A Comparison of Period and Cohort Life Tables

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I Introduction

Forensic economists have two types of life tables available to them: cohort life tables and period life tables. A cohort life table is based on the experience of a specific cohort of individuals, for example, all persons born in the year 1910. Based on age-specific death rates observed through consecutive calendar years, a pure cohort life table reflects the mortality experience of the actual cohort from birth until no living members of the group remain. Rather than being based on the experience of a cohort of individuals born in the same year, a period life table presents what would happen to a synthetic cohort through time if it experienced the age-specific death rates for a particular period throughout the life of the cohort. The life tables published by the National Center for Health Statistics (NCHS) are period life tables. (Arias, 2010). These are the life tables that are generally utilized in the development of work life expectancy.

A pure cohort table is not relevant to the issues faced by forensic economists, since the mortality experience of individuals born over ninety years ago would not account for the many factors – for example, changes in smoking habits or medical care – affecting today's 20-, 30- or even 60-year olds. However, each year the Social Security Administration (SSA), in conjunction with the presentation of its *Annual Report of the Board of Trustees* to Congress, prepares both period and cohort life tables that are specific to individual calendar and birth years. For past calendar years, the SSA period tables are based

on the mortality experience for that year; projected mortality rates are used in the period tables for future calendar years. The SSA cohort tables are based on a combination of actual and projected mortality rates for each birth cohort, beginning with birth year 1900 and ending with birth year 2075. The SSA's period and cohort life tables both extend through age 119. (Bell and Miller, 2005).

Given the availability of three sets of life tables (the NCHS period tables and the SSA period and cohort tables), it is natural to examine the differences among them and to ask whether these differences are material with respect to the estimation of economic damages. This paper examines these differences and seeks to answer this question by comparing loss estimates for 20-, 30-, 40-, 50- and 60-year old males and females. In each case, the results derived from the NCHS period tables published in Arias (2010) are taken as a baseline, with the differences resulting from use of the SSA period and cohort tables being reported.[1]

II Differences in Life Expectancy and Survival Probabilities

Figure 1 presents the changes from the NCHS remaining life expectancy for 20-, 30-, 40-, 50- and 60-year old males and females in 2010. Two patterns are apparent for both males and females: (1) the change in remaining life expectancy is greater for the SSA cohort life expectancies and (2) the change in remaining life expectancy decreases as the starting age increases. Additionally, the differences are greater for males for all starting ages.

These patterns are the result of the differences in the survival probabilities shown in Figure 2 for males and females. Again, the change is greater for the SSA cohort survival probabilities and the change in survival probabilities decreases as the starting age increases. As with the differences in remaining life expectancy, the differences in survival probabilities are greater for males for all starting ages. Finally, for both males and females, the change in survival probability is relatively minor until after age 55, and reaches a peak some time after age 80.

III Differences in Economic Loss Estimates

The impact of these differences on economic loss estimates will be determined not only by the age at which the loss begins, but also by the type of economic loss. For example, the change in an earnings loss for a given individual may be relatively smaller than the change in the same person's lost pension: because most of the SSA cohort tables' increases in survival probability come near or after the end of the individual's expected work life, future expected earnings will not be affected as much as future pension payments that last for as long as the individual is alive. Similarly, damage estimates related to the loss of household services would likely be more affected by use of the cohort tables than would earnings losses, since provision of household services can continue after an individual finally leaves the labor force.

To quantify the impact of the differences depicted in Figure 2, a loss of $10,000 per year was modeled for males and females at age 20, 30, 40, 50 and 60 years. For earnings and household services the loss was assumed to commence on each individual's birthday and was discounted to present value using net discount rates ranging from 0.50 to 3.00 percent in steps of 50 basis points. To model the impact on a pension loss, the pension was assumed to have started at age 65. In each instance, the results utilizing the NCHS period tables represent the base case. The loss period is assumed to have started in 2010. Accordingly, the comparisons below are based on the SSA period tables for calendar year 2010 and on the SSA cohort tables for birth years 1990, 1980, 1970, 1960 and 1950.

A. Lost Income

In order to mimic lost earnings, the $10,000 annual loss was reduced for the probability the individual might die, might not participate in the labor force if he or she were alive, and for the probability that he or she might not be employed even if active in the labor force. In other words, the $10,000 annual earnings loss was modeled using the LPE (Life/Participation/Employment) methodology. The probability of life, or the mortality risk, was based on the NCHS period life table and the SSA's period and cohort life tables discussed above. The probabilities of labor force participation and employment were based on data compiled by the Bureau of Labor Statistics (BLS) showing population,

labor force and employment totals by gender for all levels of educational attainment for the years 1994 through 2009.[2] Specifically, the labor force participation rates and employment probabilities were determined by the linear splines shown in Figures 3 and 4. In these figures, the X's correspond to the BLS data and the solid lines correspond to the linear spline between the midpoints of each interval or step. For both the labor force and employment data, the midpoint of the last step was taken to be 70 years. The present value calculations were carried out until the probability of labor force participation fell below zero. For males, the calculations continued through age 73; for females, the calculations continued through age 72.

The results of these calculations, expressed as the percent change from the base case, appear in Figure 5. For both males and females, it is clear that the biggest difference results from use of the SSA cohort life table. These differences range from 1.0 to 1.5 percent for a 20-year old male, and decline as age increases. For a 20-year old female, the cohort differences are smaller and range from 0.4 to 0.7 percent. The SSA cohort differences also decline as the starting age increases. By comparison, use of the SSA period life table produces a difference that is no greater than 0.4 percent for males, and 0.2 percent for females. For both males and females, the SSA period differences decline as the starting age increases.

B. Lost Pension

The results of the pension loss calculations appear in Figure 6. In all cases, the pension loss was assumed to start at age 65. Presumably, the lost pension would be based on past earned income that already reflects the probability the plaintiff or decedent might have died but for the event that gave rise to the tort. Accordingly, the $10,000 pension loss is reduced by multiplying by the probability of surviving from age 65 – to multiply by the survival probability from the starting age would reduce the pension loss twice for the mortality risk prior to age 65.[3]

As with the earnings loss, it is clear that the greatest difference results from use of the SSA cohort life tables. For a 20-year old male, the differences range from 6.3 to 21.4 percent; for a 20-year old female, the range is 3.6 to 16.2 percent. Use of the SSA period life table produces a difference that is no

greater than 1.4 percent for males. For females, the SSA period differences are slightly negative, but the decrease is never greater than -0.04 percent. For all starting ages, the differences for males are greater than those for females. For both males and females, the differences decline as the starting age increases.

Note that the differences presented in Figure 6 likely do not capture the total effect of using the SSA period or cohort tables in lieu of the NCHS period table. The pension earned by an individual is normally a function of past earnings. To the extent that use of the SSA period or cohort life table increases the plaintiff's or decedent's projected earnings, the resulting pension may increase as well. Accordingly, the percent differences presented in Figure 6 are understated, though by how much depends on the specific pension plan in question.

Additionally, the net discount rate used to calculate the present value of lost earnings implicitly assumes some level of real growth in earnings. The lost future pension payments may only be indexed for inflation or may even be fixed in nominal terms. In the former case, the appropriate rate used to discount the pension loss should be increased by 25 to 50 basis points over the net discount rate used to evaluate the earnings loss. In the latter case, the discount rate for the lost pension should be further increased by some measure of expected inflation. These increases in the discount rate would serve to decrease the difference shown in Figure 6. For males, an increase of 250 basis points to each discount rate in Figure 6 reduces the maximum difference for the SSA cohort table to 16.7 percent and lowers the minimum difference to 5.0 percent. For females, the comparable values are 12.2 and 2.7 percent.

C. Lost Household Services

Like earnings, the provision of household services is subject to risks associated with death, sickness and disability. Forensic economists generally either project household services out to some date certain, with or without an adjustment for mortality risk, or attempt to account for both mortality risk and for the risk of loss of function by using some measure like healthy life expectancy. Healthy life expectancy is a concept analogous to work life expectancy. The measure explicitly accounts for mortality

risk through use of a life table and also accounts for loss of function via an age-specific measure of average morbidity. See, for example, Expectancy Data (2010).

Both of these approaches were utilized to assess the impact of the use of the three life tables on the estimation of household services loss. Specifically, for the hypothetical 20-, 30-, 40-, 50- and 60-year old males and females, an annual $10,000 loss was reduced by the probability of surviving to each successive age up to and including age 75. The risk-adjusted losses were discounted to present values using the same net discount rates discussed above, with the results using the NCHS period table being again taken as a base. The resulting percent differences are shown in Figure 7 for males and females. The risk of loss of function was accounted for by further reducing the annual $10,000 loss by the morbidity measure utilized in *Healthy Life Expectancy, 2006 Tables*.[4] The resulting percent differences are shown in Figure 8 for males and females.

The results are similar for both approaches: the percent changes are greater for the SSA cohort table than they are for the SSA period table and are greater for males than they are for females. Additionally, the differences decrease with increases in the discount rate and with increases in the starting age. The incremental effect of incorporating morbidity is to decrease the percent change from the NCHS period table base case.

IV Discussion and Conclusions

Whether judged by the impact on remaining life expectancy, survival probability or the value of economic losses, it seems clear that there are no material differences between use of the period life tables produced by the NCHS or the SSA. For males, with respect to the economic loss examples above, the biggest difference occurred for the modeled pension loss, with percent differences in loss ranging from 1.2 to 1.4 percent depending on the discount rate used. For females, the impact on the pension loss was nil, and the biggest impact was on the provision of household services with percent differences no greater than 0.2 percent. These are not significant differences in terms of a tort action involving personal injury or wrongful death.

By comparison, the differences resulting from use of the SSA cohort life tables are larger and, in some cases, significant. Several patterns are apparent. First, whether measured by changes in remaining life expectancy, survival probability or the impact on economic losses, the impact of using the SSA cohort tables in place of the NCHS period tables is greater for males than for females. Second, the impact on the economic losses decreases as the net discount rate increases. Third, the loss impact decreases as the starting age increases, though the decline is not as pronounced for household services at higher net discount rates. Finally, the impact is smallest for earnings losses and greatest for lost pensions, as illustrated in Table 1 below:

Table 1
Range of Impact of SSA Cohort Tables
By Sex and Loss Category

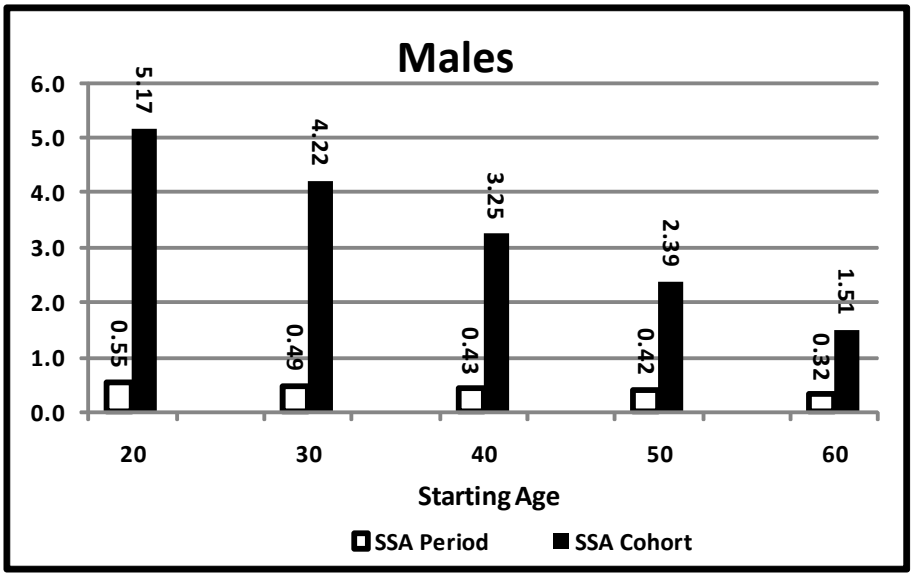
	Males		Females	
Loss Category	**Minimum**	**Maximum**	**Minimum**	**Maximum**
Earnings	0.60%	1.52%	0.16%	0.67%
Household Services	1.33%	2.91%	0.36%	1.53%
Pension	6.30%	21.41%	3.60%	16.23%

Indeed, the increases in the loss estimates resulting from the use of the SSA cohort tables are probably only material for losses associated with pensions. This is not surprising, since most of the mortality improvement in the SSA cohort tables occurs in the years after age 55.

Even though the pension loss estimates increase significantly due to use of the SSA cohort tables, it is not a foregone conclusion that these tables should be used when estimating the value of such losses. Such a conclusion assumes that the projected declines in death rates underlying the SSA cohort tables are more likely to be representative of future mortality by age than is recent experience. Figure 9 depicts the annual decline in the age- and sex-adjusted death rates that the cohort tables discussed above are ultimately based on. While the SSA Trustees' *Annual Report* presents the projected death rates, and gives a general description of the underlying mortality assumptions, there is nothing in the report that would

support such a conclusion other than the fact that the cohort tables are produced by the SSA Trustees. Of greater importance, there is nothing in most forensic economists' training that would permit a professional opinion on the adequacy of the projected declines in the death rates. Accordingly, the most that can be said based on the analysis and discussion presented in this paper is that use of the SSA cohort tables in lieu of the NCHS period tables will not likely produce a material difference in losses dealing with earnings or household services, but may result in a material difference in estimates dealing with lost pensions. A determination of which set of tables is more appropriate cannot be made on the basis of the results reported here.

Figure 1
Change from NCHS Life Expectancy



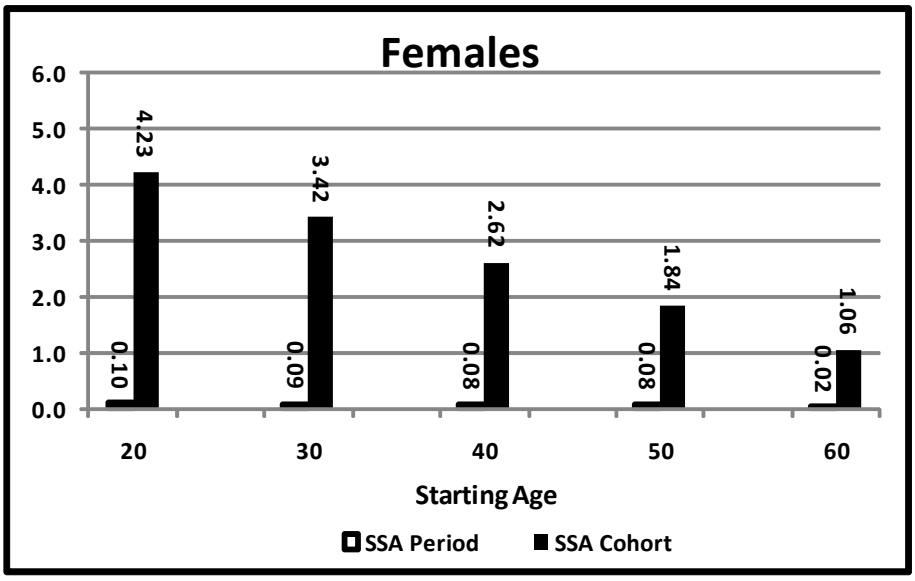


Figure 2
Change from NCHS Survival Probability

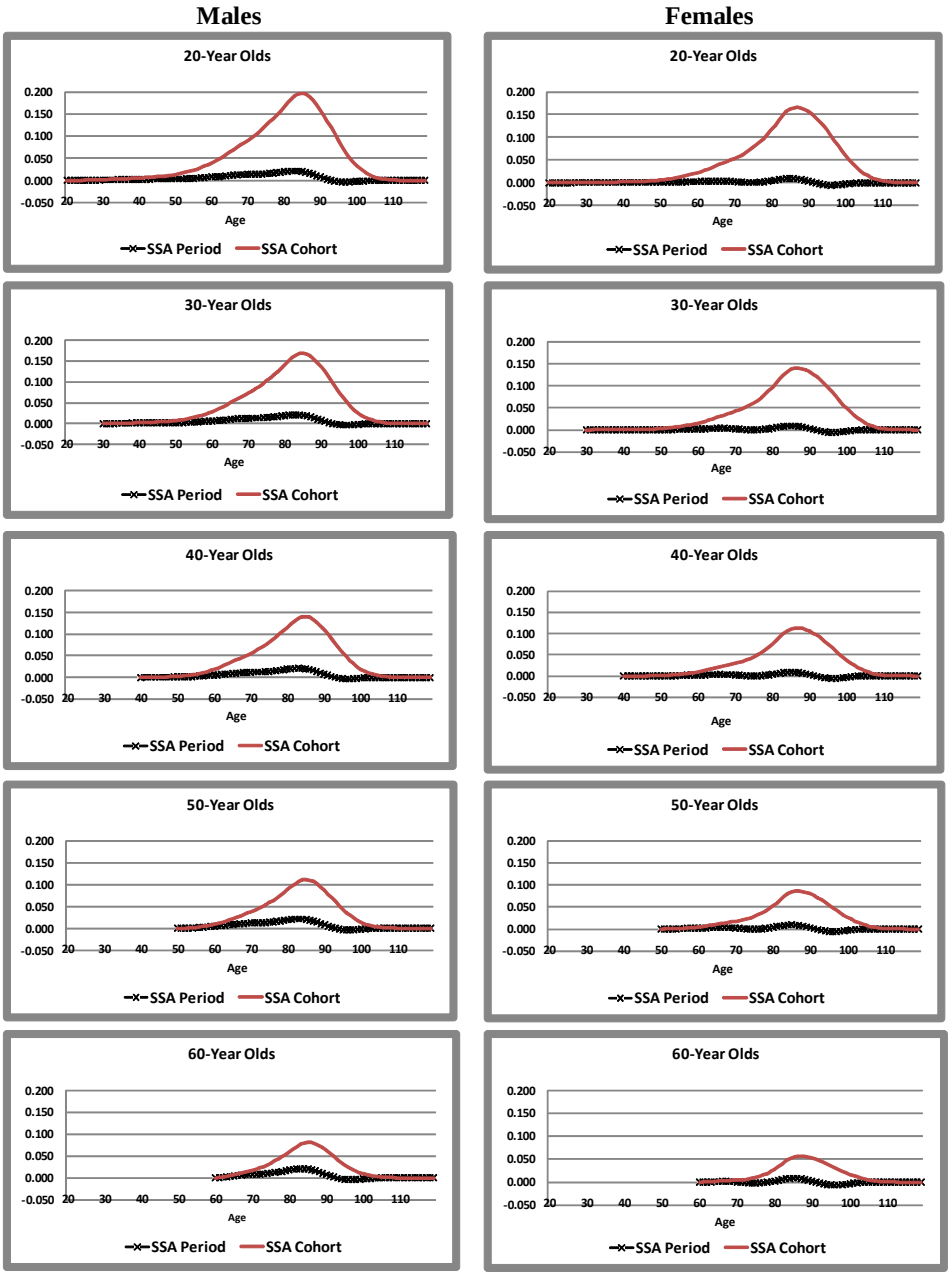
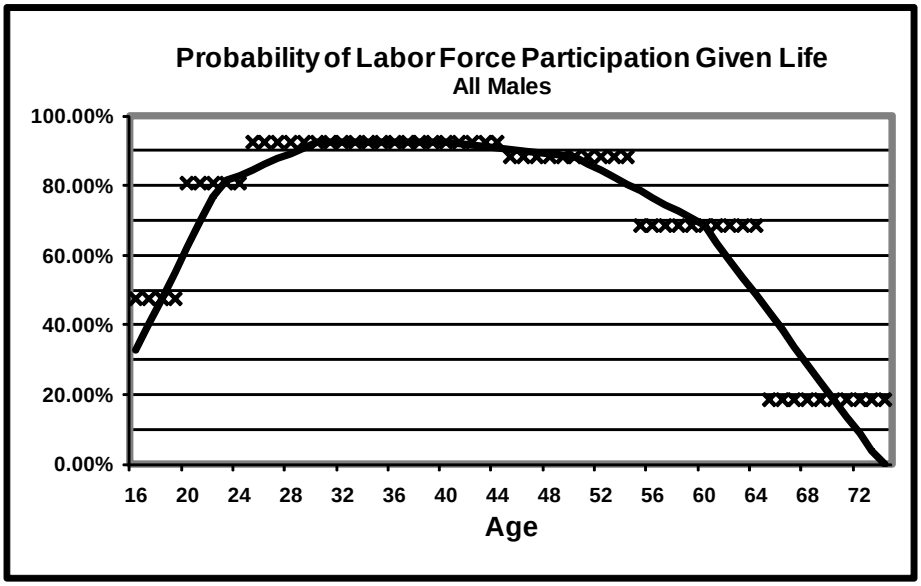


Figure 3
Male and Female Labor Force Participation
All Levels of Educational Attainment



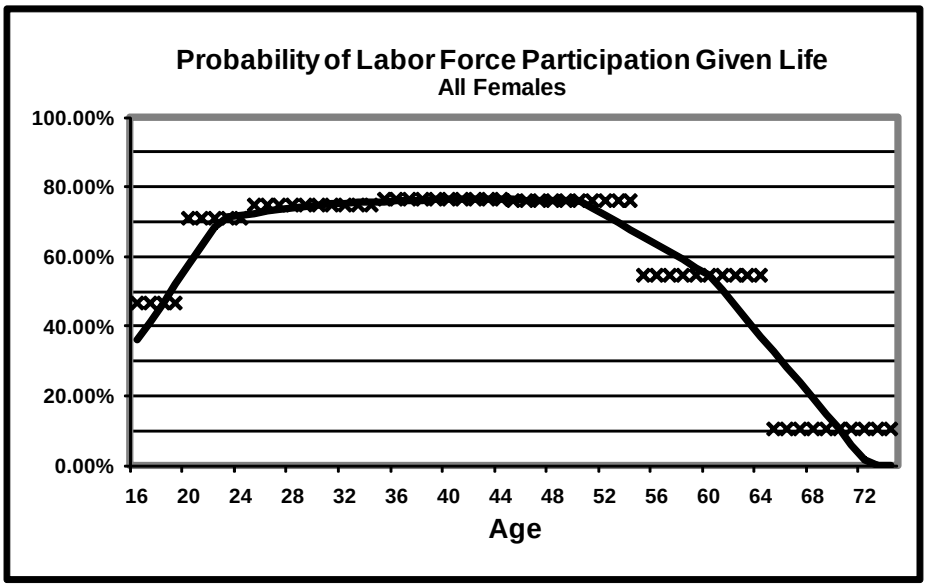


Figure 4
Male and Female Probability of Employment
All Levels of Educational Attainment

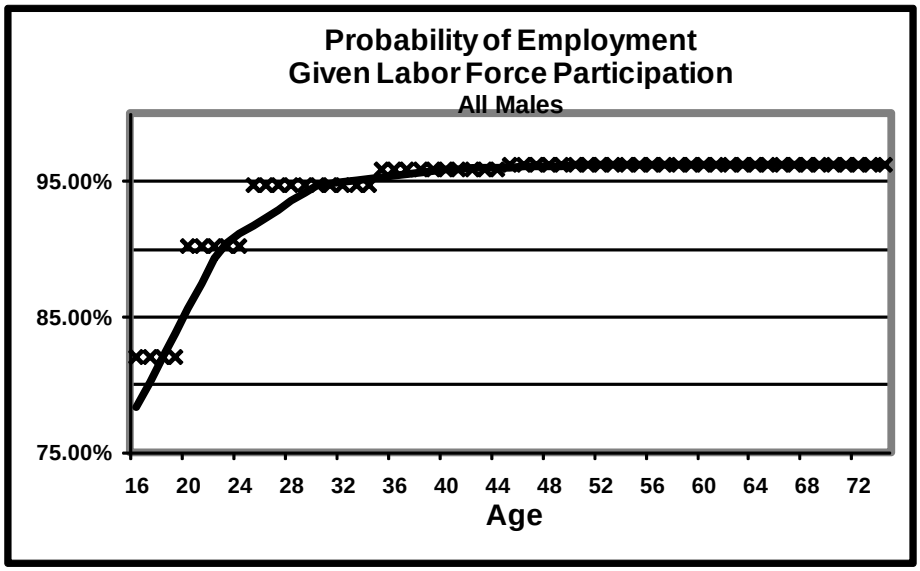


Figure 5
Impact on Earnings Loss

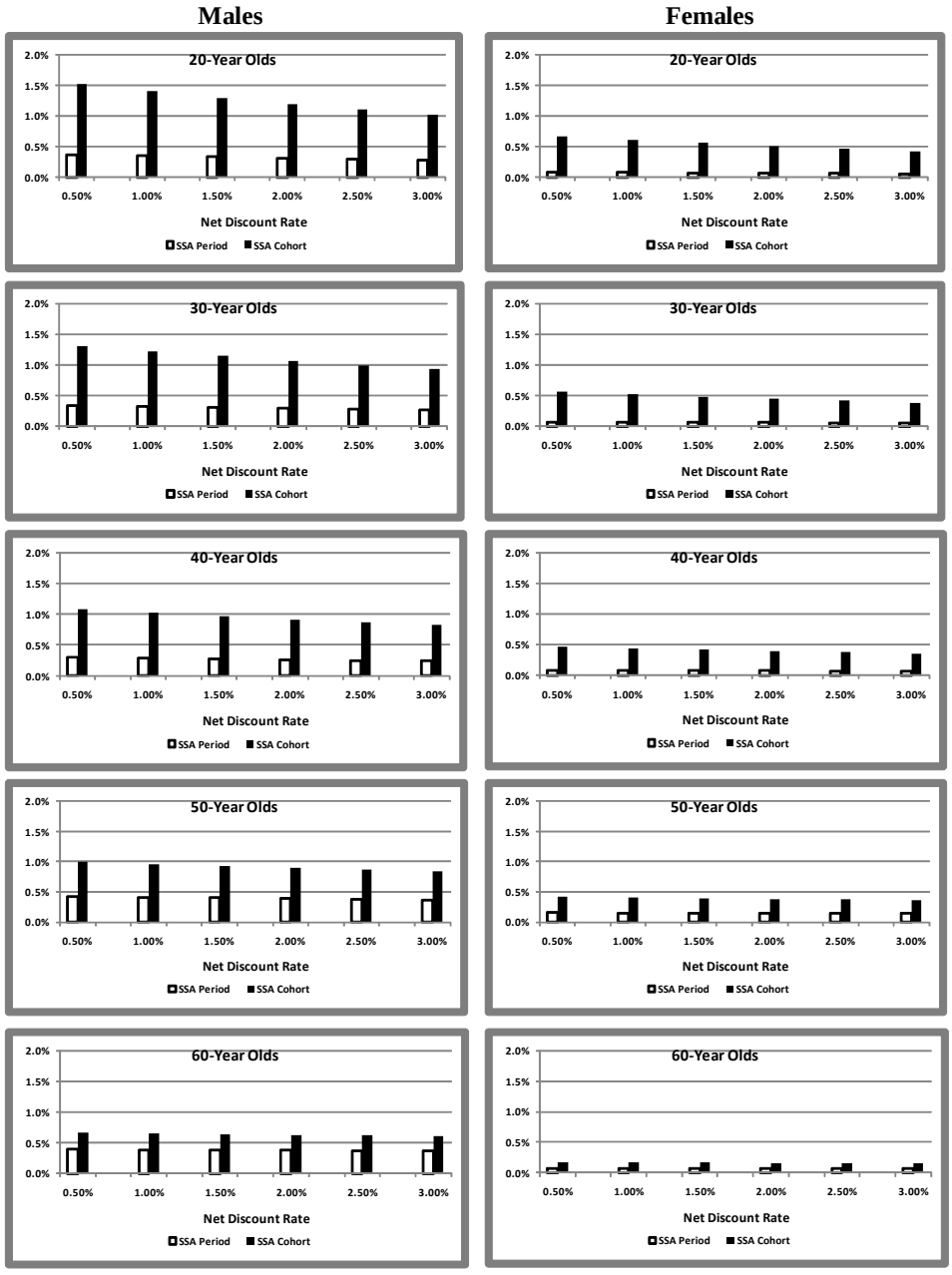


Figure 6
Impact on Pension Loss

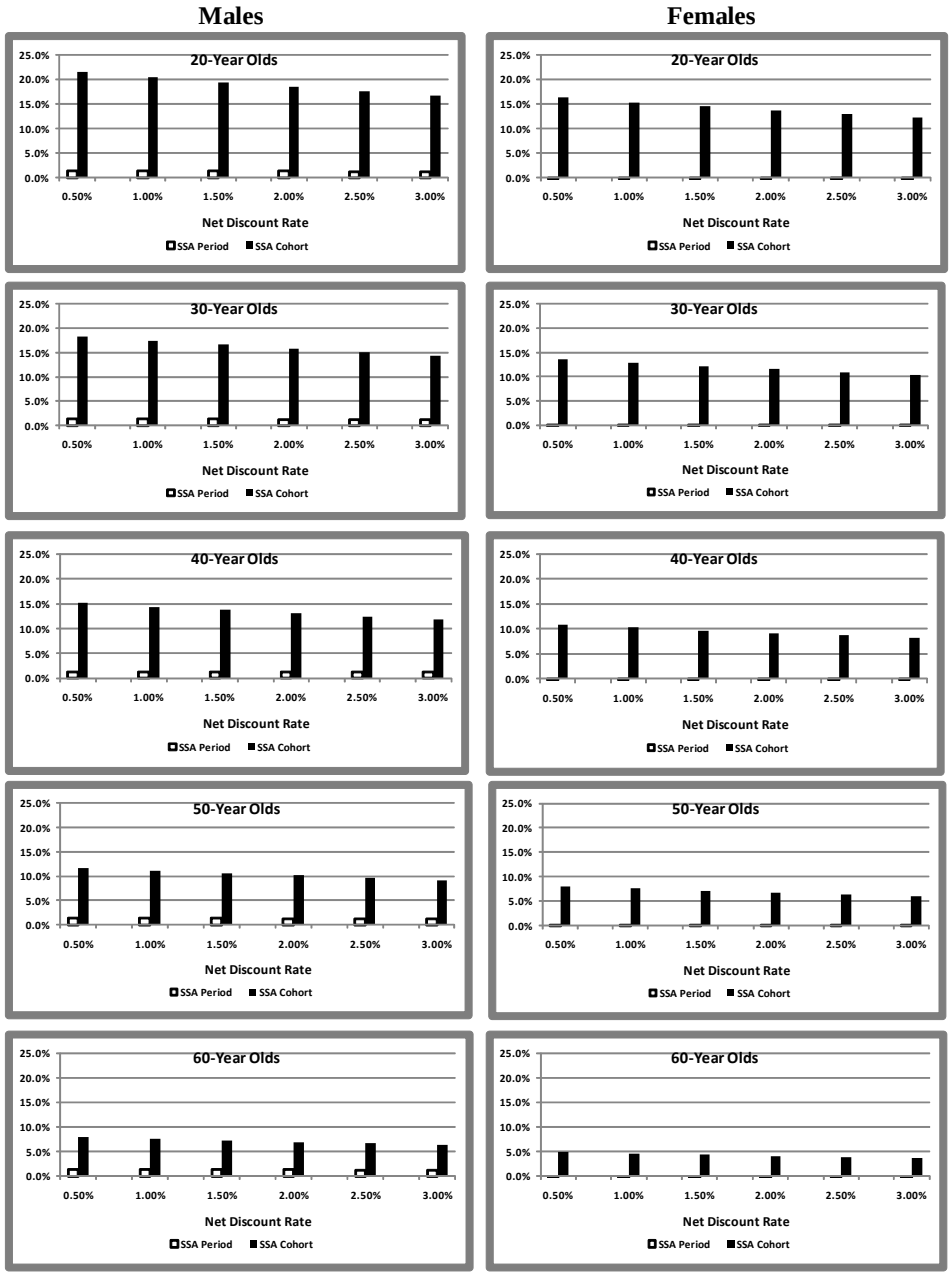


Figure 7
Impact on Household Services Loss
Through Age 75 with Mortality Risk Only

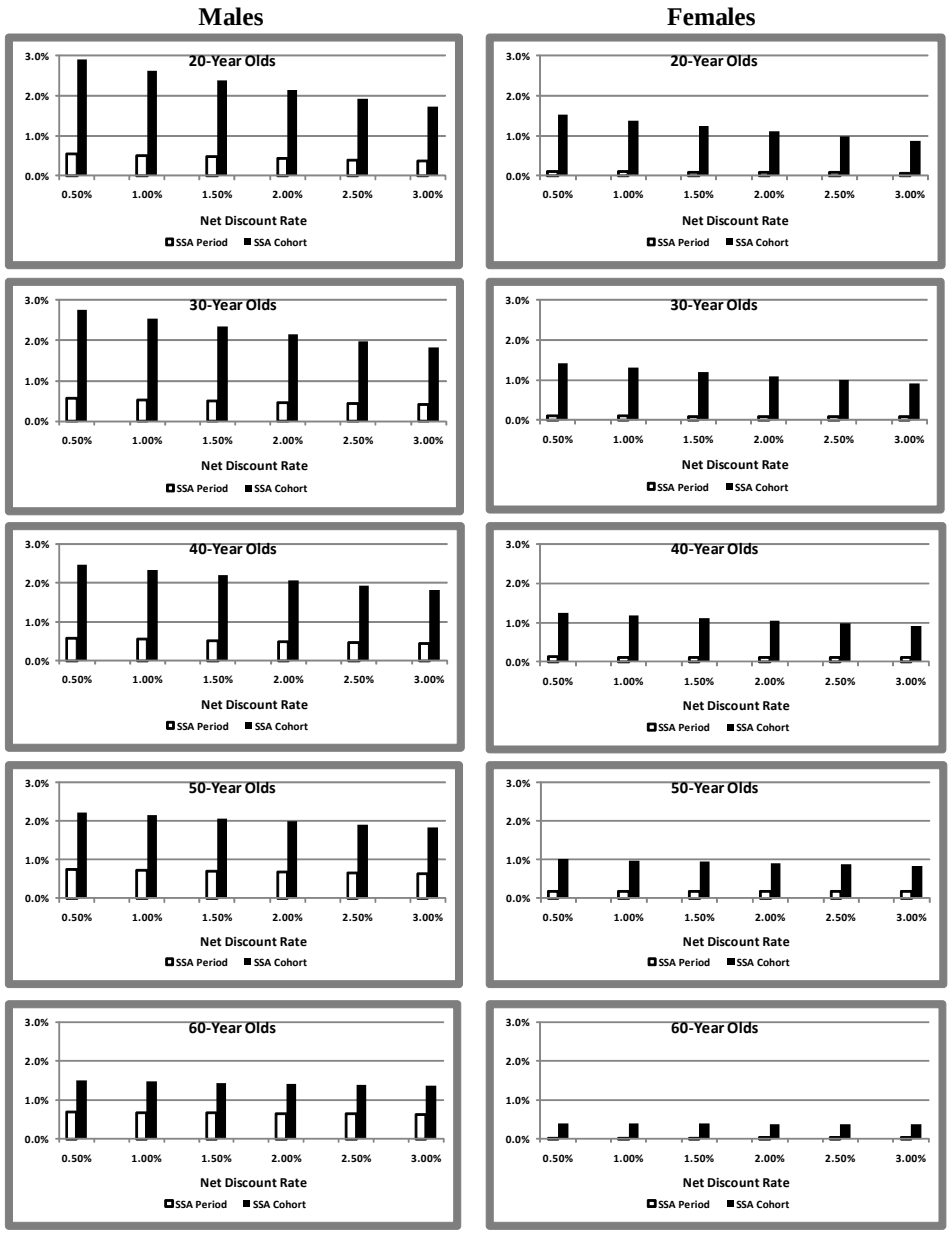


Figure 8
Impact on Household Services Loss
Through Age 75 with Mortality and Morbidity Risk

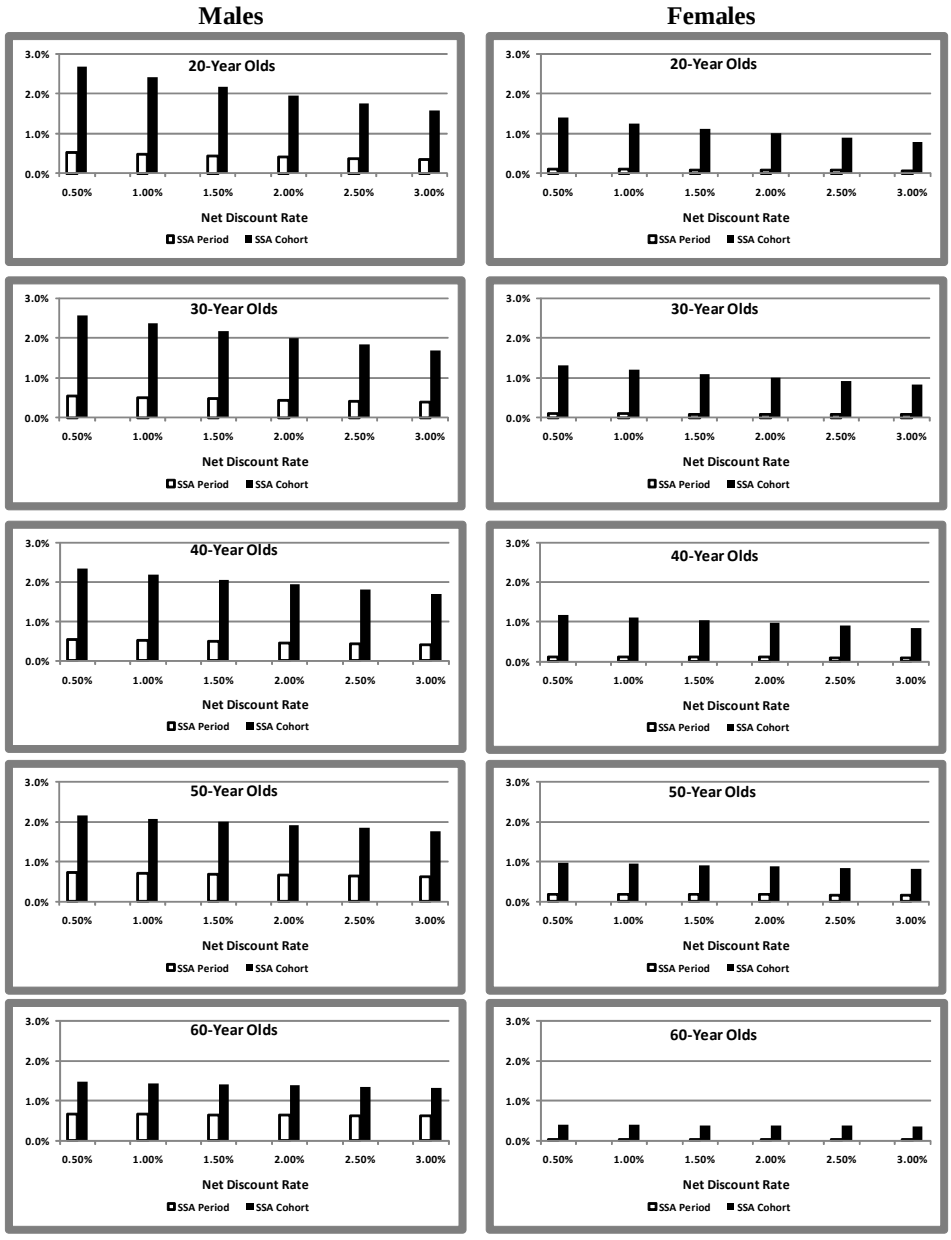
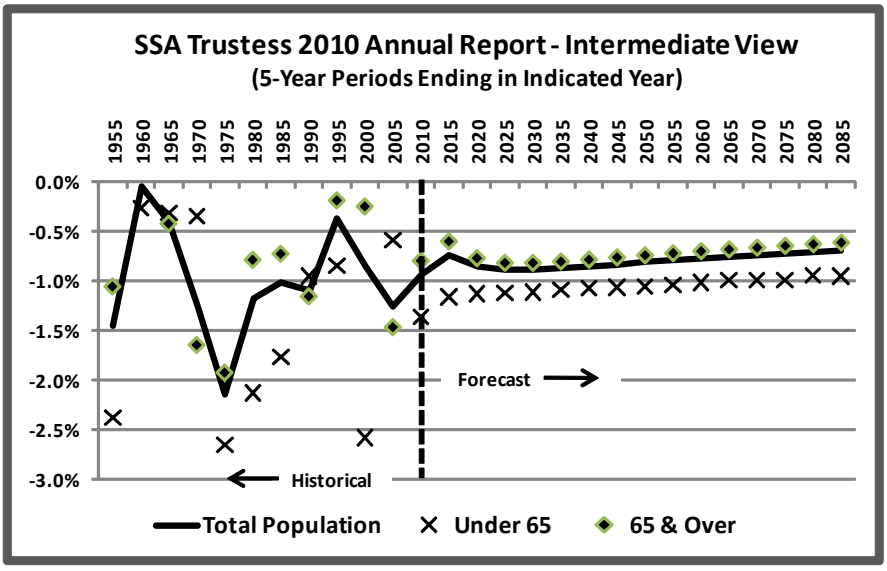


Figure 9
Annual Rate of Decline in
Age and Sex Adjusted Death Rates



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Expectancy Data, 2010, *Healthy Life Expectancy, 2006 Tables*.

Social Security Administration, *The 2010 Annual Report Of The Board Of Trustees Of The Federal Old-Age And Survivors Insurance And Federal Disability Insurance Trust Funds*, U.S.Government Printing Office, Washington, 2010.

End Notes

[1] The NCHS period tables for all males and all females have been extended to age 130, using the coefficients found in Table III (p. 38) of Arias. The SSA period tables relied on in this paper are those underlying the SSA Trustees' 2010 Annual Report for calendar year 2010. The SSA cohort tables relied on are those for birth years 1990, 1980, 1970, 1960 and 1950. The Trustees' report presents three separate projections – intermediate, low cost, and high cost – of the future income and expenditures of the Old-Age, Survivors, and Disability Insurance (OASDI) program, with corresponding period and cohort life tables. The intermediate projections represent the Trustees' best estimate of future experience and this paper utilizes the life tables corresponding to these projections. The author thanks Tom Hale for his assistance in obtaining the SSA life tables. An Excel version of the SSA period and cohort life tables may be found at http://www.valueeconomics.com/ . Note that these tables are different than those found in the SSA's Actuarial Study No. 120.

[2] The population, labor force and employment data are a subset of data compiled by the BLS in what is known as "Table 10." This unpublished table reports the employment status of the civilian noninstitutional population by level of educational attainment, age, sex, and race. PDF versions of the reports beginning with 1994 can be found at http://www.valueeconomics.com/ along with an Excel file containing the population, labor force and employment counts.

[3] Of course, not all pensions are determined by past income levels -- for example, some are calculated as a flat dollar amount per month per year of service. In such instances, the mortality adjustment should be calculated based on the starting age rather than on the age the pension is assumed to begin. Doing so increases the period differences in Figure 6 by up to 140 basis points for 20-year old males, and by up to 40 basis points for 20-year old females. For the cohort differences, the increases are substantially greater: more than 900 basis points for a 20-year old male, and almost 500 basis points for a 20-year old female. These increases decline as the starting age increases for both the period and cohort differences.

[4] These data stop at age 100 – extending the calculations discussed above to this age increases the reported SSA cohort percent changes significantly. However, this increase is all due to the change in survival probability beyond age 75. The addition of the morbidity probability serves to decrease the reported differences out to both age 75 and 100. The author thanks Kurt Krueger for facilitating these calculations by providing Tables 2 and 3 from *Healthy Life Expectancy* in an electronic format.