac W. Eberstein, Bryan M. Giblin, Charles B. Nam,
Amy Walsh, & Kyle Reese-Cassal

Center for Demography & Population Health

Florida State University

Contact information: I. Eberstein, Center for Demography & Population Health, Florida State University, Tallahassee, FL 32306-2240, 850-644-6416 (voice), 850-644-6208 (fax), ieberstn@fsu.edu.

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This research is grounded in prior studies demonstrating substantial variability in the extent and direction of cause-of-death-specific adult mortality differentials across values of demographic, socioeconomic, behavioral, and health variables (e.g., Rogers, Hummer & Nam, 2000). Much of this work has been based on the more simplified concept of "underlying" cause of death, reflecting the "disease or injury that initiated the train of morbid events leading directly to death, or the circumstances of the accident or violence which produced the fatal injury" (NCHS, 2003a). However, conceptual considerations as well as other studies suggest that failing to consider comorbidity ("associated" causes of death) dramatically understates the true magnitude of adult mortality linked to particular diseases or conditions (Manton & Stallard, 1982; 1984; Israel, Rosenberg & Curtin, 1986; Nam, 1990; Stallard, 2002).

We explore whether information on multiple causes of death suggests different conclusions in regard to the magnitude and/ or direction of important cause-specific mortality *differentials* according to demographic, socioeconomic, and health characteristics (e.g., Wrigley & Nam, 1987). Our findings are relevant to discussion about whether the added complexity of multiple-cause measures is justified by new findings or additional insights regarding differential mortality, beyond those apparent from data on underlying cause of death.

Data are from the National Health Interview Survey-Multiple Cause of death (NHIS-MCD) linked files for 1986-1997 (NCHS 2000). This is a widely used data set having well known strengths and relatively limited weaknesses for purposes such as ours. We use the most current version of the NHIS-MCD data, including NHIS years of 1986-94 linked to death information through December of 1997. Of 704,502 adults in the NHIS, 54,534 were statistically matched to a death certificate.

We follow the lead of Manton & Stallard (1982) in distinguishing between underlying (UC) and associated (AC) causes of death, where associated causes are any conditions listed in Parts 1 or 2 of the death certificate, except the underlying cause (see NCHS, 2003b). This decomposes the total mentions (MC) of a condition into two non-overlapping components. Mortality differentials in, say, heart disease as an underlying cause of death can be compared with differentials in heart disease as an associated cause of death, across mutually exclusive groups. This strategy for measuring comorbidity is much more straightforward than analyses based on either a total mentions or a cause combination approach. We focus on thirteen leading causes of death (Table 1), excluding external causes and a residual category.

Table 1

Table 1 presents descriptive information on the numbers deaths and ICD-9 codes for leading causes nationally, broken down into the categories of UC and AC, and giving information on the total number of times each condition is mentioned on death certificates as either underlying or an associated cause of death (MC). In addition, the table indicates the percent underlying (UC as a percent of MC) and the ratio of the number of total mentions to the number of times a cause is considered to be underlying (ratio of MC to UC). Conditions are ranked by MC.

Information in this table shows that there are numerous reports of associated causes; reliance on UC omits information and substantially underestimates the relative mortality contribution of each of the medical conditions examined here. For instance, heart disease is associated with 18,115 deaths as UC and an additional 10,407 as AC. Failure to consider AC would understate the number of deaths linked to this condition by more than a third. The external causes of suicide and homicide are least likely to be noted as associated causes.

Excluding external causes (accidents, suicide, and homicide) and the "residual" category, there is also wide variability in the percent of deaths where each medical condition is classified as UC versus AC (e.g., HIV and neoplasms are reported as underlying about 90% of the time, while hypertension is reported as underlying slightly more than 7% of the time). This is illustrated graphically by comparing the two frames in Chart 1. Perhaps cancer is most striking because of the absolute number of deaths involved, but some of the less frequently cited causes (e.g, diabetes, hypertension, or nephritis) are relatively more common as AC than as UC. The charts illustrate (based on the data in Table 1) that cancer is cited as UC in 31.4% of deaths but listed as AC in only 4.9%. Diabetes is three times more common as an AC (9.4%) than UC (3.1%), and analogous conclusions are apparent for hypertension (0.6% as UC and 9.9% as AC), nephritis (1.3% as UC and 7.4% as AC), and other medical conditions.

Chart 1

Another indicator of the extent to which medical conditions are cited as UC or AC is the MC/UC ratio – the ratio of the total number of times a condition is listed to the number of times it is cited as underlying cause of death. Manton & Stallard (1982:532) consider this ratio to be a rough inverse indicator of "lethality," where higher ratios indicate the extent to which medical conditions are reported to be associated instead of underlying causes. Perhaps more precisely, this ratio indicates the extent of "complexity" of deaths linked to this medical condition. For instance, hypertension, atherosclerosis, nephritis, and septicemia are least "lethal" (more likely to be reported as AC than UC) while cancer, HIV, and aneurysms are most lethal. (Obviously, though, everyone with a death certificate is dead, so the idea of "lethality" should be taken only to illustrate the complexity of the cause reports for specific conditions.) The most important point for present purposes is that considering only UC gives a more limited picture of the circumstances surrounding death than is apparent by including AC.

Our purpose in this paper is to examine the relative magnitude and/ or direction of cause-of-death-specific adult mortality differentials by UC and AC across a number of demographic, social and health characteristics. Throughout, age (years) is used as a control. Other demographic and social variables include sex, race/ethnicity, education, family income, and health selectivity. Race/ethnicity is limited to the two categories of Blacks and non-Hispanic Whites because available sample sizes for Hispanics and Asians were too small to examine these groups separately. Nativity information was not included in the NHIS during 1986-1988, so we do not examine this factor. Education is measured as years of school completed and is included in the analysis as a continuous variable. We measure family income in categories of $5,000, adjusted for family size as detailed in previous research (Rogers et al. 2000: 123-124); this variable is also specified in continuous format using a metric of $1,000. Three measures of health status are examined. Self-reported health is a frequently used five-category measure ranging from excellent to poor (where higher scores indicate poorer health). Despite being self-reported, it reflects a person's general health condition well and has been found to be a strong predictor of mortality risk in many studies (e.g., Idler and Benyamini 1997). A separate analysis of the present data set demonstrates that self-reported poor health is associated with more medical conditions being listed on the death certificate (Reindl, Hummer, Eberstein, and Nam, 2004). We also include two variables reporting more objective health indicators, a measure of activity limitations (yes/no) at the time of the survey and relative weight-for-height (BMI), operationalized as the bottom and top quintiles in comparison to the middle 60% (considered "underweight" and "overweight," respectively).

Means and standard deviations for these variables are presented in Table 2. As expected, at the time of the baseline survey decedents were more likely than survivors to have been reported to be male, older, Black, unmarried, and either underweight or overweight. In addition, they were more likely to have had lower education, poorer health, lower income, and more activity limitations.

Table 2

In the discussion to follow, we use multinomial logit models to estimate the relationships of interest. This approach takes into account the categorical outcome variable (survive versus die of different causes). The models are specified in terms of multiple outcomes separately for each medical cause of death (e.g., survive versus die of cause1 as underlying, survive versus die of cause1 as associated), with individuals who die of other causes censored. The analysis is run using STATA and incorporates weights and design features of the NHIS to produce accurate parameter estimates and unbiased standard errors and confidence intervals.

Table 3 presents the odds-ratios of death for each independent variable and medical condition, separately for UC and AC. These relationships are essentially "unadjusted" – the one risk factor and mortality, with the important caveat that age is also controlled in every equation. Given its fundamental importance for adult mortality, failure to adjust for age differences would effectively render the coefficients meaningless.

Note that the age effects in Table 2 are truly bivariate. Of particular interest for present purposes is the coefficient labeled "ratio." This is the ratio of the odds ratio for UC to that for AC, and it indicates the difference in the relative magnitude of the two coefficients (and the statistical significance of this difference). For instance, if this number is equal to 1, then the odds of death from this medical condition are the same for both UC and AC. Ratios are computed for all causes of death and all independent variables.

Table 3

To illustrate, consider gender and heart disease. Our question is whether the sex mortality differential varies depending on whether heart disease is UC or AC. The data in Table 2 indicate that it does. Controlling age, males have higher odds of dying from heart disease, whether considered UC or AC, but the odds are significantly greater when heart disease is UC. That is, the odds ratios of heart disease mortality for males (relative to females) are 1.654 ($p<.001$) and 1.555 ($p<.001$) for UC and AC, respectively. The ratio of these coefficients is 1.064 ($p<.001$). This suggests that after age is controlled the magnitude of the sex differential in the odds of death from heart disease varies significantly depending on which model of cause of death is used – underlying or associated.

Taking another example, after age is controlled males have higher odds of dying from stroke, whether UC (OR = 1.115 [$p<.001$]) or AC (OR = 1.303 [$p<.001$]). However, the sex mortality differential from stroke is greater for AC than UC (ratio = 0.859 [$p<.001$]). More generally, controlling age the estimated sex differential in mortality is larger when examining AC data for some medical conditions (cancer, diabetes, respiratory conditions, septicemia, aortic aneurysms, and HIV/AIDS, in addition to stroke).

Conclusions regarding the existence of a sex mortality differential are not necessarily the same from the UC and AC data. While UC suggests only insignificant gender mortality differentials for diabetes, hypertension, and septicemia controlling for age, AC indicates that these differentials are significant. However, the UC and AC data do *not* suggest reversals in the direction of the sex mortality differential for any of these medical conditions. Finally, the sex mortality differential does not vary significantly between UC and AC for the remaining medical conditions (nephritis, influenza, liver diseases, hypertension, and atherosclerosis).

Given an interest in differential mortality by gender, the conclusion may be important that the estimated size of this differential varies significantly net of age depending on whether underlying or associated causes of death are being examined. Note that the findings do not imply that one estimate is an over-statement of the sex differential while another is an under-statement. Rather, both are meaningful within the context of the alternative models of cause of death; neither indicates the "true" mortality differential. Our point is simply that a fuller picture of the pattern of cause-specific mortality differentials is evident when both UC and AC are examined. Depending on

interest, the UC and AC differences may in turn be substantively important for other problems.

Turning to race/ ethnicity, Whites have lower odds than Blacks of dying from heart disease as UC (OR = .654 [p<.001]) and as AC (OR = .599 [p<.001]) controlling age, but the race differential is significantly *larger* for AC (UC:AC ratio = 1.087 [p<.001]). This interpretation may be counterintuitive since the magnitude of the UC coefficient seems to imply the opposite. However, because the odds-ratios are less than one (an inverse relationship), the UC coefficient actually indicates a smaller Black disadvantage from heart disease (an odds ratio closer in absolute value to one – the point of no difference).

More generally, mortality is lower for Whites than Blacks from almost all medical conditions controlling age, regardless of whether the data are UC or AC. However, Whites have higher odds of dying from respiratory conditions (both UC and AC). Similarly, Whites have higher odds of dying from aneurysms and atherosclerosis (AC only); the UC racial differential is not significant for either medical condition.

Focusing on our primary purpose, comparing the racial mortality differential by UC and AC, bigger UC differentials are evident for some medical conditions (respiratory diseases, nephritis, diabetes, and hypertension), and two causes are larger for AC (aneurysms and heart disease). Controlling for age, cause of death model is not important for the size of the estimated race/ethnic differential for cancer, stroke, influenza, liver diseases, septicemia, and HIV/AIDS.

Older age is associated with higher mortality, except for HIV/AIDS as an associated cause. In this case, there is an inverse association of HIV/AIDS and age. The age pattern of HIV/AIDS as UC is positive. This is the sole occasion where the data suggest significant and mortality differentials in opposite directions between UC and AC for any of these independent variables or medical conditions. Importantly, when all independent variables are controlled (Table 4, below), the age pattern of HIV/AIDS mortality is the same for UC and AC (and inverse).

More generally, age effects are stronger for some medical conditions as UC (heart disease, nephritis, influenza, hypertension, atherosclerosis) and for some (cancer, diabetes, stroke, liver diseases, and aneurysms) as AC. Only in the case of respiratory disease does the age pattern of mortality not vary by UC or AC.

Education is associated with lower mortality, so it is again imperative to exercise care in interpreting the relative magnitude of the odds ratios by underlying and associated causes. The general conclusion from Table 3 is that controlling age, educational mortality differentials are larger for liver disease and septicemia as UC but for respiratory conditions, hypertension, and aneurysms as AC. Educational mortality differentials are the same for UC and AC net of age for heart disease, cancer, nephritis, stroke, influenza, and HIV/AIDS.

Being married, too, is linked to generally lower mortality. The main exception to this is aneurysms, where married persons have higher odds of death net of age. In general, controlling age, marital status differentials in the odds of mortality are higher for UC (diabetes, nephritis, stroke, respiratory conditions, liver disease, and hypertension). However, marital status differentials are higher for HIV/AIDS as AC, net of age.

Family income is like education and exhibits an inverse relationship with mortality net of age for all causes of death. The UC and AC data give essentially the same estimates of the relative income differentials for some medical conditions (heart disease, cancer, nephritis, respiratory disease, influenza, septicemia, atherosclerosis, and HIV/AIDS). But, the UC data indicate larger income differentials for other conditions (stroke, diabetes, liver disease, hypertension, and aneurysms). In no case are net income differentials bigger for AC.

Turning to the health variables, self reported health is coded so that a higher score reflects poorer subjective health status and, thus, a positive relationship with mortality net of age. The data in Table 3 indicate two medical conditions where net mortality differentials by SRH are stronger for UC than AC; these are diabetes and respiratory conditions. Otherwise, differentials controlling for age are stronger for AC (cancer, heart disease, stroke, influenza, aneurysms, and atherosclerosis).

Reported activity limitations are very strongly associated with mortality net of age. Estimated UC differentials are larger for diabetes and nephritis, but AC differentials are larger for heart disease, cancer, stroke, influenza, aneurysms, and HIV/AIDS.

The mortality effects of extreme values of BMI are complex. Controlling age, underweight tends to be associated with higher mortality relative to mid-range BMI, although diabetes-related mortality is higher for the latter group. Overweight tends to be associated with lower mortality net of age, although the odds of death from HIV/AIDS as an underlying cause are higher for this group. AC mortality differentials for underweight are larger for some conditions net of age (cancer, heart, and aneurysms), smaller for others (stroke, respiratory conditions), and essentially the same for the remaining conditions (nephritis, diabetes, influenza, liver diseases, hypertension, septicemia, atherosclerosis, and HIV/AIDS). AC mortality differentials net of age for overweight tend to be stronger than UC (nephritis, stroke, respiratory conditions, liver diseases, hypertension, atherosclerosis), although larger UC differentials are evident for diabetes and influenza.

Looking within each medical condition, there is a lot of variability in demographic, social and health mortality differentials by UC and AC. Cancer, heart disease, stroke, respiratory conditions, aneurysms, atherosclerosis, and HIV/AIDS all tend to have stronger AC than UC differentials, although not without exception. In contrast, nephritis, diabetes, and hypertension tend to have larger UC differentials, but again not without exception. No clear patterns are evident among the remaining medical conditions (respiratory conditions, influenza, liver disease, and septicemia). Interestingly, AC differentials seem to be larger for those medical conditions most likely to be

identified as underlying causes of death (e.g., cancer), and UC differentials seem to be larger for medical conditions most likely to be identified as associated causes (e.g., hypertension). We return to this point below.

Overall, the data in Table 3 provide substantial detail to demonstrate that the relative magnitude of estimated cause-specific mortality differentials varies significantly by underlying or associated cause of death. These are essentially bivariate equations, controlling only age. Multivariate models are shown in Table 4. These data provide insight into whether the patterns in Table 3 are due to compositional differences in the independent variables. Succinctly, although there are some differences in the size and/ or statistical significance of specific coefficients, the general conclusion from Table 3 continues to be very much in evidence. Specifically, the data suggest that the magnitude of observed differentials in adult mortality varies depending on UC or AC. Also, as noted above, there continues to be a tendency for AC differentials to be greater for medical conditions most likely to be identified as underlying causes of death (e.g., cancer) and vice versa (e.g., hypertension).

Table 4

Further, although not of first priority in the present analysis, it is also apparent from the table that that some mortality differentials change direction with controls. This is particularly true for race, and less so for education. Controlling for all the independent variables in Table 4, deaths from several causes (cancer, heart disease, stroke, respiratory conditions, influenza, liver disease, aneurysms, and atherosclerosis) are higher among whites, while higher mortality among Blacks remains evident from other causes (diabetes, nephritis, hypertension, septicemia, and HIV/AIDS). Similarly, educational differentials in mortality tend to become smaller with the controls in Table 4 and to lose statistical significance, while some go a bit further to flip direction to a positive relationship for some medical conditions (e.g., diabetes, hypertension, aneurysms, and HIV/AIDS as UC, and nephritis, liver disease, septicemia, and atherosclerosis as AC). The other relationships in Table 3 continue to be evident even after the controls in Table 4.

To illustrate, the data in Table 4 suggest that males continue to evidence higher odds of death from each cause than do females, whether UC or AC. Some medical conditions have a larger sex mortality differential for AC (diabetes, stroke, respiratory conditions, septicemia, aortic aneurysms, and HIV/AIDS), others have a smaller differential for AC (heart disease, nephritis), and there is no UC:AC difference for the remaining causes of death (cancer, influenza, liver disease, hypertension, and atherosclerosis). Similar detailed interpretation is possible for other independent variables and medical conditions, but the general conclusion from the analysis in terms of our primary objectives should be clear. Specifically, the data clearly indicate that UC and AC information often give different estimates of the size of demographic, social, and health differentials in adult mortality, across a range of specific medical conditions. In no case do significant differentials vary in direction according to AC or UC, controlling for the other independent variables. In some cases one differential is significant while the

other is not. Most generally, information on multiple causes does add to our understanding of differential adult mortality, although mainly in terms of the estimated magnitude of relationships, rather than their existence or direction.

Discussion

Two general conclusions are suggested by the analysis. First, it is clear that the multiple-cause data give additional information concerning the prevalence and complexity of medical conditions reported at death than do reports grounded solely on a single underlying cause. UC data substantially understate the reported prevalence of many conditions, some by a dramatic amount (e.g., hypertension), and UC data fail to reflect the range of medical conditions often present at the time of death.

Second, there is a substantial degree of variability in the odds of adult mortality for several demographic, socioeconomic and health characteristics across a range of specific medical conditions. In some cases, UC data indicate a larger differential (stronger odds of death), and in some cases AC data indicate a larger differential. Some variables seem to have stronger impacts on mortality with UC data (e.g., income), while other differentials are stronger in AC data (e.g., self reported health or sex). Finally, the strength of other relationships seems to vary more by medical condition than UC or AC (e.g., race or age).

More generally, demographic, social and health-related mortality differentials for medical conditions that are more commonly identified as underlying causes of death (e.g., cancer) seem to be stronger when AC data are examined. Conversely, medical conditions that are usually considered associated causes (e.g., hypertension) have stronger differentials in UC data. This pattern may illustrate an inverse relationship between how common a reported condition may be and the specificity of its occurrence. Less conventional reports of mortality linked to specific medical conditions (e.g., hypertension as UC or cancer as AC) are perhaps more closely associated with the demographic, social, and health characteristics of decedents than are more common patterns.

Clearly, no information is available to assess the correspondence between the pattern of medical conditions reported to be present at the time of death and actual morbidity. Thus, it is not possible to assess whether AC or UC reports misrepresent events at the time of death. Rather, the data do suggest the general conclusion that relying solely on information on underlying cause of death may give only a narrow or limited assessment of the pattern of demographic, social, and health differentials in adult mortality. Depending on interest, the limitations of considering only UC data may be substantively important. Additional research is necessary to examine this possibility in further detail.

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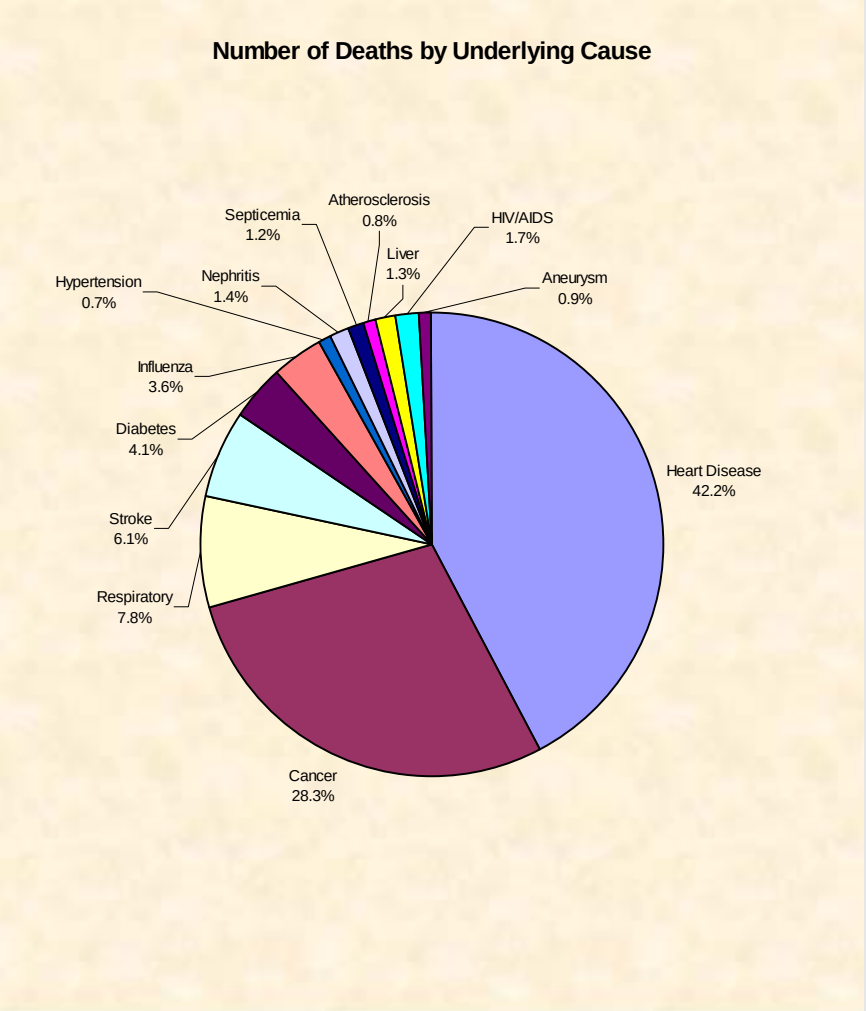
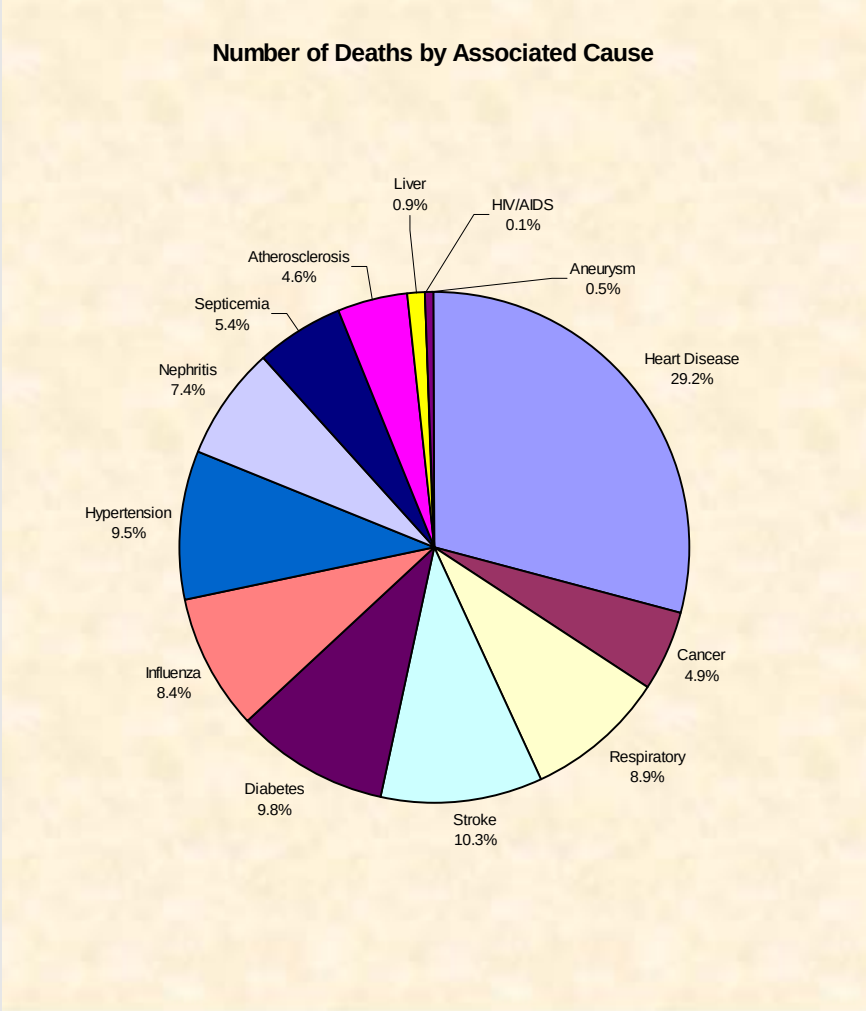
Chart 1 – Percentage of Deaths by Underlying and Associated Causes





*Source: National Health Interview Survey-Multiple Cause of Death (NHIS-MCD) linked files for 1986-1997 (NCHS 2000)

Table 1. Number of deaths by cause for underlying, associated, and total mentions, along with percent underlying, the ratio of total mentions to underlying, and ICD – 9 codes for each medical condition.

Cause of Death	*Underlying*	*Associated*	*Total Mentions*	*% Underlying*	*MC/UC*	*ICD - 9*
Diseases of Heart	**18115**	**10407**	**28522**	**63.5**	**1.57**	**390-398, 402, 404, 410-429**
Malignant Neoplasms	**14244**	**1702**	**15946**	**89.3**	**1.12**	**140-165, 170-175, 179-208**
Cerebrovascular Diseases	**3607**	**2766**	**6373**	**56.6**	**1.77**	**430-438**
Chronic Obstructive Pulmonary Diseases	**2490**	**3208**	**5698**	**43.7**	**2.29**	**490-496**
Diabetes Mellitus	**1411**	**3263**	**4674**	**30.2**	**3.31**	**250**
Pneumonia and Influenza	**1732**	**2887**	**4619**	**37.5**	**2.67**	**480-487**
Hypertension, with or without Renal disease	**275**	**3454**	**3729**	**7.4**	**13.6**	**401, 403**
Nephritis, Nephrotic Sydrome & Nephrosis	**593**	**2573**	**3166**	**18.7**	**5.34**	**580-589**
Septicemia	**492**	**2071**	**2563**	**19.2**	**5.21**	**38**
Atherosclerosis	**336**	**1583**	**1919**	**17.5**	**5.71**	**440**
Chronic Liver Disease & Cirrhosis	**612**	**358**	**970**	**63.1**	**1.58**	**571**
HIV/AIDS	**660**	**72**	**732**	**90.2**	**1.11**	**42, 44**
Aortic Aneurysm	**419**	**175**	**594**	**70.5**	**1.42**	**441**
Accidents	**1844**	**1505**	**3349**	**55.1**	**1.82**	**800-807, 810-838, 840-848, 850-858, 860-876, 878-888, 890-949**
Suicide	**655**	**6**	**661**	**99.1**	**1.01**	**950-959**
Homicide	**494**	**16**	**510**	**96.9**	**1.03**	**960-978**
Residual	**8217**	**14929**	**23146**	**35.1**	**2.82**	**All other codes**

Table 2. Descriptive Statistics for Independent Variables by Survival Status. (Means with standard deviations in parentheses).

	Survived	Died
Male	**.519**	**.568**
	(.050)	**(.050)**
Age	**45.167**	**59.14**
	(1.802)	**(1.101)**
Education	**12.40**	**10.56**
	(.314)	**(.377)**
Self Reported Health	**2.43**	**3.54**
	(.121)	**(.124)**
White	**.795**	**.760**
	(.043)	**(.040)**
Married	**.632**	**.530**
	(.050)	**(.052)**
Income	**20.120**	**14.550**
	(1.180)	**(1.010)**
Underweight	**.170**	**.204**
	(.038)	**(.040)**
Overweight	**.219**	**.230**
	(.044)	**(.044)**
Activity Limitations	**.279**	**.670**
	(.045)	**(.047)**

Table 3. Mortality Odds Ratios for Medical Conditions by Underlying or Associated Cause of Death. (Only Age controlled)

		White	Activity Limitations	Income	Sex	Self Reported Health	Under-weight	Over-weight	Education	Married	Age
Nephritis	***Underlying***	**.388*** **	**7.731*** **	**.950*** **	**1.733*** **	**2.411*** **	**1.126**	**0.801** **	**0.916*** **	**0.683*** **	**1.108*** **
	Associated	**.524*** **	**6.284*** **	**.957*** **	**1.589*** **	**2.380*** **	**1.301*** **	**0.534*** **	**0.919*** **	**0.805*** **	**1.092*** **
	Ratio	**.741*** **	**1.230*** **	**.993**	**1.090**	**1.013**	**0.866**	**1.498*** **	**0.997**	**0.848** **	**1.014*** **
Cancer	***Underlying***	**.840*** **	**4.373*** **	**.974*** **	**1.5894*** **	**1.768*** **	**1.450*** **	**0.831*** **	**0.939*** **	**1**	**1.080*** **
	Associated	**.894*** **	**5.830*** **	**.974*** **	**2.266*** **	**2.099*** **	**1.630*** **	**0.762*** **	**0.934*** **	**1.065***	**1.208*** **
	Ratio	**.939**	**.750*** **	**1.002**	**.705*** **	**.8421*** **	**0.889** **	**1.09**	**1.001**	**0.942**	**0.974*** **
Diabetes	***Underlying***	**.395*** **	**10.019*** **	**.938*** **	**0.953**	**3.012*** **	**0.762*** **	**0.332*** **	**0.908*** **	**0.634*** **	**1.079*** **
	Associated	**.538*** **	**7.718*** **	**.955*** **	**1.279*** **	**2.677*** **	**0.820*** **	**0.391*** **	**0.909*** **	**0.830*** **	**1.080*** **
	Ratio	**.733*** **	**1.298*** **	**.982*** **	**.745*** **	**1.125*** **	**0.929**	**0.848*** **	**0.999**	**0.764*** **	**0.990*** **
Heart Disease	***Underlying***	**.654*** **	**5.821*** **	**.961*** **	**1.654*** **	**2.042*** **	**1.446*** **	**0.595*** **	**0.918*** **	**0.755*** **	**1.104*** **
	Associated	**.599*** **	**6.687*** **	**.961*** **	**1.555*** **	**2.190*** **	**1.718*** **	**0.618*** **	**0.920*** **	**0.762*** **	**1.096*** **
	Ratio	**1.087*** **	**.871*** **	**1.000**	**1.064*** **	**.933*** **	**0.842*** **	**0.963**	**0.997**	**0.991**	**1.007*** **
Stroke	***Underlying***	**.685*** **	**4.653*** **	**.961*** **	**1.115*** **	**1.856*** **	**1.709*** **	**0.809*** **	**0.944*** **	**0.765*** **	**1.111*** **
	Associated	**.653*** **	**6.857*** **	**.965*** **	**1.303*** **	**2.181*** **	**1.543*** **	**0.738*** **	**0.943*** **	**0.838*** **	**1.111*** **
	Ratio	**1.050**	**.679*** **	**.995***	**.8558*** **	**.851** **	**1.1076** **	**1.096***	**1.001**	**0.914** **	**0.997*** **
Respiratory	***Underlying***	**1.490*** **	**7.587*** **	**.958*** **	**1.741*** **	**2.779*** **	**4.284*** **	**1.021**	**0.921*** **	**0.850*** **	**1.098*** **
	Associated	**1.307*** **	**7.095*** **	**.955*** **	**2.317*** **	**2.598*** **	**3.031*** **	**0.807*** **	**0.911*** **	**0.911*** **	**1.100*** **
	Ratio	**1.140***	**1.069**	**1.003**	**.7514*** **	**1.070*** **	**1.414*** **	**1.266*** **	**1.011** **	**0.933***	**0.999**
Influenza	***Underlying***	**.970*** **	**5.149*** **	**.962*** **	**1.859*** **	**2.006*** **	**2.442*** **	**0.776*** **	**0.927*** **	**0.886*** **	**1.123*** **
	Associated	**.898*** **	**5.842*** **	**.964*** **	**1.849*** **	**2.104*** **	**2.447*** **	**0.969**	**0.933*** **	**0.860*** **	**1.106*** **
	Ratio	**1.080**	**.881*** **	**.994**	**1.006**	**.953***	**0.998**	**0.801*** **	**0.993**	**1.03**	**1.016*** **

Table 3. (cont) Mortality Odds Ratios for Medical Conditions by Underlying or Associated Cause of Death. (Only Age controlled)

		White	Activity Limitations	Income	Sex	Self Reported Health	Under-weight	Over-weight	Education	Married	Age
Liver Disease	***Underlying***	**.923**	**8.527*** **	**.950*** **	**1.876*** **	**2.489*** **	**1.411*** **	**0.629*** **	**0.910*** **	**0.562*** **	**1.053*** **
	Associated	**.873**	**7.612*** **	**.960*** **	**2.020*** **	**2.504*** **	**1.17**	**0.580*** **	**0.949*** **	**0.667*** **	**1.059*** **
	Ratio	**1.057**	**1.120**	**.989***	**0.929**	**0.994**	**1.206**	**1.411*** **	**0.959*** **	**0.843***	**0.994** **
Hypertension	***Underlying***	**.330*** **	**5.912*** **	**.945*** **	**1.013**	**2.088*** **	**1.310***	**0.520*** **	**0.971** **	**0.546*** **	**1.108*** **
	Associated	**.464*** **	**5.852*** **	**.956*** **	**1.160*** **	**2.163*** **	**1.200*** **	**0.478*** **	**0.929*** **	**0.741*** **	**1.098*** **
	Ratio	**.716*** **	**1.010**	**.988***	**0.874**	**0.965**	**1.092**	**1.310***	**1.045*** **	**0.735*** **	**1.009*** **
Septicemia	***Underlying***	**.432*** **	**6.541*** **	**.950*** **	**1.042**	**2.290*** **	**1.690*** **	**0.545*** **	**0.909*** **	**0.712*** **	**1.088*** **
	Associated	**.490*** **	**6.478*** **	**.948*** **	**1.320*** **	**2.286*** **	**1.467*** **	**0.592*** **	**0.925*** **	**0.682*** **	**1.087*** **
	Ratio	**.882**	**1.010**	**1.002**	**.7897** **	**1.002**	**1.152**	**0.92**	**0.983***	**1.043**	**1.001**
Aneurysm	***Underlying***	**.847**	**3.628*** **	**.970*** **	**1.900*** **	**1.791*** **	**1.435*** **	**1.128**	**0.984**	**1.144***	**1.097*** **
	Associated	**1.421***	**5.292*** **	**.984*** **	**2.718*** **	**2.050*** **	**2.083*** **	**1.368**	**0.949*** **	**1.363*** **	**1.115*** **
	Ratio	**.596** **	**.686*** **	**.986***	**.6988** **	**.874***	**0.689*** **	**0.825**	**1.037** **	**0.839**	**0.983*** **
Atherosclerosis	***Underlying***	**.952**	**4.553*** **	**.961*** **	**1.673*** **	**1.676*** **	**1.801*** **	**1.206**	**0.959*** **	**1.029**	**1.140*** **
	Associated	**1.114***	**4.847*** **	**.968*** **	**1.524*** **	**2.007*** **	**1.676*** **	**0.716*** **	**0.947*** **	**0.910*** **	**1.121*** **
	Ratio	**.855**	**0.939**	**0.992**	**1.098**	**.835*** **	**1.075**	**1.685*** **	**1.013**	**1.13**	**1.017*** **
HIV/AIDS	***Underlying***	**.360*** **	**6.749*** **	**.964*** **	**1.999*** **	**2.096*** **	**1.950*** **	**1.388*** **	**0.935*** **	**0.259*** **	**1.036*** **
	Associated	**.249*** **	**20.103*** **	**.961*** **	**3.743*** **	**2.446*** **	**1.363**	**0.597***	**0.899*** **	**0.136*** **	**0.988** **
	Ratio	**1.449**	**.336*** **	**1.003**	**.5340** **	**0.857**	**1.431**	**2.323*** **	**1.04**	**1.915*** **	**1.049*** **

Table 4. Mortality Odds Ratios for Medical Conditions by Underlying or Associated Cause of Death. (Controlling all independent variables.)

		Age	White	Activity Limitations	Income	Sex	Self Reported Health	Under-weight	Over-weight	Education	Married
Nephritis	***Underlying***	**1.097*** **	**.668*** **	**3.332*** **	**.980*** **	**2.088*** **	**1.867*** **	**0.89**	**1.356*** **	**1.005**	**0.623**
	Associated	**1.080*** **	**0.926**	**2.287*** **	**.984*** **	**1.776*** **	**2.007*** **	**1.114***	**.731*** **	**1.010***	**.746*** **
	Ratio	**1.016*** **	**.721*** **	**1.457*** **	**0.996**	**1.176***	**.931***	**0.798**	**1.851*** **	**0.994**	**.836***
Cancer	***Underlying***	**1.071*** **	**1.161*** **	**2.150*** **	**.989*** **	**1.638*** **	**1.554*** **	**1.481*** **	**1.041**	**0.998**	**.950*** **
	Associated	**1.102*** **	**1.420*** **	**2.413*** **	**.993*** **	**2.436*** **	**1.828*** **	**1.322*** **	**0.954**	**0.993**	**.852*** **
	Ratio	**.972*** **	**.818*** **	**.891***	**0.959**	**0.821**	**.850*** **	**0.893**	**1.092**	**1.005**	**1.114** **
Diabetes	***Underlying***	**1.067*** **	**.786*** **	**3.114*** **	**.978*** **	**1.108***	**2.248*** **	**.605*** **	**.554*** **	**1.022*** **	**.780*** **
	Associated	**1.080*** **	**.980*** **	**2.631*** **	**.987*** **	**1.363*** **	**2.175*** **	**.620*** **	**.592*** **	**0.998**	**.863*** **
	Ratio	**.988*** **	**.802*** **	**1.184*** **	**.991*** **	**.813*** **	**1.034**	**0.974**	**0.935**	**1.024*** **	**.905***
Heart Disease	***Underlying***	**1.094*** **	**1.120*** **	**2.356*** **	**.984*** **	**1.970*** **	**1.748*** **	**1.313*** **	**.779*** **	**.991*** **	**.688*** **
	Associated	**1.084*** **	**1.005**	**2.601*** **	**.986*** **	**1.791*** **	**1.834*** **	**1.492*** **	**.834*** **	**1**	**.713*** **
	Ratio	**1.008*** **	**1.115*** **	**.906*** **	**0.999**	**1.099*** **	**.954*** **	**.880*** **	**.934***	**.991*** **	**0.965**
Stroke	***Underlying***	**1.0986*** **	**1.130*** **	**2.357*** **	**.979*** **	**1.189*** **	**1.621*** **	**1.465*** **	**1.061**	**1.006**	**.819*** **
	Associated	**1.104*** **	**1.163*** **	**3.053*** **	**.987*** **	**1.325*** **	**1.821*** **	**1.247*** **	**1.058**	**1.006**	**.803*** **
	Ratio	**.996** **	**0.972**	**.772*** **	**.992*** **	**.897** **	**.890*** **	**1.175** **	**1.003**	**1**	**1.02**
Respiratory	***Underlying***	**1.081*** **	**2.601*** **	**2.408*** **	**.984*** **	**2.018*** **	**2.286*** **	**3.476*** **	**1.370*** **	**0.992**	**.650*** **
	Associated	**1.085*** **	**2.398*** **	**2.304*** **	**.978*** **	**2.554*** **	**2.146*** **	**2.631*** **	**1.032**	**0.988**	**.679*** **
	Ratio	**.996***	**1.085**	**1.045**	**1.006***	**.747*** **	**1.065** **	**1.321*** **	**1.327*** **	**1.005**	**0.969**
Influenza	***Underlying***	**1.107*** **	**1.583*** **	**2.368*** **	**.978*** **	**2.306*** **	**1.689*** **	**2.234*** **	**1.014**	**0.994**	**.704*** **
	Associated	**2.140*** **	**1.433*** **	**2.579*** **	**.982*** **	**2.140*** **	**1.757*** **	**2.172*** **	**1.318*** **	**1.002**	**.703*** **
	Ratio	**2.306*** **	**1.104**	**0.918**	**0.9958**	**1.078**	**0.961**	**1.028**	**.770** **	**0.992**	**1.002**

Table 4. (cont) Mortality Odds Ratios for Medical Conditions by Underlying or Associated Cause of Death. (Controlling all independent variables.)

		Age	White	Activity Limitations	Income	Sex	Self Reported Health	Under-weight	Over-weight	Education	Married
Liver	***Underlying***	**1.037*** **	**1.728*** **	**2.892*** **	**.981*** **	**2.178*** **	**2.011*** **	**1.175**	**0.876**	**1.008**	**.547*** **
	Associated	**1.047*** **	**1.366** **	**2.729*** **	**.982*** **	**2.096*** **	**2.004*** **	**.680*** **	**0.855**	**1.042** **	**.629*** **
	Ratio	**.991** **	**1.266**	**1.06**	**0.999**	**1.039**	**1.004**	**1.727** **	**1.024**	**.967*** **	**0.87**
Hypertension	***Underlying***	**1.101*** **	**.531*** **	**2.577*** **	**.968*** **	**1.457*** **	**1.646*** **	**1.006**	**.697** **	**1.068*** **	**.608*** **
	Associated	**1.088*** **	**.772*** **	**2.399*** **	**.983*** **	**1.288*** **	**1.798*** **	**0.978**	**.711*** **	**1.003**	**.826*** **
	Ratio	**1.012** **	**.688*** **	**1.074**	**.984** **	**1.132**	**.915*** **	**1.029**	**0.981**	**1.065*** **	**.737** **
Septicemia	***Underlying***	**1.076*** **	**0.763*** **	**2.561*** **	**0.979*** **	**1.197** **	**1.836*** **	**1.531*** **	**0.802** **	**1.009**	**0.845** **
	Associated	**1.074*** **	**0.849*** **	**2.527*** **	**0.976*** **	**1.527*** **	**1.849*** **	**1.150** **	**0.891** **	**1.012** **	**0.715*** **
	Ratio	**1.002**	**0.899**	**1.013**	**1.003**	**0.784*** **	**0.993**	**1.332** **	**0.901**	**0.997**	**1.181** **
Aneurysm	***Underlying***	**1.089*** **	**1.128**	**2.079*** **	**0.978*** **	**1.927*** **	**1.601*** **	**1.449*** **	**1.349** **	**1.042*** **	**0.952**
	Associated	**1.114*** **	**1.885*** **	**2.798*** **	**0.999**	**2.833*** **	**1.735*** **	**2.031*** **	**1.308**	**0.982**	**1.047**
	Ratio	**0.978*** **	**0.598** **	**0.743**	**0.980*** **	**0.680*** **	**0.923**	**0.714**	**1.032**	**1.061*** **	**0.91**
Atherosclerosis	***Underlying***	**1.129*** **	**1.319** **	**2.723*** **	**0.968*** **	**1.869*** **	**1.425*** **	**1.702*** **	**1.615*** **	**1.011**	**0.948**
	Associated	**1.108*** **	**1.743*** **	**2.261*** **	**0.984*** **	**1.733*** **	**1.810*** **	**1.472*** **	**0.989**	**1.010**	**0.787*** **
	Ratio	**1.018*** **	**0.757** **	**1.205**	**0.984*** **	**1.079**	**0.787*** **	**1.157**	**1.633*** **	**1.001**	**1.205**
HIV/AIDS	***Underlying***	**1.027*** **	**0.572*** **	**2.452*** **	**0.998**	**2.780*** **	**1.707*** **	**1.711*** **	**1.869*** **	**1.035*** **	**0.272*** **
	Associated	**0.989**	**0.392*** **	**6.999*** **	**1.012**	**5.068*** **	**1.556*** **	**1.528**	**0.823**	**1.047**	**0.150*** **
	Ratio	**1.038*** **	**1.459**	**0.350*** **	**0.986**	**0.549** **	**1.097**	**1.122**	**2.270*** **	**0.988**	**1.815*** **